

Delivery of acute ischaemic stroke treatments in the European region in 2019 and 2020

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Abstract

Introduction: We assessed best available data on access and delivery of acute stroke unit (SU) care, intravenous thrombolysis (IVT) and endovascular treatment (EVT) in the European region in 2019 and 2020.

Patients and methods: We compared national data per number of inhabitants and per 100 annual incident first-ever ischaemic strokes (AIS) in 46 countries. Population estimates and ischaemic stroke incidence were based on United Nations data and the Global Burden of Disease Report 2019, respectively.

Results: The estimated mean number of acute SUs in 2019 was 3.68 (95% CI: 2.90–4.45) per one million inhabitants (MIH) with 7/44 countries having less than one SU per one MIH. The estimated mean annual number of IVTs was 21.03 (95% CI: 15.63–26.43) per 100,000 and 17.14% (95% CI: 12.98–21.30) of the AIS in 2019, with highest country rates at 79.19 and 52.66%, respectively, and 15 countries delivering less than 10 IVT per 100,000. The estimated mean annual number of EVTs in 2019 was 7.87 (95% CI: 5.96–9.77) per 100,000 and 6.91% (95% CI: 5.15–8.67) of AIS, with 11 countries delivering less than 1.5 EVT per 100,000. Rates of SUs, IVT and EVT were stable in 2020. There was an increase in mean rates of SUs, IVT and EVT compared to similar data from 2016.

Conclusion: Although there was an increase in reperfusion treatment rates in many countries between 2016 and 2019, this was halted in 2020. There are persistent major inequalities in acute stroke treatment in the European region. Tailored strategies directed to the most vulnerable regions should be prioritised.

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Introduction

From 1990 to 2019, the absolute number of incident strokes increased by 70.0% and, in 2019, there were 12.2 million incident cases of stroke globally.¹ Stroke remains the second most common cause of death in Europe, where it is responsible for more than one million deaths per year and the leading cause of long-term disability.² Across European Union countries, stroke accounted for 375,000 deaths in 2017, and the number is expected to rise by one-third by 2035 due to population ageing and increases in some risk factors.³ Among all strokes, the ischaemic subtype is the most common, representing approximately 80% of cases in Europe.⁴ As a result, stroke is associated with a high use of health and social-care resources, with 8% of the 798 billion cost of brain disorders being attributable to stroke.⁵ Productivity losses cost was estimated to be 12 billion euros in Europe alone, equally split between early death and lost working days.⁶

The main pillars of acute ischaemic stroke treatment are stroke unit (SU) care^{7,8} and treatments promoting reperfusion, namely intravenous thrombolysis (IVT)⁹ and endovascular treatment (EVT).¹⁰ These three interventions are highly effective in reducing mortality and morbidity. Although information on the implementation of these treatment strategies is crucial to guide any tailored measures, a single study with unified methodology designed to provide complete information for all European countries is unlikely to be feasible. In 2016, a task force of European associations representing professionals dedicated to stroke and patient organisations collected data on the access to and delivery of SU care, IVT and EVT in 44 countries in the European region.¹¹ The results of this study confirmed large disparities across Europe. Ten countries did not have at least one SU per million inhabitants, 15 countries had thrombolysis rates below 5% and the overall proportion of patients with acute ischaemic stroke treated with mechanical thrombectomy was less than 2%. Since then, large efforts have been made in several European countries in order to increase the access to acute stroke treatment. Of note, ESO and SAFE have started a programme for the implementation of the Stroke Action plan for Europe^{12,13} and the ESO-EAST programme, dedicated to the improvement of stroke care in Eastern Europe countries also runs in parallel¹⁴ Moreover, the time-window for IVT and EVT has been extended, increasing the number of potentially eligible patients.⁹ In 2020, the coronavirus disease 2019 (COVID-19) pandemic placed an unprecedented burden on health systems, thus threatening their

ability to operate effectively for acute conditions such as cerebrovascular disorders.^{15,16}

To better allocate resources to deal with stroke burden in Europe, it is crucial to identify the evolution of these metrics of delivery of acute stroke care, track the persisting asymmetries, and correctly identify the most vulnerable areas. Therefore, the European Stroke Organisation (ESO) together with the European Academy of Neurology (EAN) and the European Society of Minimally Invasive Neurological Therapy (ESMINT) and the Stroke Alliance for Europe (SAFE) surveyed the access to and delivery rates of acute SU care, IVT and EVT throughout Europe in 2019 and 2020.

Objectives

We aimed to collect and compare national data on access to and delivery rates for acute SU care, IVT and EVT throughout the European region. We also aimed to estimate how many patients could be treated with IVT and EVT if the current highest treatment rates were to be followed in all countries.

Methods

Study design and participants

The current work was preceded by a survey to identify scientific societies related with stroke in all European countries, using the existing network of contacts provided by the European Stroke Organisation and the working group dedicated to the implementation of the Stroke Action Plan for Europe, created by ESO and SAFE in 2018. As a second step, this committee completed a survey directed to these national scientific societies on the best available national sources of information concerning surveillance data on stroke. Finally, the leadership of the identified national scientific societies was invited to nominate the national experts for the task of collecting the best available national data on the number of acute SU, IVT and EVT interventions delivered in 2019 and 2020 and the corresponding information on the data sources. These experts would be preferably those related with the public health surveillance and data collection in the field of stroke. Their names and affiliations are shown in Supplemental Appendix 1. A representative from a patient organisation (SAFE) was involved in all stages of the project to incorporate the patient perspective and ensure dissemination of the results to national stroke support organisations.

We adopted the World Health Organization (WHO)'s definition of the European region as including 53 countries. Countries with less than 100,000 inhabitants (Monaco, Andorra, Vatican City, Liechtenstein and San Marino) were excluded. The definition of SU was based on the national criteria in place, at each participating country. Because there is a prospective registry audited by the regional health authority in the Spanish region of Catalonia, we also collected data for this specific province.

Data collection

The study was drafted by the steering committee after a series of meetings and consisted of 14 items. A pilot study was performed in Denmark, Austria, Switzerland, Czechia and Sweden to assess feasibility. The study was performed between March, 2021 and July, 2022. Collected data were independently reviewed by two authors (UF, DAS). Whenever there was ambiguity and/or missing or conflicting responses, the steering committee requested clarifications.

Data analyses

Our analyses focused on access to and delivery rates of acute SU care, IVT and EVT as well as the number of centres delivering IVT and EVT. All data were analysed using appropriate descriptive methods. We calculated crude rates of acute SUs, centres providing IVT, and centres providing EVT per one million inhabitants, in each country, using United Nations population estimates (2019 Revision of World Population Prospects),¹⁷ with the exception of Kosovo, for which official governmental information was used. Similar calculations were done for annual numbers of IVT and EVT performed per 100,000 inhabitants. The annual incidence of first-ever acute ischaemic stroke per country was based on the estimates from the Global Burden of Disease Report (2019)^{1,18} and was used to calculate the rate of IVT and EVT treatments per 100 first-ever acute ischaemic strokes and which is described as a percentage. Linear regression was used to determine the strength of the association between gross domestic product (GDP) per capita (PPP) and the annual number of IVT or EVT treatments for ischaemic stroke delivered per 100,000 inhabitants in each country.

Additionally, we calculated how many additional patients could be treated if an IVT rate of 40% could be achieved in all countries. Similar calculations were done for patients treated with EVT if an EVT rate of 16% could be achieved in all countries. Both cut-offs were determined using a data-driven approach, specifically based on the next lower whole-numbered value observed among the three countries with the highest rates. This approach ensured that the calculated thresholds for IVT and EVT were grounded in the existing data and represented achievable targets across all countries. The data obtained from the study were

collected and analysed in Microsoft Excel, version 16.62 (Microsoft Corporation, Redmond, WA, USA).

Results

Overall, 46/51 invited countries participated. The total number of inhabitants in these 46 participating countries was estimated to be 878.6 million according to the United National Population prospects. The total incidence of first-ever ischaemic stroke in these 46 countries was 1.195 million cases in 2019, according to the Global Burden of Disease estimates. Data was based on national stroke registries in 12 countries and one province (Catalonia, Supplemental Table 2) and on health surveillance data collected by governmental bodies in nine countries (Supplemental Table 1). Two countries (Czechia and Croatia) contribute extensively to international stroke registries and therefore the data obtained can be deemed as having appropriate national coverage, even in the absence of a dedicated national registry. For the remaining countries, data sources are described in Supplemental Table 1. They include restricted registries (e.g. a national registry for endovascular treatment in Italy), national surveys, or direct contact with national stroke units and hospitals dedicated to acute stroke care.

Acute stroke units, IVT hospitals and EVT centres

Information on acute SU care was provided for 44 countries. Overall, in 2019 there were 2165 acute SUs in 44 countries, corresponding to a pooled mean of 3.68 SUs per million inhabitants (95% CI: 2.90–4.45) in 2019. There was a considerable heterogeneity among the 44 countries. The country with highest rate had 11 acute SUs per one million population. Seven countries had less than one acute SU per one million inhabitants. Data for 2020 was mostly similar to that of 2019 (Table 2).

Overall, 44 countries reported the number of hospitals delivering IVT and EVT (Tables 1 and 2). In 2019, IVT was performed at 2468 hospitals, corresponding to a mean number of 4.04 (95% CI: 3.23–4.85) IVT hospitals per one million inhabitants. The three countries with highest rates had more than 8 IVT hospitals per one million population (Iceland, Montenegro and Norway). EVT was performed at 646 stroke centres, corresponding to a mean number of 1.03 (95% CI: 0.84–1.22) EVT centres per one million inhabitants. Five countries had more than two EVT centres per one million population (Germany, Lithuania, Estonia, Malta and Iceland). Twenty-six countries had less than one stroke centre capable of performing EVT per one million inhabitants. Data for 2020 is described in Table 2.

Intravenous thrombolysis (IVT)

Data on the number of IVTs performed in 2019 was provided for 42 countries (Table 1). IVT was not available in

Table 1. Overview of stroke treatment facilities and reperfusion treatments by country, 2019.

	Population UN prospects*	No. of first-ever incident ischaemic strokes per year	No. Of Stroke Units	Rate of Stroke Units per million inhabitants	No. of beds dedicated to stroke care (Stroke units/centres)	No. of beds dedicated to stroke care in units able to provide IVT	No. of beds dedicated to stroke care in units able to provide EVT	IVT hospitals	Rate of IVT hospitals per million inhabitants	No. IVT for acute ischaemic stroke	Rate of IVT treatments per 100,000 inhabitants	Percentage of incident ischaemic strokes treated with IVT	EVT hospitals	Rate of EVT hospitals per million inhabitants	No. EVT for acute ischaemic stroke	Rate of EVT treatments per 100,000 inhabitants	Percentage of incident ischaemic strokes treated with EVT
Albania	2,881,000	2894	2	0.69	50	7	4	2	0.69	160	5.55	5.53	1	0.35	32	1.11	1.11
Armenia	2,957,728	2972	2	0.68	200	30	30	2	0.68	226	7.64	7.61	2	0.68	159	5.38	5.35
Austria	8,955,108	8695	37	4.13	194	194	60	37	4.13	2675	29.87	30.77	10	1.12	1001	11.18	11.51
Belgium	11,539,326	10,143	60	5.20	240	240	78	60	5.20	2120	18.37	20.90	18	1.56	1077	9.33	10.62
Bosnia and Herzegovina	3,300,998	9404	10	3.03	150	80	15	10	3.03	78	2.36	0.83	2	0.61	3	0.09	0.03
Bulgaria	7,000,117	24,139	48	6.86	NA	NA	NA	48	6.86	1119	15.99	4.64	4	0.57	79	1.13	0.33
Croatia	4,130,000	8396	23	5.57	300	125	60	23	5.57	800	19.37	9.53	4	0.97	434	10.51	5.17
Czechia	10,689,213	16,974	45	4.21	2035	2035	819	45	4.21	5241	49.03	30.88	15	1.40	1503	14.06	8.85
Cyprus	1,198,574	694	1	0.83	5	5	0	4	3.34	NA	NA	NA	2	1.67	NA	NA	NA
Denmark	5,771,877	5420	16	2.77	NA	NA	NA	11	1.91	2604	45.12	48.04	4	0.69	730	12.65	13.47
Germany	83,517,046	99,537	535	6.41	3210	3210	1424	535	6.41	37,009	44.31	37.18	178	2.13	16,833	20.16	16.91
Estonia	1,325,649	1614	6	4.53	144	144	82	6	4.53	850	64.12	52.66	3	2.26	190	14.33	11.77
Finland	5,532,159	6774	21	3.80	90	50	40	22	3.98	1200	21.69	17.71	5	0.90	740	13.38	10.92
France	65,129,731	55,516	140	2.15	NA	841	326	208	3.19	11,520	17.69	20.75	42	0.64	7570	11.62	13.64
Georgia	3,996,762	5225	5	1.25	NA	NA	NA	5	1.25	46	1.15	0.88	3	0.75	23	0.58	0.44
Greece	10,473,452	14,143	10	0.95	30	15	5	40	3.82	600	5.39	4.24	12	1.15	60	0.57	0.42
Hungary	9,684,680	21,030	39	4.03	NA	NA	NA	39	4.03	3195	32.99	15.19	7	0.72	1197	12.36	5.69
Iceland	339,037	250	1	2.95	12	12	12	5	14.75	NA	NA	NA	1	2.95	NA	NA	NA
Ireland	4,882,498	2595	25	5.12	210	160	36	25	5.12	389	7.97	14.99	2	0.41	302	6.19	11.64
Israel	8,656,000	5212	26	3.00	60	10	50	26	3.00	1500	17.61	28.78	9	1.04	749	8.79	14.37
Italy	60,550,092	61,057	223	3.68	737	737	NA	223	3.68	11,948	19.73	19.57	66	1.09	4808	7.94	7.87
Kosovo	1,788,878	1768	6	3.37	105	0	0	0	0.00	0	0.00	0.00	1	0.56	0	0.00	0.00
Kyrgyzstan	6,415,851	4426	5	0.78	186	20	10	1	0.16	NA	NA	NA	1	0.16	NA	NA	NA
Latvia	1,906,740	5553	8	4.20	250	50	24	8	4.20	1510	79.19	27.19	2	1.05	184	9.65	3.31
Lithuania	2,759,631	7491	11	3.99	120	120	92	11	3.99	1219	44.17	16.27	6	2.17	518	18.77	6.92
Luxembourg	615,730	383	4	6.50	17	17	6	4	6.50	73**	11.86	19.08	1	1.62	28	4.55	7.32
Malta	440,377	395	1	2.27	4	4	4	1	2.27	NA	NA	NA	1	2.27	38	8.63	9.62
Montenegro	627,988	851	6	9.55	115	115	25	6	9.55	50	7.96	5.88	1	1.59	11	1.75	1.29
North Macedonia	2,083,458	5425	4	1.92	NA	NA	NA	4	1.92	67	3.22	1.23	1	0.48	31	1.49	0.57
Norway	5,378,859	5416	46	8.55	435	435	118	46	8.55	1691	31.44	31.22	5	0.93	487	9.05	8.99
Poland	37,887,771	56,055	174	4.59	2700	2700	350	174	4.59	11,716	30.92	20.90	17	0.45	1132	2.99	2.02
Portugal	10,226,178	12,554	38	3.72	270	270	90	38	3.72	2467	24.12	19.65	10	0.98	2057	20.12	16.39
Republic of Moldova	4,043,258	6182	5	1.24	190	107	18	7	1.73	80	1.98	1.29	2	0.49	14	0.35	0.23
Romania	19,364,558	48,906	39	2.01	NA	800	100	39	2.01	2296	11.86	4.69	4	0.21	132	0.68	0.27
Russian Federation	145,872,260	321,938	NA	NA	NA	NA	NA	NA	NA	19,794	13.57	6.15	NA	NA	NA	NA	NA
Serbia	8,772,228	24,038	25	2.85	NA	NA	NA	20	2.28	800	9.12	3.33	5	0.57	160	1.82	0.67
Slovakia	5,457,012	9617	43	7.88	559	215	60	43	7.88	2030	37.20	21.11	10	1.83	983	18.01	10.22
Slovenia	2,078,654	2624	24	11.55	218	218	16	12	5.77	625	30.07	23.82	2	0.96	295	14.19	11.24
Spain	46,736,782	42,020	65	1.39	342	342	NA	80	1.71	5367	11.48	12.77	47	1.03	5911	12.65	14.07
Sweden	10,036,391	11,265	72	7.17	1023	1023	95	72	7.17	2571	25.62	22.82	6	0.60	927	9.24	8.23
Switzerland	8,591,361	6556	19	2.21	350	150	100	35	4.07	1287	14.98	19.63	10	1.16	1428	16.62	21.78
The Netherlands	17,097,123	16,590	NA	NA	NA	NA	NA	64	3.74	6797	40.97	49.97	17	0.99	2233	13.06	13.46
Turkey	83,430,000	81,599	84	1.01	1200	1200	650	148	1.77	8000	9.59	9.80	64	0.77	2300	2.76	2.82
Ukraine	43,993,643	87,590	6	0.14	140	60	140	74	1.68	912	2.07	1.04	17	0.39	197	0.45	0.22
United Kingdom	67,530,161	49,376	205	3.04	5377	NA	NA	205	3.04	11,314	16.75	22.91	26	0.39	1467	2.17	2.97
Uzbekistan	32,981,715	23,984	0	0	0	0	0	NA	NA	100	0.30	0.42	0	0	0	0.00	0.00

UN: United Nations; NA: not available; IVT: intravenous thrombolysis; EVT: endovascular treatment.

*Except Kosovo (source: national estimates from the Statistical Office of Kosovo).

**Data on number of intravenous thrombolysis for acute ischaemic stroke from three out of four national hospitals dedicated to acute stroke care.

Table 2. Overview of stroke treatment facilities and reperfusion treatments by country, 2020.

Country	Population UN prospects*	No. Of Stroke Units	Rate of Stroke Units per million inhabitants	IVT hospitals	Rate of IVT hospitals per million inhabitants	No. IVT for acute ischaemic stroke	Rate of IVT treatments per 100,000 inhabitants	Percentage of incident ischaemic strokes treated with IVT	EVT hospitals	Rate of EVT hospitals per million inhabitants	No. EVT for acute ischaemic stroke	Rate of EVT treatments per 100,000 inhabitants	Percentage of incident ischaemic strokes treated with EVT
Albania	2,877,800	2	0.69	2	0.69	125	4.34	4.32	1	0.35	34	1.18	1.17
Armenia	2,963,234	2	0.68	2	0.68	142	4.79	4.78	2	0.68	239	8.07	8.04
Austria	9,006,400	37	4.13	37	4.13	2710	30.09	31.17	10	1.12	884	9.82	10.17
Belgium	11,589,616	60	5.20	60	5.20	2120	18.29	20.90	18	1.56	1077	9.29	10.62
Bosnia and Herzegovina	3,280,815	10	3.03	10	3.03	52	1.58	0.55	2	0.61	2	0.06	0.02
Bulgaria	6,948,445	49	7.00	49	7.00	954	13.73	3.95	4	0.57	74	1.06	0.31
Croatia	4,105,268	23	5.57	23	5.57	650	15.83	7.74	5	1.21	502	12.23	5.98
Czechia	10,708,982	45	4.21	45	4.21	4632	43.25	27.29	15	1.40	1449	13.53	8.54
Cyprus	1,207,361	0	0.00	2	1.67	NA	NA	NA	1	0.83	NA	NA	NA
Denmark	5,792,203	15	2.60	11	1.91	2607	45.01	48.10	4	0.69	747	12.90	13.78
Germany	83,783,945	535	6.41	535	6.41	34,896	41.65	35.06	178	2.13	17,414	20.78	17.50
Estonia	1,326,539	6	4.53	6	4.53	1008	75.99	62.44	3	2.26	260	19.60	16.11
Finland	5,540,718	21	3.80	22	3.98	1050	18.95	15.50	5	0.90	700	12.63	10.33
France	65,273,512	140	2.15	208	3.19	NA	NA	NA	42	0.64	7189	11.01	12.95
Georgia	3,989,175	8	2.00	8	2.00	84	2.11	1.61	4	1.00	47	1.18	0.90
Greece	10,423,056	10	0.95	40	3.82	600	3.84	2.83	12	1.15	70	0.67	0.35
Hungary	9,660,350	39	4.03	39	4.03	3042	31.49	14.46	7	0.72	1274	13.19	6.06
Iceland	341,250	1	2.95	5	14.75	NA	NA	NA	1	2.95	NA	NA	NA
Ireland	4,937,796	25	5.12	25	5.12	466	9.44	17.95	25	5.12	379	7.68	14.60
Israel	8,656,000	26	3.00	26	3.00	719	8.31	13.80	9	1.04	442	5.11	8.48
Italy	60,461,828	223	3.68	223	3.68	10,821	17.90	17.72	66	1.09	5579	9.23	9.14
Kosovo	1,790,133	6	3.37	0	0.00	0	0.00	0.00	1	0.56	12	0.67	0.68
Kyrgyzstan	6,524,191	6	0.94	2	0.31	NA	NA	NA	2	0.31	NA	NA	NA
Latvia	1,886,202	8	4.20	8	4.20	1623	86.05	29.22	3	1.57	211	11.19	3.80
Lithuania	2,722,291	11	3.99	11	3.99	1206	44.30	16.10	6	2.17	606	22.26	8.09
Luxembourg	625,976	4	6.50	4	6.50	NA	NA	NA	4	6.50	28	4.47	7.32
Malta	441,539	1	2.27	1	2.27	NA	NA	NA	1	2.27	31	7.02	7.85
Montenegro	628,062	6	9.55	6	9.55	44	7.01	5.17	1	1.59	7	1.11	0.82
North Macedonia	2,083,380	4	1.92	4	1.92	25	1.20	0.46	1	0.48	3	0.14	0.06
Norway	5,421,242	46	8.55	46	8.55	1587	29.27	29.30	7	1.30	410	7.56	7.57
Poland	37,846,605	174	4.59	174	4.59	10,905	28.81	19.45	17	0.45	2144	5.66	3.82
Portugal	10,196,707	38	3.72	38	3.72	2112	20.71	16.82	10	0.98	2203	21.61	17.55
Republic of Moldova	4,033,963	5	1.24	8	1.98	55	1.36	0.89	2	0.49	5	0.12	0.08
Romania	19,237,682	40	2.07	40	2.07	2206	11.47	4.51	5	0.26	214	1.11	0.44
Serbia	8,737,370	25	2.85	20	2.28	500	5.72	2.08	5	0.57	100	1.14	0.42
Slovakia	5,459,643	43	7.88	43	7.88	2096	38.39	21.80	10	1.83	944	17.29	9.82
Slovenia	2,078,932	24	11.55	12	5.77	586	28.19	22.33	2	0.96	206	9.91	7.85
Spain	46,754,783	65	1.39	80	1.71	4860	10.39	11.57	48	1.03	5766	12.33	13.72
Sweden	10,099,270	72	7.17	72	7.17	2273	22.51	20.18	6	0.60	942	9.33	8.36
Switzerland	8,654,618	19	2.21	35	4.07	1475	17.04	22.50	10	1.16	1281	14.80	19.54
The Netherlands	17,134,873	NA	NA	64	3.74	6490	37.88	39.12	18	1.05	2322	13.55	14.00
Turkey	84,339,000	84	1.01	148	1.77	NA	NA	NA	64	0.77	NA	NA	NA
Ukraine	43,733,759	14	0.32	97	2.20	1573	3.60	1.80	20	0.45	362	0.83	0.41
United Kingdom	67,886,004	NA	NA	NA	NA	9351	13.77	18.94	NA	NA	1603	2.36	3.25
Uzbekistan	33,469,199	0	0	NA	NA	100	0.30	4.17	0	0	0	0.00	0.00

NA: not available; IVT: intravenous thrombolysis; EVT: endovascular treatment.

*Except Kosovo (source: national estimates).

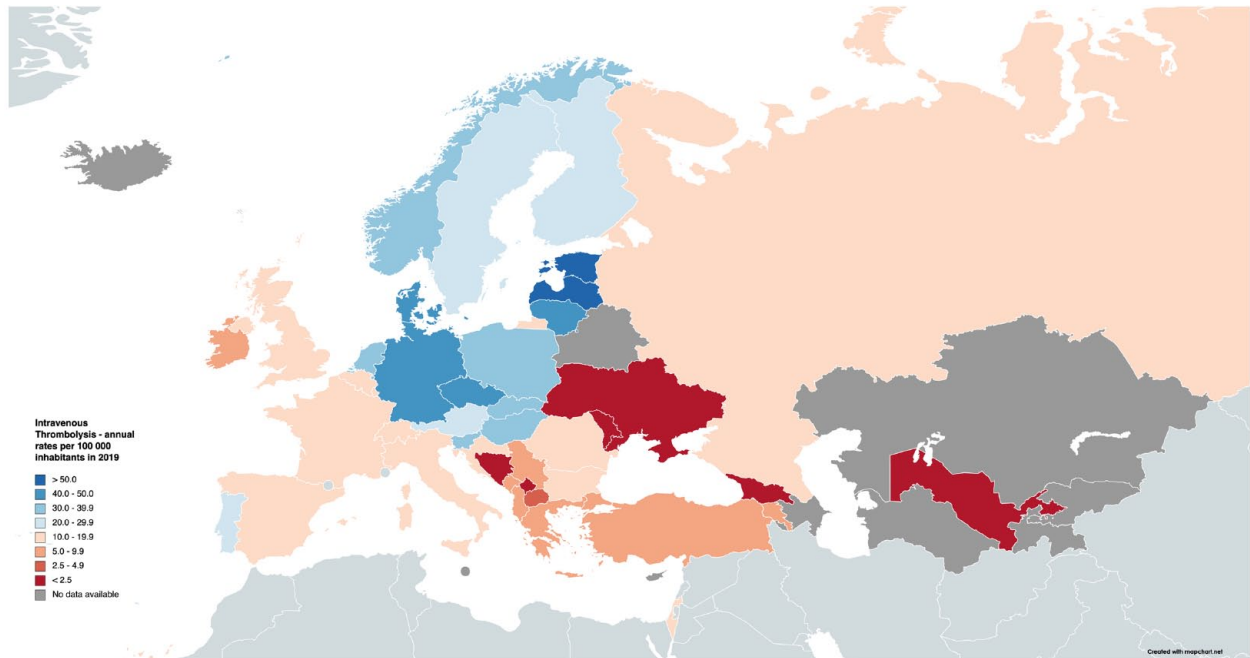


Figure 1. Estimates for the annual rate of patients receiving intravenous thrombolysis per 100 000 inhabitants in 42 countries from the European region in 2019.

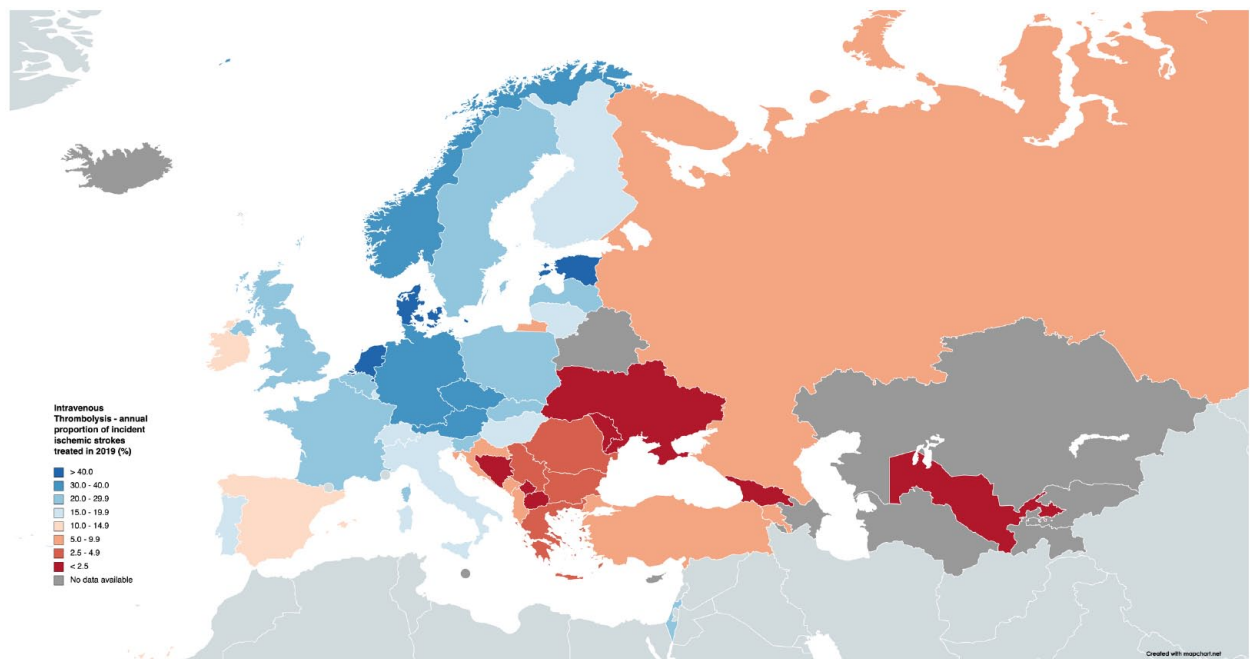


Figure 2. Estimates for the annual proportion of incident ischaemic strokes receiving intravenous thrombolysis in 42 countries from the European region in 2019.

Kosovo. The number of IVTs performed came from national registries in 13 countries. The remaining countries provided data collected from governmental sources or by direct contact of national stroke units (Supplemental Table 1).

Overall, the total annual number of patients receiving IVT in these 42 European countries was 164,011 in 2019.

In 2019, the estimated mean number of IVTs per 100,000 inhabitants was 21.03 (95% CI: 15.63–26.43) and 17.14% (95% CI: 12.98–21.30) of the annual incident ischaemic strokes (Table 1), while the highest country rates were 79.19 and 52.66%, respectively (Figures 1 and 2). In 14 countries, the estimated annual numbers of IVT treatments

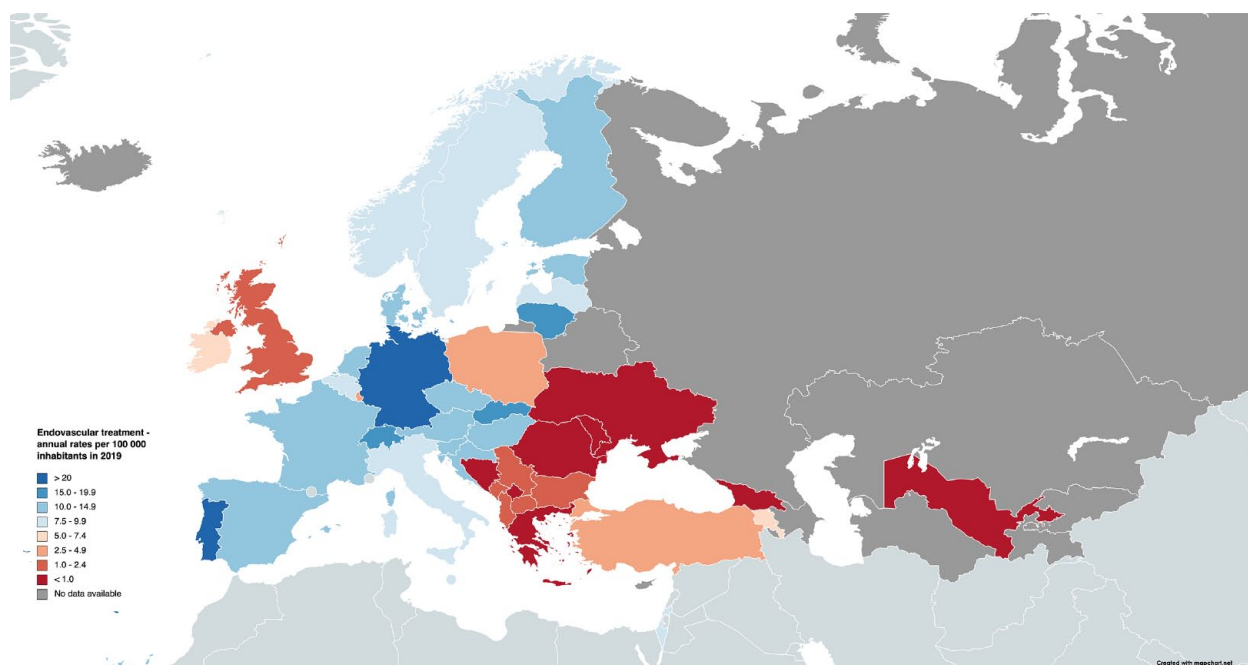


Figure 3. Estimates for the annual rate of patients receiving endovascular treatment per 100,000 inhabitants in 42 countries from the European region in 2019.

delivered per 100,000 inhabitants were fewer than 10 whereas six countries had rates above 40 (Table 1 and Supplemental Figure 1).

Data on the number of IVTs performed in 2020 was provided for 38 countries (Table 2). In 2020, the estimated mean number of IVTs per 100,000 inhabitants was 20.96 (95% CI: 14.60–27.32) and 16.59% (95% CI: 12.062–21.16) of the annual incident ischaemic strokes (Table 1), while the highest country rates were 86.05 and 62.44%, respectively (Supplemental Figures 2 and 3).

There was a trend towards an association between GDP per capita and the annual number of IVT treatments for ischaemic stroke delivered per 100,000 inhabitants in each country ($p=0.068$) (Supplemental Figure 4).

Endovascular treatment (EVT)

Forty-one countries provided information on annual numbers of EVTs performed in 2019 (Table 1). The number of EVTs performed came from national registries in 14 countries. The remaining countries provided data collected from governmental sources or by direct contact of national stroke units (Supplemental Table 1).

Overall, 58,023 procedures were performed in 2019 in these 42 countries, corresponding to a mean number of 7.87 (95% CI: 5.96–9.77) procedures per 100,000 inhabitants and 6.91% (95% CI: 5.15–8.67) of annual incident ischaemic strokes, while highest country rates were 20.16 and 21.78%, respectively. The annual number of treatments

delivered was less than 1.5 per 100,000 inhabitants in 11 countries, whereas two countries reported EVT rates above 20 per 100,000 (Supplemental Figure 7). Likewise, while 11 countries had an estimated EVT treatment rate of less than 1% of annual ischaemic strokes, three countries had treatment rates of more than 16% (Figures 3 and 4).

Data on the number of EVTs performed in 2020 was provided for 41 countries (Table 2). In 2020, the estimated mean number of EVTs per 100,000 inhabitants was 8.14 (95% CI: 6.1.0–10.18) and 7.09% (95% CI: 5.31–8.87) of the annual incident ischaemic strokes, while the highest country rates were 22.26 and 19.54%, respectively (Supplemental Figures 5 and 6).

There was an association between GDP per capita and the annual number of endovascular treatments for ischaemic stroke delivered per 100,000 inhabitants in each country ($p=0.004$) (Supplemental Figure 8).

Estimation of the number of potential additional reperfusion treatments using treatment rates in best performing countries as benchmark

In 2019, the practice rate for IVT was above 40% in three countries. The estimated number of additional patients who could be treated with IVT if this treatment rate could be also achieved in the other 39 countries in the European region for which data is available is 312,346 (Table 3).

Concerning EVT, the practice rate was above 16% in the three top countries. If we extrapolate this as an achievable

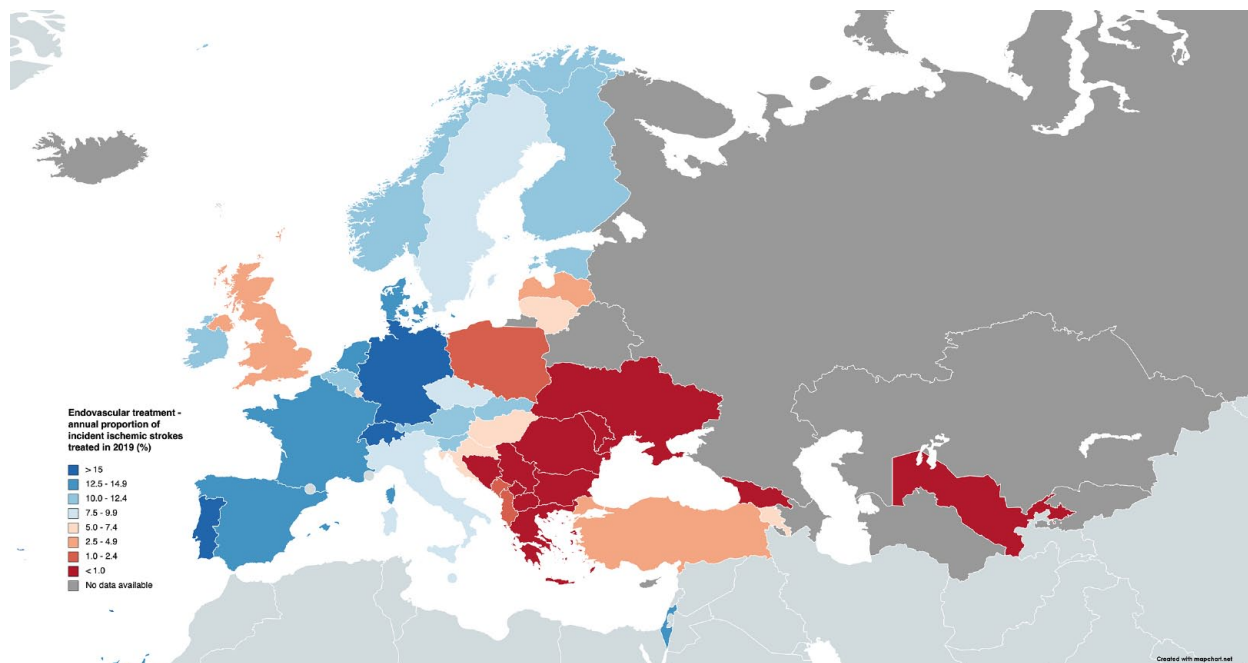


Figure 4. Estimates for the annual proportion of incident ischaemic strokes receiving endovascular treatment in 42 countries from the European region in 2019.

proportion of eligible patients in the other participating countries in the European region, the estimated number of additional patients who could have been treated with EVT in 2019 was 82,101 (Table 3).

Discussion

The current results show persisting inequalities in the provision of acute stroke care among countries in the WHO European region, particularly concerning its three main components (stroke unit care, IVT and EVT). For many countries, especially those with lower income, the number of SUs and rates of IVT and EVT are far below what was achieved in other European countries. Of note, the rate of IVT in the 11-participating middle-income countries (World Bank definition; Albania, Armenia, Bosnia and Herzegovina, Georgia, Kosovo, Montenegro, North Macedonia, Moldova, Serbia, Turkey and Uzbekistan) was 4.42 per 100,000 inhabitants in 2019 (95% CI: 26.61–70.53), which is a much lower rate compared with the 26.91 (95% CI: 20.83–32.99) treatments per 100,000 inhabitants in the other 31 participating high-income countries. The difference in EVT rates in middle and high-income countries is even more evident. In these 11 middle income countries for which data is available, the rate of EVT in 2019 was 1.39 (95% CI: 0.49–2.29) per 100,000 inhabitants, while it was 10.16 (95% CI: 8.13–12.19) for the 31 participating high-income countries. Lack of data on delivery of IVT and EVT or reachable stroke experts was also much

more common in these countries (Azerbaijan, Belarus, Kazakhstan, Russia, Tajikistan, Kyrgyz Republic).

The availability of SUs and EVT centres per country also varied significantly throughout Europe and 27 countries did not reach the benchmark of one comprehensive stroke centre per one million inhabitants.¹⁹ GDP per capita was a significant predictor of endovascular treatment delivery rates per 100,000 inhabitants.

Evolution of reperfusion treatment rates between 2016 and 2019

The comparison of the current results with previously collected data from 2016 show an increase in treatment delivery in most European countries, both of intravenous thrombolysis and endovascular treatment.¹⁶ The estimated mean rate of IVT delivery in 2016, for the 43 countries participating in that previous study, was 14.2 per 100,000 inhabitants, while in 2019 it was 21.0, in the 42 countries for which data was available. Of note, Albania and Georgia initiated the use of IVT and substantial growth in the absolute number of annual IVT treatments was recorded in several countries, especially in Bulgaria, Croatia, Poland, Latvia, Luxembourg, Romania, Serbia, Slovakia, Turkey, and Ukraine.

An even sharper increase in the number of treated patients was seen for EVT, with a mean rate of treatment per 100,000 inhabitants raising from 3.7 to 7.9 in the same period. Nevertheless, seven of 42 participating countries

Table 3. Estimated number of additional intravenous thrombolysis and endovascular treatments per country, assuming achievement of 40% and 16% rates, respectively, in 2019.

	No. of additional IVT per year (target rate 40%, 2019)	No. of additional EVT per year (target rate 16%, 2019)
Albania	998	431
Armenia	963	316
Austria	803	390
Belgium	1937	546
Bosnia and Herzegovina	3683	1502
Bulgaria	8536	3783
Croatia	2559	909
Czechia	1549	1213
Denmark	N/A	137
Estonia	N/A	68
Finland	1510	344
France	10,687	1313
Georgia	2044	813
Germany	2806	N/A
Greece	5057	2203
Hungary	5217	2168
Ireland	649	113
Israel	585	85
Italy	12,475	4961
Kosovo	490	196
Latvia	711	705
Lithuania	1777	681
Luxembourg	80	33
Malta	No data	25
Montenegro	290	125
Netherlands	N/A	421
North Macedonia	2103	837
Norway	475	380
Poland	10,706	7837
Portugal	2554	N/A
Republic of Moldova	2393	975
Romania	17,267	7693
Russian Federation	108,981	No data
Serbia	8815	3686
Slovakia	1817	556
Slovenia	425	125
Spain	11,441	812
Sweden	1935	875
Switzerland	1335	N/A
Turkey	24,639	10,756
Ukraine	34,124	13,817
United Kingdom	8436	6433
Uzbekistan	9494	3837
Total	312,347	82,101

N/A: Not Applicable, indicating that the respective IVT or EVT benchmark has already been met or exceeded for that country.
IVT: intravenous thrombolysis; EVT: endovascular treatment.

still had a rate of IVT below five patients treated per 100,000 inhabitants, showing there was no major improvement in this regard, comparing with the 10 out of 43 countries with such low rates in 2016. Concerning EVT, it is also worth noting that while only three countries had a rate of EVT above 10 patients treated per 100,000 inhabitants in the 2016 study, there were 16 countries above this rate in 2019, and 14 in 2020. Remarkably, a more dedicated implementation was started in countries like Albania, Georgia, Macedonia, Luxembourg, Montenegro, Romania, and Serbia, albeit the treatment rates still remain low. Moreover, the absolute number of treatments more than doubled in 18 other countries during this period.

Another denominator used to compare national treatment rates in this analysis was the annual number of first-ever incident ischaemic strokes, based on the 2019 Global Burden of Disease Report.¹ Highest practice rate for IVT in 2019 was 53% (Estonia), whereas six countries had IVT rates of 30% or more. Highest EVT rate was 22% (Switzerland), with 15 countries achieving 10% or more. The comparison with the rates of incidence ischaemic strokes receiving reperfusion treatments that were estimated for 2016 is hampered by the sharp changes in the Global Burden of Disease estimates for this indicator. Of note, the estimated number of incident first-ever ischaemic strokes in 2019 is lower for most countries in region Europe comparing with the estimates that were available in 2016, which translates into higher treatment rates, even for countries with a similar absolute annual number of treatments. Besides, because data is lacking on recurrent ischaemic stroke, these rates should be an overestimation of the true proportion of acute ischaemic stroke patients receiving these interventions.

Evolution of reperfusion treatment rates between 2019 and 2020

Regarding the use of reperfusion treatments, the mean rate of delivery of IVT in the 42 assessed countries was around 17% of annual incident ischaemic strokes in 2019 and 2020. The mean number of IVTs also remained stable at 21.0 per 100,000 inhabitants in this 2-years period. The mean rate of delivery of EVT was around 7% of annual incident ischaemic strokes both in 2019 and 2020, with a mean rate of treatments per 100,000 inhabitants of 7.9 and 8.1 in 2019 and 2020, respectively.

There are no major differences in treatment rates between 2019 and 2020 for most countries. Although this may have been related with the challenges imposed by the COVID-19 pandemic during 2020, it should be closely monitored. The evident lack of proper implementation of EVT in several countries and the expansion of treatment indications should translate into an increase in treatment rates in the years to follow.

Benchmarking using countries with highest treatment rates

The current evidence of persistent large disparities strongly suggests that many potentially eligible patients are left untreated in several European countries. The estimates taking the best performing countries as benchmark suggest that more than 312,000 additional patients could have been treated with IVT and that more than 82,000 additional patients could have received EVT, only in 2019 and considering those countries for which data is available. However, these are still rather conservative estimates, since it is likely that the IVT and EVT rates in countries with the highest rates can also be improved, at least by reducing the time from symptom onset to patient admission.

Implications

This study is a comparison of the best available data on country rates of SUs, IVT and EVT in the European region. The finding that several countries are highly likely to be underperforming in some of these crucial metrics for the treatment of acute stroke should guide the future organisation of acute stroke care in these countries, the implementation of specific educational interventions directed to professionals, and stroke campaigns aimed at the general population. Moreover, the specific actions implemented by the European Scientific Societies and Patient Organisations should also consider this information in order to inform priorities of action, both at the educational level and in interventions directed at stakeholders and politicians. The implementation committee for the Stroke Action Plan for Europe is currently developing a platform called 'Stroke Service Tracker', which should facilitate a closer monitoring of these metrics, and stimulate national authorities to improve data collection on the delivery of stroke care, in collaboration with national stroke experts.

Strengths and limitations

A major strength of this study is the large number of participating countries. Secondly, the collected data was mostly based on official information collected at national level, either using national registers or other tools to collect health surveillance data, as diagnostic and treatment codes. Third, the data and the information on the respective source was provided by national experts in the field, who are aware and have access to the best available information in their country, including that written in national language. Importantly, both the nominated collaborators and the main data sources were identified using a two-step approach that started with a comprehensive survey of national experts to identify all relevant scientific societies in each country and corresponding contacts and was followed by a survey of stroke registries and other data sources, which was directed to nominated national experts involved in the collection of quality data related with stroke, also indicated by the national stroke societies.

However, there are several limitations: (1) There are differences in the methodology for data collection across the participating countries. In order to minimise this, we provide information on the specific data sources used in each country, as detailed by the national experts. (2) Some countries lack high quality data and thus the best of source of data was the local collection of absolute number of annual treatments by direct contact with national hospitals. Although the national experts are familiar with the local networks and, therefore, well aware of the national completeness of the data in terms of national coverage, the use of this methodology reduces the confidence in the exact estimates. (3) Given the lack of a uniform definition of SUs, some differences in SU rates are likely to be related to differences in national definitions. Moreover, the number of available beds and length of stay varies widely across SU, as well as the regional distribution of SU across each individual country. However, since data on the proportion of stroke patients that are first admitted to a SU is not available in many countries, this was considered to be a reasonable metric. (4) We have extracted the data on the annual number of first-ever incident ischaemic strokes from the 2019 Global Burden of Disease Report. Although this the most accepted global data on stroke incidence, the nationally obtained data for stroke incidence, usually based on analysis of diagnostic codes, may differ. Moreover, these estimates are for first-ever ischaemic stroke and recurrent strokes should be also treated stroke units and considered for reperfusion therapies. Data on the proportion of all strokes that are recurrent are sparse and differ between countries and with time. Nevertheless, even for countries with high quality stroke care and secondary prevention, such as Sweden, the estimated proportion of recurrent stroke between 2017 and 2019 was 21% of all strokes.²⁰ Therefore, data on the proportion of incident ischaemic strokes receiving treatment is overestimated and we have used the data of treatment delivery per 100,000 inhabitants as the main measure for comparisons across time. (5) Finally, this analysis is only focused on the absolute rate of delivery of three acute stroke treatment interventions, and it does not consider any other measures of quality performance, such as criteria for patient selection, time metrics for delivery of reperfusion treatments, functional outcome or any other patient-centred outcomes.

Conclusions

Despite the improvement in treatment rates in recent years, there are still major inequalities in treatment of acute stroke patients between countries in the European region. In many countries, rates for access to acute SU care, IVT, and EVT are far below highest country rates suggesting that potentially eligible patients have been left untreated. Together with the Stroke Action Plan for Europe, this data should support governments, health care providers, and scientific societies when developing national stroke plans to improve the reach and efficiency of acute stroke care and reinforce

tailored educational interventions directed to professionals and general population, with the final goal to reduce stroke related mortality and morbidity in Europe.

Declaration of conflicting interests

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Informed consent

The corresponding author (UF) affirms that this is an honest, accurate and transparent account of the study being reported; that no important aspects of the study have been omitted; and that any discrepancies from the study as planned have been explained. All authors had access to the data in the study and can take responsibility for the integrity of the data and the accuracy of the data analysis.

Ethical approval

Not required

Guarantor

DAS and UF


Contributorship


UF and DAS initiated and coordinated the study. All authors contributed to the development of the survey. DAS performed the principal analysis and drafted the manuscript. All authors interpreted the data and revised critically the manuscript for important intellectual content.


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Supplemental material

Supplemental material for this article is available online.

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