

Research article

Economic burden of ischemic stroke in an eastern European tertiary stroke center

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Abstract: Ischemic stroke is currently one of the most important public health problems worldwide, affecting more and more young patients. The hospital length of stay (LOS) represents a major indicator of its economic burden. The aim of our study was to analyse the factors associated with the LOS and residual disability in patients with ischemic stroke in a Romanian tertiary center. Methods: This was a retrospective, single-center observational study including 520 patients with ischemic stroke admitted to the Neurology Department of the Emergency County Hospital Cluj-Napoca between March 2017 and March 2022. Clinical data were retrospectively extracted from the Registry of Stroke Care Quality (RES-Q). Results: The median LOS was 7 days. In univariate analysis, LOS was significantly longer in women compared to men (8 days vs. 7 days, $p=0.027$), in hypertensive compared to normotensive patients (8 days vs. 7 days, $p=0.003$), and was associated with stroke severity ($p=0.004$). No statistically significant association was observed between LOS and age, atrial fibrillation, dyslipidemia, smoking status, or intravenous thrombolysis. Among working-age patients (24.8% of the cohort), 29.45% died or were discharged with severe disability (mRS ≥ 3). Conclusions: In this registry-based analysis, LOS was associated with stroke severity, gender and hypertension in univariate testing. The high proportion of severely disabled working-age patients highlights the considerable socioeconomic burden of stroke.

Keywords: ischemic stroke, length of stay, disability, risk factors, economic burden, Eastern Europe

1. Introduction

Stroke is currently one of the most important public health problems worldwide, being the second cause of mortality in people over 50 years old [1] and the leading cause of long-term disability [2]. Globally, it is estimated that every 3 seconds another person suffers a stroke [3]. Moreover, stroke is no longer considered a pathology only of the elderly since there has been an increase in the number of young people affected by stroke over the past 30 years [4]. Thus, it is currently estimated that one in four people over 25 years old will have a stroke at some point during their life [3]. All these aspects highlight the importance of the economic and social burden of stroke. There are few studies in literature which determined the total costs of the ischemic

stroke, and even fewer studies that evaluated the major factors that influence them as well.

Despite the well-documented global burden, data regarding factor associated with hospitalization duration and indirect economic impact in Eastern European countries remain limited. The objective of this study was to provide regional data regarding the length of stay (LOS) and disability at discharge, and to explore clinical and demographic factors associated with these outcomes.

The objective of our study was to offer relevant information about the economic burden of ischemic stroke in the local settings by measuring the length of stay (LOS) in patients with ischemic stroke admitted in the Neurology Department of the Emergency County Hospital Cluj-Napoca (ECHCJ) and the disability at discharge. Moreover, the factors that can influence them, such as age, gender, stroke severity, presence of risk factors and intravenous thrombolysis were also analysed. In addition, another aim of this study was to determine the number of patients with ischemic stroke who remained unable to work due to their disability.

2. Materials and Methods

2.1. Sampling method and data collection

This was a descriptive, retrospective single-center observational study including all the patients with ischemic stroke admitted to the Neurology Department of the Emergency County Hospital Cluj-Napoca (ECHCJ) during March of each year between 2017 and 2022. The necessary data were collected from the Registry of Stroke Care Quality (RES-Q) database. RES-Q is among the largest international registries dedicated to the quality of stroke care (<https://stroke.qualityregistry.org/>). The RES-Q was established in 2016. Developed under the auspices of the European Stroke Organisation (ESO), and enables physicians to systematically monitor, evaluate, and improve the quality of stroke management across world. Participation in RES-Q constitutes an important step toward optimizing clinical outcomes for patients with stroke. In Romania, hospitals enrolled in this registry collected data on all patients discharged with a diagnosis of stroke exclusively during the month of March each year. The present study reflects this predefined registry structure rather than an investigator-driven sampling strategy. Although this ensures methodological consistency across years, it may limit seasonal representativeness. The study received ECHCJ ethics committee approval (No. 51206/06.12.2021).

For each patient included in the study data regarding gender, age, NIHSS score at admission, intravenous thrombolysis, door-to-needle time, presence of atrial fibrillation, hypertension, dyslipidemia, smoking status, destination at discharge, mRS score at discharge and LOS were extracted. The patients were then divided into age groups as follows: 18-30, 31-40, 41-50, 51-60, 61-70, 71-80, 81-90, and 91-100 years old. Patients were also included into a stroke severity class based on the NIHSS score at admission as follows: between 0 and 5 points – mild stroke, between 6 and 15 points – moderate stroke, between 16 and 20 points – moderate to severe stroke, and between 21 and 42 points – severe stroke. Regarding the intravenous thrombolysis, it was noted if the patients received rt-PA (alteplase) or not and for those who were candidates for thrombolysis, the door-to-needle time was also specified. According to the destination at discharge, each patient was included in one of the following groups: home, another centre, another department (acute rehabilitation), nursing home or deceased.

2.2. Statistical analysis of the data

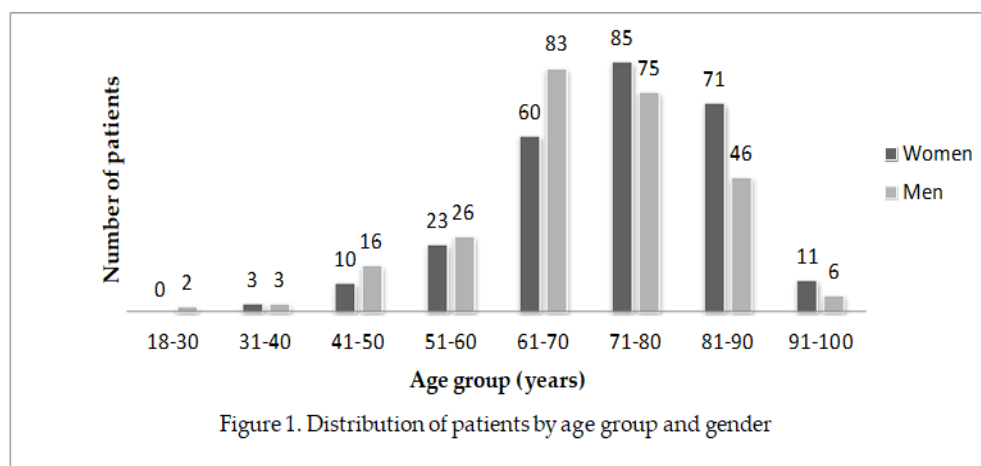
All data were statistically processed using the Data Analysis function of Microsoft Excel and the program IBM SPSS Statistics for Windows, version 29.0. In order to verify the normal distribution of the data for the numerical variables LOS, age and

mRS score at discharge, we used the Kolmogorov-Smirnov test, which showed that they do not follow a normal distribution. Therefore, non-parametric tests were applied. Mann-Whitney U and Kruskal-Wallis tests were used to evaluate associations between LOS and categorical variables. The chosen statistical significance threshold was $p < 0.05$. The present analysis focused on univariate associations; therefore, findings should be interpreted as associations rather than independent predictive effects.

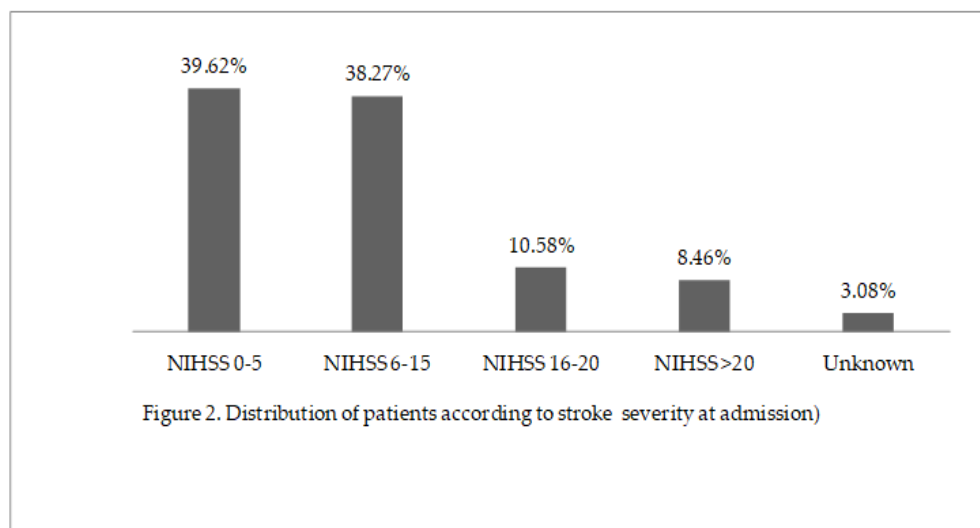
3. Results

3.1. Demographics and clinical findings

A total number of 520 patients with ischemic stroke with the age between 18 and 100 years old were included in the study. There was no significant difference between men and women distribution (49.43% versus 50.57%). The average age was 73 years old in women and 70 years old in men. Most of the female patients ($n=85$, 32.32%) were between 71 and 80 years old, while most of the male patients ($n=83$, 32.30%) were between 61 and 70 years old (see Figure 1).



Regarding the ischemic stroke severity, 206 patients had a mild ischemic stroke (NIHSS score at admission between 0 and 5 points), representing 39.62% (Figure 2). For sixteen patients (3.08%) the NIHSS score was not calculated, so these patients could not be included in any category of severity.

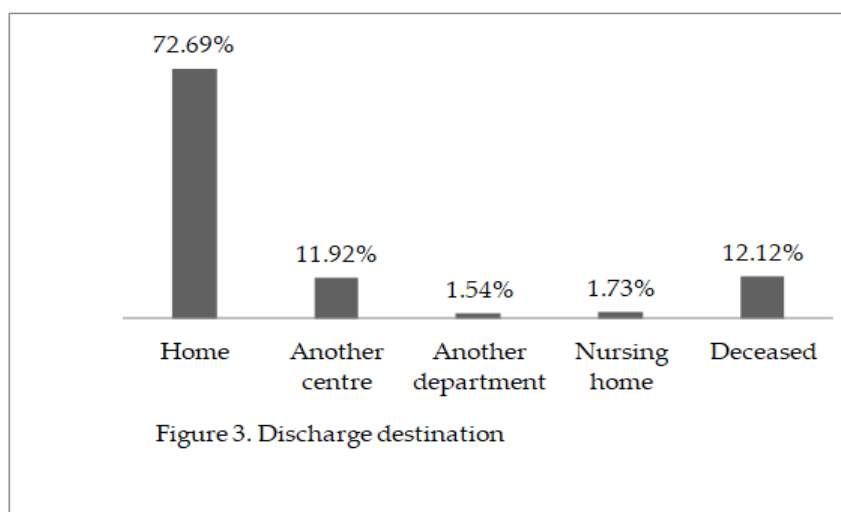


The presence of the most common risk factors for ischemic stroke among our patients is detailed in Table 1.

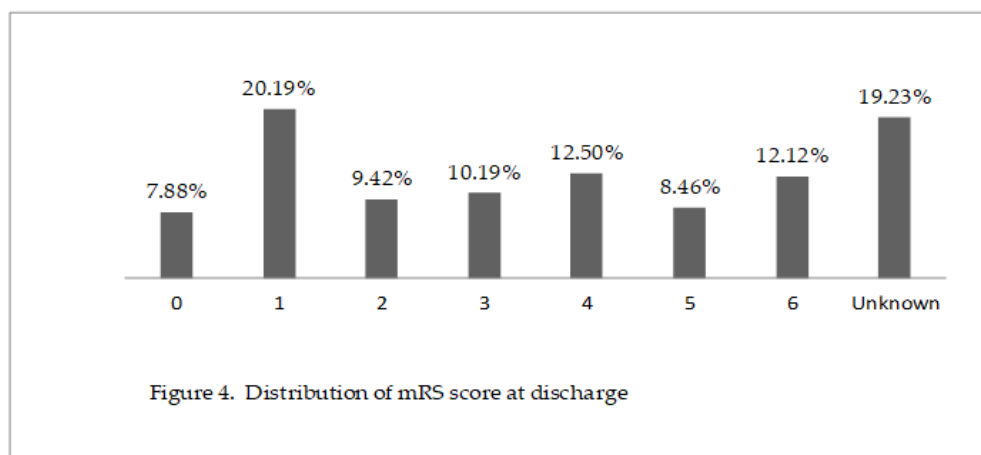
Table 1. Presence of risk factors among the patients with ischemic stroke

Risk factors		n	%
Atrial fibrillation	Yes	165	31,73
	No	355	68,27
Dyslipidemia	Yes	403	77,5
	No	54	10,38
	Unknown	63	12,12
Hypertension	Yes	395	75,96
	No	62	11,92
	Unknown	63	12,12
Smoking	Yes	100	19,23
	No	420	80,77

The majority of the patients (72.69%) were discharged home, and about 12.12% of the patients died during hospitalisation (Figure 3).



Almost one third of the patients (31.15%) had a moderate to severe disability at discharge (mRS=3, 4 or 5). For 19.23% of the patients the mRS score at discharge was not calculated, so they could not be included in any category (Figure 4).



3.2. Average hospital LOS

The median LOS in our patients was 7 days. There was a statistically significant difference between men and women ($p=0.027$), median LOS being 7 days in men and 8 days in women. The median LOS for each age group is represented in Table 2. No statistically significant difference was found between LOS and age ($p=0.668$). LOS was not associated with the presence of atrial fibrillation ($p=0.644$) or dyslipidemia ($p=0.147$).

Table 2. Median LOS according to the age group

Age group (years)	Number of patients	Median LOS (days)		
		Min	Median	Max
18-30	2	8	11	14
31-40	6	3	7,5	15
41-50	26	1	8	47
51-60	49	1	7	16
61-70	144	1	7	38
71-80	159	1	7	30
81-90	117	1	8	26
91-100	17	1	8	19

Median LOS was longer in hypertensive patients (8 days) compared to non-hypertensive patients (7days), with a significant difference between the two groups ($p=0.003$). The median LOS in smokers was 8 days, while in non-smokers it was 7 days. However, no statistically significant difference regarding the LOS depending on the smoking status was found ($p=0.546$). Median LOS was significantly higher in patients with severe stroke compared to those with mild, moderate, or moderate-severe stroke ($p=0.004$) (Table 3).

Table 3. LOS according to stroke severity

Stroke severity (NIHSS score)	Number of patients	LOS (days)		
		Min	Median	Max
Mild	206	1	7	38
Moderate	199	1	8	47
Moderate-severe	55	1	7	30
Severe	44	1	10	29

3.3. Intravenous thrombolysis

From the total of 520 patients, 15.58% of them received intravenous thrombolysis, with an average door-to-needle time of 39.51 minutes ($SD=12.8$, 95% CI= 36.67-42.34). The median LOS in patients with thrombolysis was 7 days, while in others was 8 days, but there was no significant difference between the two groups ($p=0.123$). A significant difference was noticed between the patients with and without thrombolysis regarding the mRS at discharge (mRS=2, respectively 3, $p=0.015$).

3.4. Number of previously active patients remained unable to work after the ischemic stroke

From the total number of patients included in this study, 9.23% were women under 63 years old (the retirement age for women in Romania), and 15.57% were men under 65 years old (the retirement age for men in Romania), representing 24.8% of the sample. Of them, 29.45% remained with a high degree of disability after the ischemic stroke (the mRS stroke at discharge was 3, 4 or 5) or died (Table 4).

Table 4. mRS score at discharge in non retired patients

mRS score at discharge	Women < 63 years old		Men < 65 years old	
	n	%	n	%
0	5	3.87	18	13.95
1	12	9.3	16	12.4
2	4	3.1	9	6.97
3	3	2.32	7	5.42
4	5	3.87	11	8.52
5	1	0.77	2	1.55
6	0	0	9	6.97
Unknown mRS	18	13.95	9	6.97
Total	48	9.23	81	15.57

4. Discussion

4.1. Main results of the study

The results of this study showed that the median LOS in patients with ischemic stroke admitted in the Neurology Department of the CEHCJ between March 2017 and March 2022 was 7 days. Following the analysis of the characteristics of the studied sample and the risk factors associated which could have an association with the hospital length of stay, a statistically significant association between gender, stroke severity and presence of hypertension and the LOS was noticed. Instead, contrary to our expectations, the LOS was not significantly influenced by age, presence of atrial fibrillation and dyslipidemia or smoking. These findings derive from univariate analyses and do not establish independent predictive relationships.

Regarding the intravenous thrombolysis, a total of 15.58% of the patients included in this study received this treatment, and there has been an impressive increase over time, from 0% in March 2017 to 26.67% in March 2022. This is due to the significant improvement of quality of stroke care in our country during the last years with the joint efforts of European Stroke Organization (ESO), the Romanian Society of Neurology and the Romanian Ministry of Health. There were lots of workshops, educational sessions and simulations for neurologists, radiologists, emergency physicians, nurses and ambulance personnel across the country which led to a solid and active stroke network [5]. This is also proved by the average door-to-needle time observed, of approximately 40 minutes.

A worrying result though and which demonstrates the strong social and economic impact of the ischemic stroke is represented by the percentage of people remained unable to work after the stroke. About a quarter of the patients included in our study were young, professionally active people, and almost a third of them remained with important neurological deficits (the mRS score at discharge was 3, 4 or 5), or even died.

4.2. Comparison with the results of other similar studies

Regarding the average LOS in patients with ischemic stroke, the results of numerous studies published on this topic vary significantly from one country to another, covering it between 4 and 15 days. Thus, some of the smallest median LOS are presented in a study conducted in Jordan on a sample of 142 patients, of only 4 days [6], and in another study realized on 898 patients in Thailand, of 5 days [7]. Longer average LOS were described in some studies realized in Peru – 8 days [8], China – 10 days [9], respectively 14 days [10], Germany – 14 days [11], and South Korea – 15 days [12]. In our study, the median LOS was 7 days, which was close to the one mentioned in another study performed in Cluj-Napoca – 8.3 days [13], being situated in the middle of the range found in literature. These differences could be due both to health systems and socio-economic conditions that vary from one country to another, and to the different characteristics of the studied samples.

With a view to the factors that influence the median LOS, the data found in literature are controversial. If regarding the NIHSS score at admission and the severity of the ischemic stroke, the results obtained in our study are consistent with the ones presented by other authors [6], for gender and the presence of hypertension it is difficult to reach a conclusion because of the contradictory information. Some studies argue that the gender of the patients influences the LOS [6, 9, 12], while others could not prove that there is a statistically significant connection between the gender and the LOS [8, 10, 15], and divergent results were also observed in the case of hypertension [12, 15].

In addition, even though our study could not demonstrate a statistically significant relationship between the age of the patients and the LOS, there are published studies which showed that the median LOS was significantly longer in young patients compared to older patients [8]. At the same time, other studies demonstrate the contrary, stating that the LOS was statistically significantly shorter in younger patients, excepting the age group of 18-34 years old [10].

In our cohort, women had a significantly longer median LOS compared to men. The literature regarding gender differences in LOS is inconsistent. Some studies report a significant association between female sex and longer hospitalization [6,9,12], while others failed to demonstrate such a relationship [8,10,15].

The explanation is likely multifactorial. Women with stroke are typically older at onset, which may translate into increased frailty and higher pre-stroke functional dependency. In our study, the mean age was slightly higher in women, which may partially account for the observed difference. Beyond biological aspects, social determinants should also be considered. Older women are more likely to live alone and to lack immediate informal caregiving support, which can delay discharge planning and prolong hospitalization. Therefore, gender-related differences in LOS should be interpreted as the result of an interaction between demographic structure, baseline vulnerability, and social support systems rather than as an isolated biological effect. Previous studies have shown that atrial fibrillation is associated with longer LOS, increased stroke severity, higher in-hospital mortality, and increased costs [7,15,16]. However, in our cohort, atrial fibrillation did not significantly influence the median LOS.

Several explanations may account for this discrepancy. First, LOS is not determined exclusively by stroke etiology or severity, but also by discharge logistics and organizational factors within the hospital. Standardized acute stroke pathways and early initiation of secondary prevention strategies may have reduced variability in hospitalization duration in our center. Second, atrial fibrillation may contribute more strongly to early mortality rather than prolonged hospitalization. In such cases, LOS may not increase, as in-hospital death may occur relatively early.

Finally, the restriction of data collection to the month of March each year and the sample size may have limited statistical power to detect moderate differences.

Regarding the intravenous thrombolysis, in our study the administration of alteplase did not statistically significantly influence the median LOS, which contradicts the results of other studies in which there was noticed a decrease of the LOS in patients who benefited from the intravenous thrombolysis [7, 17], but this can be due to the small number of patients who received alteplase in our study. On the contrary, the intravenous thrombolysis had a positive impact on the mRS score at discharge.

4.3. The strengths and weaknesses of the study

The main merit of this study is that it brings latest information regarding the economic burden of ischemic stroke in our region by analysing the LOS and the factors that influence it, in the context in which there are few data regarding these aspects published for Romania at this moment. Moreover, we analysed the percentage of patients remained unable to work after the stroke, raising an alarm signal with a view to the strong socio-

economic impact of this pathology due to the productivity losses and the lack of rehabilitation centres in our country. A particularly important finding of our study is the high proportion of working-age patients who remained severely disabled or died. Nearly one third of non-retired patients had an mRS score ≥ 3 or died at discharge.

Stroke is already recognized as a leading cause of long-term disability worldwide [1,3], and its increasing incidence among younger populations has been documented in recent decades [3,4]. In this context, disability in professionally active individuals generates not only direct medical costs but also significant indirect costs related to productivity loss, long-term dependency, disability pensions, and informal caregiving burden.

Previous Romanian data have highlighted the substantial societal costs associated with ischemic stroke [13]. Our findings reinforce the need for health policies focused on expanding access to early multidisciplinary neurological rehabilitation and structured post-discharge recovery pathways. Investment in rehabilitation infrastructure and return-to-work programs may reduce long-term disability and mitigate the broader economic impact of stroke.

The fact that the data were extracted from the official database of the Registry of Stroke Care Quality (RES-Q) pleads for the rigor of the data collection and their transparency.

This study has several limitations. First, sampling was restricted to March of each year, reflecting the structure of the RES-Q registry, which may limit seasonal representativeness. The absence of multivariable regression limits the ability to control for potential confounding between age, stroke severity, vascular risk factors, and sex. Therefore, observed associations should be interpreted cautiously. We couldn't analyse the relationship between all the risk factors for ischemic stroke and the LOS because the data regarding the presence of diabetes mellitus were not available in the RES-Q database. It was a study realized in a single centre from the country, so the data could be different in other parts of the country, making it difficult to extrapolate the results of our study at a national level. The study analysed the economic burden of the ischemic stroke indirectly through the LOS and the disability, because of not having access to specific information regarding the direct medical costs resulted after the hospitalization of the patients with ischemic stroke. LOS represents an indirect proxy of economic burden and may be influenced by non-clinical factors not captured in the registry.

4.4. Further research directions

This study could be a starting point to other multicentric studies that should analyse the average LOS and the factors that influence it in order to create a better picture of these aspects at a national level. In addition, given the heterogeneity of the data regarding the factors that influence the LOS found in literature, it is necessary to conduct more studies to analyse these factors, on the largest possible samples of population. Further research is also needed to determine the direct medical costs, the social care costs and the expenses resulted from the productivity losses due to the ischemic stroke in Romania.

5. Conclusions

The length of hospital stay represents a key factor associated with the economic burden of ischemic stroke. In our cohort, LOS was associated with gender, hypertension, and stroke severity in univariate analysis, reflecting the multifactorial nature of hospitalization dynamics.

Importantly, the substantial proportion of working-age patients who remained severely disabled is consistent with global data demonstrating the growing burden of stroke-related disability in younger populations [3,4]. These findings emphasize the need to strengthen prevention strategies, optimize acute stroke care pathways, and expand access to structured neurological rehabilitation services.

From a health policy perspective, improving functional outcomes in professionally active patients should be considered a strategic priority in order to reduce long-term societal and economic burden.

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Declarations of interest. The authors declare that there is no conflict of interest

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