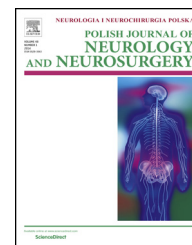


Available online at [www.sciencedirect.com](http://www.sciencedirect.com)

ScienceDirect

journal homepage: <http://www.elsevier.com/locate/pjnns>

## Original research article

# Characteristics of hospitalizations due to acute stroke in the Silesian Province, Poland, between 2009 and 2015



Anna Starostka-Tatar<sup>a</sup>, Beata Łabuz-Roszak<sup>b,\*</sup>, Michał Skrzypek<sup>c</sup>,  
Anetta Lasek-Bal<sup>d</sup>, Mariusz Gąsior<sup>e</sup>, Marek Gierlotka<sup>e</sup>

<sup>a</sup>Department of Neurology, Independent Public Clinical Hospital No. 1 in Zabrze, Medical University of Silesia, Katowice, Poland

<sup>b</sup>Department of Basic Medical Sciences, Faculty of Public Health, Medical University of Silesia, Katowice, Poland

<sup>c</sup>Department of Biostatistics, Faculty of Public Health, Medical University of Silesia, Katowice, Poland

<sup>d</sup>Department of Neurology, School of Health Sciences, Medical University of Silesia, Medical Centre of Upper Silesia, Katowice, Poland

<sup>e</sup>3rd Department of Cardiology, School of Medicine with the Division of Dentistry in Zabrze, Medical University of Silesia, Katowice, Silesian Center for Heart Diseases in Zabrze, Poland

## ARTICLE INFO

## Article history:

Received 18 June 2017

Accepted 21 November 2017

Available online 27 November 2017

## Keywords:

Stroke

Epidemiology

Incidence

In-hospital mortality

## ABSTRACT

**Introduction:** The available data on acute stroke (AS) in Poland come mainly from non-representative cohorts or are outdated. Therefore, the current study was done to access the most recent data on AS in the industrial region that covers 12% (4.6 mln) of the country's population.

**Objective:** To evaluate the epidemiological data of AS in the Silesian Province, Poland.

**Patients and methods:** Analysis of the data from stroke questionnaires, obligatory for all patients hospitalized due to AS and administered by the only public health insurer in Poland (the National Health Fund) between 2009 and 2015 ( $n = 81,193$ ).

**Results:** The annual number of hospitalizations due to AS in the analyzed period was between 239 and 259 per 100,000 inhabitants of the Silesian Province. Haemorrhagic stroke constituted 13.3%, ischaemic stroke – 85.5%, and unspecified stroke – 1.2%. The average age of patients was  $71.6 \pm 12.2$  years (M  $68.2 \pm 11.9$ , F  $74.8 \pm 11.9$ ,  $P < 0.05$ ). The mean duration of hospitalization was  $17 \pm 16$  days for haemorrhagic stroke, and  $14 \pm 11$  days for ischaemic stroke. Large-artery atherosclerosis (36.1%) and cardioembolism (18.7%) constituted the main causes of ischaemic stroke. Overall hospital mortality for AS was 18% (haemorrhagic – 40.8%, ischaemic – 14.9%). A decreasing trend in mortality was observed in ischaemic but not in haemorrhagic stroke. In-hospital mortality was significantly higher in women than in men ( $P < 0.05$ ).

\* Corresponding author at: Katedra i Zakład Podstawowych Nauk Medycznych, Wydział Zdrowia Publicznego Śląskiego Uniwersytetu Medycznego, Ul. Piekarska 18, 41-902 Bytom, Poland.

E-mail addresses: [annastarostka@wp.pl](mailto:annastarostka@wp.pl) (A. Starostka-Tatar), [broszak@sum.edu.pl](mailto:broszak@sum.edu.pl) (B. Łabuz-Roszak), [mskrzypek@sum.edu.pl](mailto:mskrzypek@sum.edu.pl) (M. Skrzypek), [alasek@gcm.pl](mailto:alasek@gcm.pl) (A. Lasek-Bal), [m.gasior@op.pl](mailto:m.gasior@op.pl) (M. Gąsior), [m.gierlotka@scs.pl](mailto:m.gierlotka@scs.pl) (M. Gierlotka).  
<https://doi.org/10.1016/j.pjnns.2017.11.010>

0028-3843/© 2017 Published by Elsevier Sp. z o.o. on behalf of Polish Neurological Society.

**Conclusions:** This comprehensive long-term analysis of the epidemiological situation related to AS in the industrial region of Poland should encourage further development of educational and treatment programmes for improvement in the health status of the population.

© 2017 Published by Elsevier Sp. z o.o. on behalf of Polish Neurological Society.

## 1. Introduction

Long-term epidemiological observations made in the US since the beginning of the 20th century have shown a gradual decrease in stroke incidence, initially in women and later in men, showing another increase in the 1980s (from 115 incidents/100,000 to 135 incidents/100,000). It was believed that the increase was due to the increasingly ageing population (new incidents in older age groups), civilization progress and wider availability of neuroimaging which led to higher detectability of minor strokes with a benign clinical course [1]. Similar research done in Europe also showed an increase in incidents of stroke in the elderly people [2,3].

In Poland, the first epidemiological research on stroke was conducted in the 1980s under the auspices of WHO MONICA [4] and 2.9 million individuals aged 34–64 were evaluated. The calculated indicators were negative for Poland and countries of the Eastern Europe. Another research, the Warsaw Stroke Registry, was done in Poland between 1991 and 1992 and it included 182,285 individuals (the standardized incidence rate for stroke was 149/100,000; including 177/100,000 for men and 126/100,000 for women) [5,6]. The subsequent epidemiological research (the Cracow Stroke Registry) was conducted by researchers from Cracow between 1999 and 2000, and stroke incidence rate was 218/100,000 in men and 152/100,000 in women [7].

Another research on stroke done as part of the Polish National Stroke Prevention and Treatment Registry between 2001 and 2002 was one of the biggest epidemiological research in Poland and involved 222 neurological units representing the majority of regions of the country. During the final analyses 8736 ischaemic stroke patients treated in 26 stroke units were evaluated [8]. The subsequent similar research, part of the National Programme for Prevention and Treatment of Cardiovascular Diseases POLKARD, was conducted up to 2009 [9].

Some of the reports concern the epidemiological situation related to stroke in certain cities, districts and provinces [10–16] (Table 1). However, no epidemiological research on stroke has been conducted for the Silesian Province, industrial region, which is the second largest province in Poland with 4,593,358 citizens i.e. nearly 12% of Poland's population.

The aim of this paper was to evaluate the epidemiological situation related to acute stroke (AS) – the incidence of hospitalized stroke, aetiology and in-hospital clinical course of stroke in the Silesian Province between 2009 and 2015.

## 2. Material and methods

The study was based on the data obtained from stroke questionnaires ( $n = 88,425$ ) which were mandatorily reported

to the National Health Fund (NHF; the only public health insurer in Poland) by all Silesian hospital departments where patients with AS were treated (homogeneous patient group – JGP – A48–A51), so data concerning stroke were based on hospital registry. The analyzed period was between 2009 and 2015. The research was done with the approval of the Silesian division of the NHF and the Consultant in Neurology for the Silesian Province.

The questionnaire data underwent analysis; incomplete or recurring data (e.g. recurring records of the same hospitalization) were not considered. Finally, 81,193 stroke questionnaires were enrolled for the analysis. Diagnosis of stroke was made according to the International Classification of Diseases version 10 (ICD-10): I60 – subarachnoid haemorrhage (SAH), I61 – intracerebral haemorrhage, I62 – other non-traumatic intracranial haemorrhage, I63 – ischaemic stroke, I64 – unspecified stroke.

The following data from the stroke questionnaires were used in the present study: age, sex, admission date, date of the first occurrence of stroke symptoms, date of death or discharge, number of hospitalization days, aetiology of ischaemic stroke (according to the Trial Org 10,172 in Acute Stroke Treatment – TOAST), clinical symptoms (i.e. consciousness disorders, hemiparesis/hemiplegia, speech disorders, sensory disorders, posterior circle syndrome). The questionnaires also included the information whether stroke was classified as first-ever-stroke. As a result, we were able to calculate the incidence of hospitalized stroke in the Silesian Province between 2009 and 2015.

According to the Bioethics Committee of the Medical University of Silesia, the study was not a medical experiment. Therefore, no approval of the Committee was required.

The statistical analysis was done using the statistical package SAS version 9.4 (SAS Institute Inc., Cary, NC). The level of statistical significance was set at  $P < 0.05$ .

The quantitative data were characterized using the mean (“X”), the standard deviation (SD), the median and the interquartile range “R”. For nominal data the percentage values were used. To evaluate the difference between fractions, the significance test of difference was used. The correlation between the nominal variables was verified using the  $\chi^2$  test. The verification of the distribution of the variables and the agreement with the normal distribution were made using the Shapiro–Wilk test. The mean difference significance was verified using the Student's t-test for two groups and the ANOVA test for three or more groups. The consistency of the distribution was verified using the Mann–Whitney  $U$  test for groups and the Kruskal–Wallis test for skewed distributions. Multiple comparisons were made based on post hoc test results for variance analysis (ANOVA) and Kruskal–Wallis test with the Bonferroni correction to assess significance of the percentage difference in the case of two or more groups. The

**Table 1 – Review of studies concerning epidemiological data of stroke in Poland.**

Study	Time of the study	Description of the study
Warsaw Stroke Registry [5,6]	1991–1992	Population-based study. Included 182,285 individuals – inhabitants of Mokotow region. Standardized incidence rate (only first-ever-stroke) was 111 per 100,000 (134 in men and 91 in women) Standardized incidence rate (first-ever-stroke and recurrent stroke) was 149 per 100,000 (177 in men and 126 in women)
Cracow Stroke Registry [7]	1999–2000	Data based on hospital registry – from neurological departments in Cracow. Standardized incidence rate (first-ever-stroke and recurrent stroke) was 180 per 100,000 (218 in men, 152 in women).
The Polish National Stroke Prevention and Treatment Registry [8]	2001–2002	Study based on hospital registry. Questionnaire data from 48 neurological units representing most regions in Poland (222 neurological departments were invited to the study) 8736 ischaemic stroke patients were finally included (from 26 centres which fulfilled all the criteria).
The European Register of Stroke [13]	2005	Population-based study Included 120,186 individuals – inhabitants of Warsaw
Cerebrovascular diseases in Ostrowiec district [33]	2003–2008	Data based on hospital registry – from the only neurological department in Ostrowiec. The total incidence of stroke was between 501 and 574 per 100,000 (TIA was also included)
Epidemiology of stroke in Zabrze [10]	2005–2006	Data based on hospital registry – from two neurological departments in Zabrze. Standardized incidence rate (first-ever-stroke and recurrent stroke) was 167 per 100,000 (212 in men, 130 in women).
The Pomeranian Stroke Registry PRUM [11]	2009	Data based on hospital registry. Questionnaire data from 3521 patients with stroke or TIA hospitalized in 12 neurological departments of Pomeranian Province
Epidemiology of stroke in Swietokrzyskie-Sandomierz Region [11]	2009	Data based on hospital registry. Questionnaire data from 1079 patients with stroke or TIA hospitalized in 3 neurological departments of Swietokrzyskie-Sandomierz Region

trend was also calculated for consecutive years by means of Jonckheere–Terpstra and Cochran–Armitage tests for continuous and categorical variables respectively.

### 3. Results

Based on the analysis of the data obtained from the stroke questionnaires, the number of AS hospitalizations in the Silesian Province between 2009 and 2015 was 81,193 (41,696 women and 39,010 men;  $P < 0.001$ ). In 487 cases the data on sex were not available.

In the analyzed period the total number of hospitalizations due to acute haemorrhagic stroke (I60, I61, I62) was 10,828, which constituted 13.3% of all stroke cases, while the number of hospitalizations due to acute ischaemic stroke (I63) was 69,403 (85.5%). The number of hospitalizations with the diagnosis of unspecified stroke (I64) was 962 (1.2%).

There was found that although the total number of stroke hospitalizations was stable over the years, the number of all hospitalizations due to haemorrhagic stroke has significantly decreased and the number of hospitalizations due to ischaemic stroke has increased during the period considered (trend test Cochran–Armitage –  $P = 0.0017$ ; Table 2). The same observation concerned the hospitalized incidence of first-ever haemorrhagic, as well as ischaemic stroke ( $P < 0.0001$ ) (Table 3).

This trend (increasing number of ischaemic strokes and decreasing number of haemorrhagic strokes) was observed

both in women ( $P = 0.016$  for trend in number of all hospitalizations;  $P = 0.002$  for trend in the hospitalized incidence of first-ever-stroke) and in men ( $P = 0.040$  for trend in number of all hospitalizations;  $P = 0.016$  for trend in the hospitalized incidence of first-ever-stroke) (Tables 2 and 3).

The mean age of patients with AS was  $71.7 \pm 12.2$  years. The age of male patients was statistically significantly lower ( $68.2 \pm 11.9$ ) compared to female patients ( $74.8 \pm 11.9$ ) ( $P < 0.05$ ). Table 3 shows the median age of incidence depending on the stroke type and patient's sex. In general, the mean age of incidence of haemorrhagic stroke (I60, I61, I62) was statistically significantly lower compared to the mean age of incidence of ischaemic stroke (I63) ( $68.0 \pm 14.1$  vs.  $72.2 \pm 11.8$ ;  $P < 0.05$ ).

The number of hospitalizations was increasing with age – except for subarachnoid haemorrhage (SAH) which was more common in younger patients. The highest number of hospitalizations was observed for patients aged 75–84 years ( $P < 0.05$ ) (Table 4). In the case of patients <75 years of age the number of hospitalizations was higher in men ( $P < 0.05$ ) while in patients  $\geq 85$  years of age it was higher in women ( $P < 0.05$ ) (Fig. 1). In terms of diagnosis, I61 and I62 were more common in men, while I60, I63 and I64 were more prevalent in women (Table 5).

The mean hospitalization time was  $17.0 \pm 15.9$  days for acute haemorrhagic stroke, and  $13.7 \pm 10.9$  days for acute ischaemic stroke (Table 6). The mean period from first symptoms of stroke to hospitalization was  $0.7 \pm 3.4$  days.

**Table 2 – Number of acute stroke-related hospitalizations in the Silesian Province between 2009 and 2015 (no data on sex in 487 patients in 2012).**

Year		Number of hospitalizations due to acute stroke (n)	Number of hospitalizations per 100,000	Number of hospitalizations in women	Number of hospitalizations per 100,000 in women	Number of hospitalizations in men	Number of hospitalizations per 100,000 in women
2009	All	11,083	239	5697	237	5386	241
	HS	1604	35	798	33	806	36
	IS	9275	200	4789	199	4486	201
2010	All	11,751	254	6126	256	5625	251
	HS	1578	34	783	33	795	36
	IS	10,058	217	5284	221	4774	213
2011	All	11,921	258	6139	257	5782	259
	HS	1562	34	747	31	815	36
	IS	10,223	221	5303	222	4920	220
2012	All	11,912	258	5905	247	5520	248
	HS	1596	35	761	32	771	35
	IS	10,187	221	5078	213	4693	211
2013	All	11,926	259	6202	261	5724	258
	HS	1518	33	740	31	778	35
	IS	10,289	224	5393	227	4896	221
2014	All	11,505	251	5956	251	5549	251
	HS	1531	33	740	31	791	36
	IS	9850	215	5143	217	4707	213
2015	All	11,095	243	5671	240	5424	246
	HS	1439	31	711	30	728	33
	IS	9521	208	4890	207	4631	210

All – all stroke types (I60-I64); HS – haemorrhagic stroke (I60-I62); IS – ischaemic stroke (I63).

**Table 3 – The incidence of hospitalized first-ever-stroke in the Silesian Province between 2009 and 2015.**

Year		Number of first-ever-stroke (n)	Incidence per 100,000	Number of first-ever-stroke in women	Incidence per 100,000 in women	Number of first-ever-stroke in men	Incidence per 100,000 in men
2009	All	7987	172	4061	169	3926	175
	HS	1251	27	629	26	622	28
	IS	6584	142	3346	139	3238	145
2010	All	8598	186	4465	186	4133	185
	HS	1219	26	608	25	611	27
	IS	7298	157	3816	159	3482	156
2011	All	8618	186	4409	184	4209	188
	HS	1211	26	583	24	628	28
	IS	7314	158	3764	157	3550	159
2012	All	8334	181	4282	179	4052	182
	HS	1209	26	604	25	605	27
	IS	7039	152	3632	152	3407	153
2013	All	8605	187	4486	189	4119	186
	HS	1169	25	584	25	585	26
	IS	7353	160	3853	162	3500	158
2014	All	8143	178	4261	180	3882	175
	HS	1125	25	557	23	568	26
	IS	6937	151	3653	154	3284	148
2015	All	7726	169	3924	166	3802	172
	HS	1038	23	511	22	527	24
	IS	6600	144	3368	142	3232	147

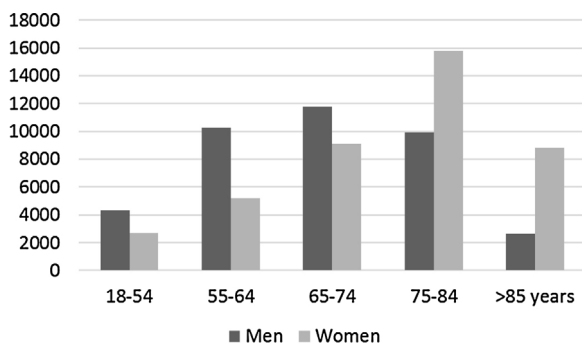
All – all stroke types (I60-I64); HS – haemorrhagic stroke (I60-I62); IS – ischaemic stroke (I63).

**Table 4 – The number of acute stroke – related hospitalizations according to the stroke type and age group in the Silesian Province between 2009 and 2015.**

Age (years)	Type of stroke					
	I60	I61	I62	I63	I64	All
18–54	586 (37.32%) <8.29%>	1282 (14.42%) <18.14%>	41 (11.17%) <0.58%>	5084 (7.33%) <71.94%>	74 (7.69%) <1.05%>	7067 (8.70%) <100%>
55–64	409 (26.05%) <2.62%>	1852 (20.83%) <11.89%>	61 (16.62%) <0.39%>	13,100 (18.88%) <84.07%>	159 (16.53%) <1.03%>	15,581 (19.19%) <100%>
65–74	273 (17.39%) <1.29%>	2091 (23.52%) <9.92%>	94 (25.61%) <0.45%>	18,361 (26.46%) <87.13%>	255 (26.51%) <1.21%>	21,074 (25.96%) <100%>
75–84	216 (13.76%) <0.84%>	2612 (29.38%) <10.07%>	127 (34.60%) <0.49%>	22,648 (32.63%) <87.34%>	327 (33.99%) <1.26%>	25,930 (31.94%) <100%>
85+	86 (5.48%) <0.74%>	1054 (11.85%) <9.13%>	44 (11.99%) <0.38%>	10,210 (14.71%) <88.47%>	147 (15.28%) <1.28%>	11,541 (14.21%) <100%>
Total	1570 (100%) <1.93%>	8891 (100%) <10.95%>	367 (100%) <0.45%>	69,403 (100%) <85.48%>	962 (100%) <1.18%>	81,193 (100%)

Percentage for the column is given in parentheses.

Percentage for the row is given in angle brackets.

**Fig. 1 – Age- and sex-adjusted total number of acute stroke-related hospitalizations in the Silesian Province between 2009 and 2015.**

The aetiology of ischaemic stroke is shown in Table 7. The main cause of ischaemic stroke was atherosclerosis of intra- and/or extracranial arteries (36.1%), followed by a cardioembolic cause (18.7%). The frequency of clinical symptoms in different stroke types is shown in Table 8, and Fig. 2 presents the occurrence of symptoms in different age groups. The older the patient was, the more evident was the clinical manifestation of acute stroke.

Between 2009 and 2015 the overall in-hospital mortality rate due to stroke (I60-I64) was 18%, and for individual diagnoses it was as follows: I60 – 21.3%, I61 – 40.8%, I62 – 17.7%, I63 – 14.9% and I64 – 26.6%. The in-hospital mortality rate was statistically significantly higher in women (19% of all hospitalized women with stroke died) than in men (16%) ( $P < 0.05$ ) (Table 9), and it was increasing with age (Fig. 3). The in-hospital mortality in ischaemic stroke in association with its aetiology is presented in Table 10.

#### 4. Discussion

Our study revealed that the number of hospitalizations due to AS and the incidence of hospitalized first-ever-stroke in the Silesian Province were significant. However, this incidence was stable in the last decade – the annual incidence rates varied from 169/100,000 to 187/100,000. To compare, the recently estimated worldwide global annual incidence of stroke was 258/100,000; in low-income countries – 281/100,000, and in high-income countries – 218/100,000 [17,18]. One of the highest annual incidence rates of first-ever-stroke was described for Tjanjin, China i.e. >300/100,000 [19]. On the other hand, the lowest stroke incidence rates were found for Perth, Australia (2000–2001; age-standardized annual incidence rates 79/100,000), Dijon, France (2000–2004; 87/100,000), Oxfordshire, UK (2002–2004; 87/100,000), Adelaide, Australia (2009–2010; 101/100,000), Ludwigshafen, Germany (2006–2007; 110/100,000), Auckland, New Zealand (2011–2012; 119/100,000), and some other regions [2,20–35].

It should be borne in mind that the number of hospitalizations due to stroke in Silesian Province seemed to be more similar to the Eastern rather than to Western European countries [36–38]. This suggests that primary prevention of stroke may be improperly implemented in our country and the awareness of cerebrovascular risk factors is insufficient.

Comparing the annual incidence of hospitalized first-ever-stroke in this study (169–187/100,000) to the previously presented in the Warsaw Stroke Registry between 1991 and 1992 (111/100,000) for a similar urban and industrial region, it may be noted that the current incidence of hospitalized stroke is much higher. Such a difference over the last 25 years might be related to continuously growing population of the elderly, better diagnostic procedures of stroke, and more accurate

**Table 5 – The number of acute stroke-related hospitalizations and the mean age according to the type of stroke and sex in the Silesian Province between 2009 and 2015.**

Type of stroke		Number of hospitalizations n (%)	P <sup>a</sup> Comparison of number of hospitalizations in men and women with AS	Age median (Q1–Q3)	P <sup>b</sup> Comparison of age in hospitalized men and women with AS
I60	All	1566 (1.94%)		59 (50–71)	
	M	657 (1.68%)	<0.001	57 (47–66)	<0.001
	F	909 (2.18%)		62 (52–74)	
I61	All	8831 (10.94%)		71 (60–80)	
	M	4634 (11.88%)	<0.001	66 (57–76)	<0.001
	F	4197 (10.07%)		76 (65–83)	
I62	All	367 (0.45%)		73 (64–80)	
	M	193 (0.49%)	0.102	70 (59–79)	<0.001
	F	174 (0.42%)		76.5 (68–81)	
I63	All	68,987 (85.48%)		74 (64–81)	
	M	33,107 (84.87%)	<0.001	69 (61–77)	<0.001
	F	35,880 (86.07%)		77 (69–84)	
I64	All	955 (1.18%)		74 (65–82)	
	M	419 (1.07%)	0.006	70 (61–78)	<0.001
	F	536 (1.29%)		78 (70–83.5)	

Number of hospitalizations presented as n(%). Age presented as median and interquartile range. F – female; M – male; AS – acute stroke.

<sup>a</sup> Level of significance for the difference between the number of hospitalizations in female and male patients (Bonferroni correction – significance level set at 0.01).

<sup>b</sup> Level of significance for the difference between the age of female and male patients.

**Table 6 – Duration of hospitalization in days for different stroke types in the Silesian Province between 2009 and 2015.**

Year	Duration of hospitalization in days Median (Q1–Q3)						P <sup>a</sup>
	All	I60	I61	I62	I63	I64	
2009	11 (9–17)	3 (1–17)	14 (4–26)	9.5 (1–16)	11 (9–16)	6 (2–12)	<0.001
2010	11 (9–17)	3 (1–17)	15 (4–25)	8 (2–14)	11 (9–16)	9 (6–16)	<0.001
2011	11 (9–16)	4 (1–14)	15 (4–25)	5 (2–13.5)	11 (9–15)	9 (4–14)	<0.001
2012	11 (9–15)	4 (1–18)	13 (4–24)	5 (2–12)	11 (9–15)	10 (7–14)	<0.001
2013	11 (9–15)	5 (1–18)	14 (4–24)	9 (2–13)	10 (9–15)	10 (3–14)	<0.001
2014	11 (9–16)	8 (2–18)	15 (5–25)	9 (3–17)	11 (9–15)	9 (5–13)	<0.001
2015	11 (9–15)	6 (1–17)	14 (4–23)	9 (2–18)	11 (9–15)	9 (4–11)	<0.001
P <sup>b</sup>	<0.001	0.009	0.273	0.447	<0.001	0.025	–
All	11 (9–16)	4 (1–17)	14 (4–25)	9 (2–14)	11 (9–15)	9 (4–14)	<0.001

Data are presented as median and interquartile range.

<sup>a</sup> Kruskal–Wallis test (comparison of days of hospitalizations between different types of stroke).

<sup>b</sup> The Jonckheere–Terpstra test for trend (Bonferroni correction – significance level set at 0.01) (level of significance for trend in duration of hospitalization for different stroke types between 2009 and 2015 year).

registry methods. The possibility that the current diagnosis is overestimated cannot be ruled out either.

There are only a few recent reports which analyzed epidemiological data on stroke in other Polish provinces [10–16,38,39]. There are regions where the annual hospitalized incidence of first-ever-stroke is much higher (up to 574/100,000 in Ostrowiecki region; however transient ischaemic attacks were also included) [38]. There are also regions with similar epidemiological indices [39]. Sometimes it was very difficult to compare the reported incidence rates of stroke due to different methods of the analysis (Table 1).

The sex-adjusted annual incidence of hospitalized stroke was similar in men (172–188/100,000) and in women (169–189/100,000), which is different from previous Polish studies [5–7]. However, when adjusted to age, the number of stroke-related

hospitalizations was higher in men <75 years of age. In older individuals (≥75 years) the situation was different, i.e. the number of hospitalizations was higher in women. The total number of hospitalizations was higher in women as compared to men due to longer life expectancy among women. Genetic factors should also be considered as a reason for the differences in stroke incidence between sexes in various age groups [40].

The most frequent type of stroke in the Silesian Province was ischaemic stroke – more than 85% of diagnoses, which is consistent with the observations of other authors who described the percentage of ischaemic stroke ranging from 55% to 90% [25]. Only in Chinese patients the diagnosis of haemorrhagic stroke was much more frequent compared to other populations [41].



**Table 7 – Aetiology of ischaemic stroke in the Silesian Province between 2009 and 2015, according to the TOAST classification.**

Year	Aetiology of ischaemic stroke				
	Large-artery atherosclerosis	Cardio-embolism	Small-vessel occlusion (lacune)	Other determined aetiology	Undetermined aetiology
2009	3493 (37.66%)	1568 (16.91%)	937 (10.10%)	192 (2.07%)	3085 (33.26%)
2010	3675 (36.51%)	1622 (16.14%)	869 (8.65%)	151 (1.51%)	3741 (37.19%)
2011	3662 (35.82%)	1933 (18.91%)	990 (9.68%)	137 (1.34%)	3501 (34.25%)
2012	3774 (37.04%)	2090 (20.52%)	934 (9.17%)	185 (1.82%)	3204 (31.45%)
2013	3622 (35.3%)	2023 (19.66%)	1024 (9.95%)	173 (1.68%)	3447 (33.5%)
2014	3471 (35.23%)	1888 (19.17%)	1036 (10.52%)	233 (2.37%)	3222 (32.71%)
2015	3357 (35.26%)	1849 (19.42%)	956 (10.04%)	194 (2.04%)	3165 (33.24%)
P <sup>a</sup>	<0.001	<0.001	0.012	0.004	<0.001
Total	25,054 (36.10%)	12,973 (18.69%)	6746 (9.72%)	1265 (1.82%)	23,365 (33.67%)

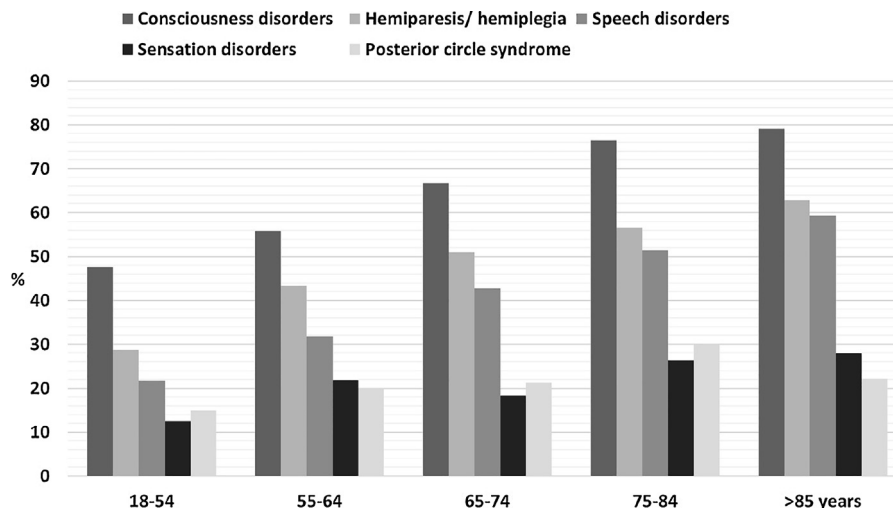
<sup>a</sup> The Cochran–Armitage test for trend (Bonferroni correction – significance level set at 0.01) (level of significance for trend in percentage distribution for different stroke types according to aetiology between 2009 and 2015 year).

**Table 8 – Clinical symptoms of acute stroke in the Silesian Province between 2009 and 2015.**

Clinical symptoms	All	Type of stroke					P <sup>a</sup>
		I60 n = 1570	I61 n = 8891	I62 n = 367	I63 n = 69,403	I64 n = 962	
Consciousness disorders	28,342 (34.91%)	922 (58.73%)	5700 (64.11%)	178 (48.50%)	21,035 (30.31%)	507 (52.70%)	<0.001
Hemiparesis/hemiplegia	65,698 (80.92%)	660 (42.04%)	7132 (80.22%)	254 (69.21%)	56,962 (82.07%)	690 (71.73%)	<0.001
Speech disorders	47,946 (59.05%)	536 (34.14%)	5425 (61.02%)	185 (50.41%)	41,200 (59.36%)	600 (62.37%)	<0.001
Sensation disorders	26,803 (33.01%)	293 (18.66%)	3124 (35.14%)	94 (25.61%)	22,978 (33.11%)	314 (32.64%)	<0.001
Posterior circle syndrome	18,190 (22.40%)	311 (19.81%)	2183 (24.55%)	67 (18.26%)	15,447 (22.26%)	182 (18.92%)	<0.001

Data presented as n (%).

<sup>a</sup> Chi<sup>2</sup> test (comparison of symptoms between different types of stroke).

**Fig. 2 – Stroke symptoms in different age categories in the Silesian Province between 2009 and 2015.**

The percentage of unspecified stroke (I64) in the present study was rather low (1.2%). In the literature it varies from 0% in high-income countries to 10% in low-income countries [17].

As it was also noticed by other authors, the mean age of male patients hospitalized in Silesian hospitals due to AS was significantly lower (about 6 years) than of female patients

[40,42,43]. Women were not only older when admitted to hospital, but in the case of female patients stroke was more severe and functional outcome was worse [43,44]. Information on stroke severity as measured by different scales (e.g. NIHSS, SSS) was not included in our questionnaires. Therefore, we could only indirectly conclude on stroke severity,

**Table 9 – In-hospital mortality in the Silesian Province between 2009 and 2015. Data presented as the number and percentage of deaths, n (%).**

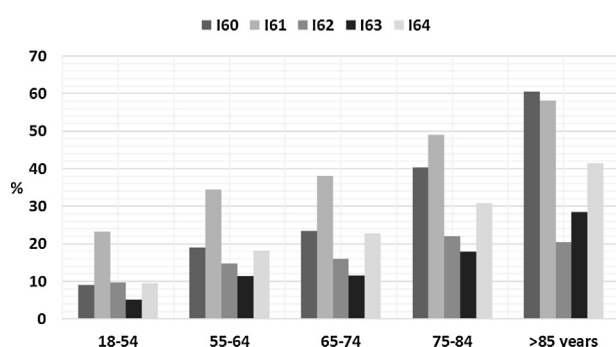
Year	Overall hospital mortality n = 81,193	Overall female hospital mortality n = 41,696	Overall Male hospital mortality n = 39,010	I60 n = 1570	I61 n = 8891	I62 n = 367	I63 n = 69,403	I64 n = 962
2009	2115 (19.08%)	1174 (20.61%)	941 (17.47%)	35 (15.15%)	510 (38.43%)	5 (10.87%)	1464 (15.78%)	101 (49.51%)
2010	2129 (18.12%)	1188 (19.39%)	941 (16.73%)	61 (24.80%)	529 (41.04%)	8 (18.60%)	1511 (15.02%)	20 (17.39%)
2011	2207 (18.51%)	1245 (20.28%)	962 (16.64%)	49 (23.44%)	503 (38.09%)	12 (20.00%)	1599 (15.64%)	44 (32.35%)
2012	2100 (17.63%)	1125 (19.05%)	895 (16.21%)	43 (16.93%)	547 (43.00%)	9 (12.86%)	1487 (14.60%)	14 (10.85%)
2013	2097 (17.58%)	1175 (18.95%)	922 (16.11%)	58 (26.48%)	529 (42.42%)	13 (25.00%)	1470 (14.29%)	27 (22.69%)
2014	1984 (17.24%)	1088 (18.27%)	896 (16.15%)	46 (22.33%)	526 (41.22%)	8 (16.33%)	1385 (14.06%)	19 (15.32%)
2015	1994 (17.97%)	1111 (19.59%)	883 (16.28%)	42 (20.49%)	488 (41.11%)	10 (21.28%)	1423 (14.95%)	31 (22.96%)
P	0.002 <sup>a</sup>	0.015 <sup>b</sup>	0.048 <sup>b</sup>	0.326 <sup>c</sup>	0.094 <sup>c</sup>	0.287 <sup>c</sup>	0.002 <sup>c</sup>	<0.001 <sup>c</sup>
All	14,626 (18.01%)	8106 (19.44%)	6440 (16.51%)	334 (21.27%)	3632 (40.85%)	65 (17.71%)	10,339 (14.90%)	256 (26.61%)

Data presented as n (%).

<sup>a</sup> The Cochran–Armitage test for trend (level of significance for trend in in-hospital mortality between 2009 and 2015 year).

<sup>b</sup> Bonferroni correction – significance level set at 0.025.

<sup>c</sup> Bonferroni correction – significance level set at 0.01.

**Fig. 3 – Age-adjusted hospital mortality in different types of stroke in the Silesian Province between 2009 and 2015.**

based on in-hospital mortality (which was higher in women than in men).

As regards the aetiology of ischaemic stroke, our study revealed that the most common causes of stroke in the

Silesian Province were the following: large-artery arteriosclerosis (36.1% of all AS), cardioembolism (18.7%) and small-vessel occlusion (10.0%). However, the situation was different 25 years ago (in the Warsaw Stroke Registry: 20–24%, 11–15%, and 14–16%, respectively). Currently, approximately 33% of all ischaemic strokes were of undetermined aetiology, whereas 25 years ago – up to 55% [5,6]. Such a decrease might be the result of a greater availability of diagnostic methods (such as ultrasonography, magnetic resonance, angiography, broader cardiologic diagnostic possibilities). But it seems that the percentage of cardioembolic stroke found in this study was too low in comparison to percentage of stroke caused by large-artery arteriosclerosis. It could be caused by still insufficient evaluation for cardioembolism in patients with acute stroke in Poland.

Epidemiological studies conducted over the years have indicated a favourable trend in 30-day mortality among the populations studied. The first studies in the United States and Western Europe (1950s) indicated that over 30% of deaths occurred within 30 days of the onset of stroke to decline to 20%

**Table 10 – In-hospital mortality (n = 10,339, 14.90%) in association with the aetiology of ischaemic stroke (I63; n = 69,403) in the Silesian Province between 2009 and 2015.**

Year	Aetiology of ischaemic stroke				
	Large-artery atherosclerosis n = 25,054	Cardio-embolism n = 12,973	Small-vessel occlusion (lacune) n = 6746	Other determined aetiology n = 1265	Undetermined aetiology n = 23,365
2009	532 (15.23%)	308 (19.64%)	31 (3.31%)	23 (11.98%)	570 (18.48%)
2010	533 (14.50%)	313 (19.30%)	43 (4.95%)	19 (12.58%)	603 (16.12%)
2011	512 (13.98%)	437 (22.61%)	52 (5.25%)	18 (13.14%)	580 (16.57%)
2012	549 (14.55%)	391 (18.71%)	46 (4.93%)	20 (10.81%)	481 (15.01%)
2013	504 (13.91%)	380 (18.78%)	65 (6.35%)	9 (5.20%)	512 (14.85%)
2014	477 (13.74%)	341 (18.06%)	57 (5.50%)	27 (11.59%)	483 (14.99%)
2015	492 (14.66%)	330 (17.85%)	72 (7.53%)	33 (17.01%)	496 (15.67%)
P <sup>a</sup>	0.285	0.012	<0.001	0.587	<0.001
All	3599 (14.36%)	2500 (19.42%)	366 (5.43%)	149 (11.78%)	3725 (15.94%)

Data presented as the number and percentage of deaths in the given year for the given aetiology, n (%).

<sup>a</sup> The Cochran–Armitage test for trend (Bonferroni correction – significance level set at 0.01) (level of significance for trend in in-hospital mortality in different stroke types according to aetiology between 2009 and 2015 year).



in the 1980s and to 15–17% in 1990s [1]. These rates were higher in haemorrhagic stroke, in older age groups, and in Eastern European countries, although they also showed a downward trend. The 30-day mortality rate calculated in the Warsaw Stroke Registry (1991–1992) was 40% in total (61.1% for haemorrhagic stroke, and 26.8% for ischaemic stroke) [5,6]. However, it was only 17.8% as calculated in the Cracow Stroke Registry (1999–2000) [7].

The data included in the stroke questionnaires allowed to analyze only early in-hospital mortality due to stroke. It seemed to be higher (18%) compared to other European countries where it was even below 10% [47]. Similar to other studies, it was higher in the elderly and in haemorrhagic strokes [45]. To compare, there are some data from rare recent studies conducted in other Polish regions: in-hospital stroke mortality in the Swietokrzyskie Province was 19.1%; in the Pomeranian Province – 12.4%, and in Białystok – 13.5% [11,46]. It should be stressed that the number of patients analyzed in these studies was much lower compared to the present study.

## 5. Conclusions

1. Our study is the first to present such a comprehensive (extensive and long-term) analysis of the epidemiological and clinical aspects of stroke in the Silesian Province.
2. The annual incidence of hospitalized first-ever-stroke in the Silesian Province ranged from 169/100,000 to 187/100,000. Haemorrhagic strokes constituted about 13% of all cases, whereas ischaemic strokes – 87%.
3. Overall in-hospital mortality rate in the Silesian Province was 18% (about 40% due to haemorrhagic stroke and 15% due to ischaemic stroke). It was lower than 25 years ago, however it was still higher than in some other European countries. This is the evidence that treatment and care of stroke patients in some Silesian hospitals should be improved.
4. This research should encourage further development of educational and treatment programmes in acute stroke for the improvement in the health status of the population.

## 6. Limitations of the study

There are some limitations to this study. First, in our paper we analyzed only stroke-related hospitalizations, and the incidence of hospitalized stroke (not total incidence) of AS could only be calculated. However, the awareness of stroke symptoms among Polish population and primary care physicians is relatively high. Therefore, almost all patients with AS are admitted to hospitals (according to the literature, the percentage of patients with stroke in Poland who are not hospitalized is less than 2%) [12]. Second, we could not estimate the number of stroke-related deaths that had occurred prior to the patient's arrival at hospital and therefore the true hospitalized incidence of stroke might be underestimated. Third, we only analyzed the questionnaire data. As a result, some human errors could have been made. It is also

possible that in the case of some acute strokes the questionnaires might not been sent to the NHF.

## Conflict of interest

None declared.

## Contribution statement

AST and BLR contributed to this study design, data interpretation, and manuscript draft. AST, MS and MGİ performed statistical analysis. ALS and MGa contributed to data interpretation, and literature review. All authors edited and approved the final version of the manuscript.

## Acknowledgement and financial support

The authors wish to thank Professor Krystyna Pierzchała, MD, PhD, the former Consultant in Neurology for the Silesian Province, for supporting the initiative of the epidemiological study on stroke in the Silesian Province. The authors wish to thank also to Arkadiusz Badziński, DHSc, Assistant Professor at the University of Silesia, authorized medical interpretator and translator, for language correction of the paper.

## REFERENCES

- [1] Dhamoon MS, Moon YP, Paik MC, Sacco RL, Elkind MS. Trajectory of functional decline before and after ischemic stroke: the Northern Manhattan Study. *Stroke* 2012;43:2180–4.
- [2] Rothwell PM, Coull AJ, Silver LE, Fairhead JF, Giles MF, Lovelock CE, et al. Population-based study of event-rate, incidence, case fatality, and mortality for all acute vascular events in all arterial territories (Oxford Vascular Study). *Lancet* 2005;366:1773–83.
- [3] Rothwell PM, Coull AJ, Giles MF, Howard SC, Silver LE, Bull LM, et al. Change in stroke incidence, mortality, case-fatality, severity, and risk factors in Oxfordshire, UK from 1981 to 2004 (Oxford Vascular Study). *Lancet* 2004;363:1925–30.
- [4] Thorvaldsen P, Asplund K, Kuulasmaa K, Rajakangas AM, Schroll M. Stroke incidence, case fatality, and mortality in the WHO MONICA project. World Health Organization Monitoring Trends and Determinants in Cardiovascular Disease. *Stroke* 1995;26:361–7.
- [5] Ryglewicz D. Epidemiology of stroke: a prospective community-based study of stroke in Warsaw, 1991–1992. *Neurol Neurochir Pol* 1994;28(Suppl. 1):35–49.
- [6] Członkowska A, Ryglewicz D, Weissbein T, Barańska-Gieruszczak M, Hier DB. A prospective community-based study of stroke in Warsaw, Poland. *Stroke* 1994;25:547–51.
- [7] Słowik A, Turaj W, Zwolińska G, Róg T, Dziedzic T, Pera J, et al. Stroke attack rates and case fatality in the Krakow Stroke Registry. *Neurol Neurochir Pol* 2007;41:291–5.
- [8] Niewada M, Skowrońska M, Ryglewicz D, Kamiński B, Członkowska A. Acute ischemic stroke care and outcome in centers participating in the Polish National Stroke Prevention and Treatment Registry. *Stroke* 2006;37:1837–43.

- [9] Członkowska A, Niewada M, Sarzyńska-Długosz I, Kobayashi A, Skowrońska M. Ten years of stroke programmes in Poland: where did we start? Where did we get to? *Int J Stroke* 2010;5:414–6.
- [10] Wawrzyńczyk M, Pierzchała K, Braczkowska B, Mańka-Gaca I, Kumor K, Borowski D, et al. Indicators of morbidity and mortality in stroke in the population of Zabrze inhabitants in 2005–2006. *Neurol Neurochir Pol* 2011;45(1):3–10 [in Polish].
- [11] Kozera G, Chwojnicki K, Sobolewski P, Stoiński J, Broła W, Zdrojewski T, et al. Epidemiology and treatment of stroke in the Pomeranian Province and the Swietokrzyskie-Sandomierz Region in the light of data from the Pomeranian Stroke Registry. *Udar Mózgu* 2010;12:1–9 [in Polish].
- [12] Jucha R. Incidence and mortality due to stroke in the population of Krosno and Krosno County. *Przeg Lek* 2013;70:191–4 [in Polish].
- [13] Sienkiewicz-Jarosz H, Gluszkiewicz M, Pniewski J, Niewada M, Członkowska A, Wolfe Ch, et al. Incidence and case fatality rates of first-ever stroke – comparison of data from two prospective population-based studies conducted in Warsaw. *Neurol Neurochir Pol* 2011;45(3):207–12.
- [14] Bembenek JP, Karliński M, Kobayashi A, Członkowska A. The pre-stroke use of vitamin K antagonists for atrial fibrillation – trends over 15 years. *Int J Clin Pract* 2015;69(2):180–5.
- [15] Bembenek JP, Karliński M, Mendel TA, Niewada M, Sarzyńska-Długosz I, Kobayashi A, et al. Temporal trends in vascular risk factors and etiology of urban Polish stroke patients from 1995 to 2013. *J Neurol Sci* 2015;357(1–2):126–30.
- [16] Bembenek JP, Karliński M, Kurkowska-Jastrzebska I, Członkowska A. Changes in pre-hospital management of vascular risk factors among patients admitted due to recurrent stroke in Poland from 1995 to 2013. *Arch Med Sci* 2016;12(4):754–9.
- [17] Béjot Y, Daubail B, Giroud M. Epidemiology of stroke and transient ischemic attacks: current knowledge and perspectives. *Rev Neurol (Paris)* 2016;172:59–68.
- [18] Feigin VL, Forouzanfar MH, Krishnamurthi R, Mensah GA, Connor M, Bennett DA, et al. Global and regional burden of stroke during 1990–2010: findings from the Global Burden of Disease Study 2010. *Lancet* 2014;383:245–54.
- [19] Fang XH, Wang WH, Zhang XQ, Liu HJ, Zhang HM, Qin XM, et al. Incidence and survival of symptomatic lacunar infarction in a Beijing population: a 6-year prospective study. *Eur J Neurol* 2012;19:1114–20.
- [20] Béjot Y, Daubail B, Jacquin A, Durier J, Osseby GV, Rouaud O, et al. Trends in the incidence of ischaemic stroke in young adults between 1985 and 2011: the Dijon Stroke Registry. *J Neurol Neurosurg Psychiatry* 2014;85:509–13.
- [21] Stranjalis G, Kalamatanos T, Gatzonis S, Loufardaki M, Tzavara C, Sakas DE. The incidence of the first-ever stroke in a Mediterranean island population: the isle of Lesbos stroke study. *Neuroepidemiology* 2014;43:206–12.
- [22] Olindo S, Chausson N, Mejdoubi M, Jeannin S, Rosillette K, Saint-Vil M, et al. Trends in incidence and early outcomes in a Black Afro-Caribbean population from 1999 to 2012: étude réalisée en Martinique et centrée sur l'incidence des accidents vasculaires cérébraux II study. *Stroke* 2014;45:3367–73.
- [23] Corbin DOC, Poddar V, Hennis A, Gaskin A, Rambarat C, Wilks R, et al. Incidence and case fatality rates of first-ever stroke in a Black Caribbean population: the Barbados register of strokes. *Stroke* 2004;35:1254–8.
- [24] Hallstrom B, Jonsson AC, Nerbrand C, Norrving B, Lindgren A. Stroke incidence and survival in the beginning of the 21st century in southern Sweden: comparisons with the late 20th century and projections into the future. *Stroke* 2008;39:10–5.
- [25] Vibo R, Korv J, Roose M. The Third Stroke Registry in Tartu, Estonia: decline of stroke incidence and 28-day case-fatality rate since 1991. *Stroke* 2005;36:2544–8.
- [26] Corso G, Bottacchi E, Giardini G, De la Pierre F, Meloni T, Pesenti Campagnoni M, et al. Community-based study of stroke incidence in the Valley of Aosta, Italy—CAR-Cerebrovascular Aosta Registry: years 2004–2005. *Neuroepidemiology* 2009;32:186–95.
- [27] Islam MS, Anderson CS, Hankey GJ, Hardie K, Carter K, Broadhurst R, et al. Trends in incidence and outcome of stroke in Perth, Western Australia During 1989 to 2001: The Perth Community Stroke Study. *Stroke* 2008;39:776–82.
- [28] Leyden JMM, Kleinig TJMP, Newbury JMM, Castle S, Cranefield J, Anderson CS, et al. Adelaide Stroke Incidence Study: declining stroke rates but many preventable cardioembolic strokes. *Stroke* 2013;44:1226–31.
- [29] Palm F, Urbanek C, Rose S, Buggle F, Bode B, Hennerici MG, et al. Stroke incidence and survival in Ludwigshafen am Rhein, Germany: the Ludwigshafen Stroke Study (LuSS). *Stroke* 2010;41:1865–70.
- [30] Benatru I, Rouaud O, Durier J, Contegal F, Couvreur G, Bejot Y, et al. Stable stroke incidence rates but improved case-fatality in Dijon, France, from 1985 to 2004. *Stroke* 2006;37:1674–9.
- [31] Manobianca G, Zoccollella S, Petruzzellis A, Miccoli A, Logroscino G. The incidence of major stroke subtypes in southern Italy: a population-based study. *Eur J Neurol* 2010;17:1148–55.
- [32] Kita Y, Turin TC, Ichikawa M, Sugihara H, Morita Y, Tomioka N, et al. Trend of stroke incidence in a Japanese population: Takashima stroke registry, 1990–2001. *Int J Stroke* 2009;4:241–9.
- [33] Syme PD, Byrne AW, Chen R, Devenny R, Forbes JF. Community-based stroke incidence in a Scottish population: the Scottish Borders Stroke Study. *Stroke* 2005;36:1837–43.
- [34] Feigin VL, Krishnamurthi RV, Barker-Collo S, McPherson KM, Barber PA, Parag V, et al. 30-year trends in stroke rates and outcome in Auckland, New Zealand (1981–2012): A Multi-Ethnic Population-Based Series of Studies. *PLoS ONE* 2015;10(8).
- [35] Kulesh SD, Filina NA, Frantava NM, Zhytko NL, Kastsinevich TM, Kliatskova LA, et al. Incidence and case-fatality of stroke on the East border of the European union: The Grodno Stroke Study. *Stroke* 2010;41:2726–30.
- [36] Feigin VL, Lawes CM, Bennett DA, Barker-Collo SL, Parag V. Worldwide stroke incidence and early case fatality reported in 56 population-based studies: a systematic review. *Lancet Neurol* 2009;8:355–69.
- [37] Sedova P, Brown RD, Zvolosky M, Kadlecova P, Bryndziar T, Kubelka T, et al. Incidence of hospitalized stroke in the Czech Republic: The National Registry of Hospitalized Patients. *J Stroke Cerebrovasc Dis* 2017;26:979–86.
- [38] Cichońska M, Borek M, Krawczyk W, Iłżecka J. Frequency of vascular lesions in the population of the Ostrowiec district. *Med Og Nauk Zdr* 2012;18(2):77–83 [in Polish].
- [39] Szczudlik A, Członkowska A, Kozubski W, et al. Management of acute ischemic stroke. Report of a team of experts from the National Program for the Prevention and Treatment of Stroke 2000. 2000 [in Polish].
- [40] Traylor M, Rutten-Jacobs LCA, Holliday EG, Malik R, Sudlow C, Rothwell PM, et al. Differences in common genetic predisposition to ischemic stroke by age and sex. *Stroke* 2015;46:3042–7.
- [41] Tsai C-F, Anderson N, Thomas B, Sudlow CLM. Comparing risk factor profiles between intracerebral haemorrhage and ischaemic stroke in Chinese and white populations: systematic review and meta-analysis. *PLOS ONE* 2016;11(3): e0151743.
- [42] Andersen MN, Andersen KK, Kammersgaard LP, Olsen TS. Sex differences in stroke survival: 10-Year Follow-up of the

- Copenhagen Stroke Study Cohort. *J Stroke Cerebrovasc Dis* 2005;14:215-20.
- [43] Acciarresi M, De Luca P, Caso V, Agnelli G, D'Amore C, Alberti A. Acute stroke symptoms: do differences exist between sexes? *J Stroke Cerebrovasc Dis* 2014;23:2928-33.
- [44] Santalucia P, Pezzella FR, Sessa M. Sex differences in clinical presentation, severity and outcome of stroke: results from a hospital-based registry. *Eur J Intern Med* 2013;24:167-71.
- [45] You J, Condon JR, Zhao Y, Guthridge SL. Stroke incidence and case-fatality among Indigenous and non-Indigenous populations in the Northern Territory of Australia, 1999-2011. *Int J Stroke* 2015;10:716-22.
- [46] Syta-Krzyżanowska A, Chorąży M, Drozdowski W. Etiological characteristics of strokes treated in the Department of Neurology of the Medical University of Białystok with the analysis of risk factors. *Polish. Aktualn Neurol* 2010;10:26-30.
- [47] Członkowska A, Niewada M, El-Baroni IS, Mendel T, Ryglewicz D, Sandercock P, et al. High early case fatality ischemic stroke in Poland: exploration of possible explanations in the International Stroke Trial. *J Neurol Sci* 2002;202(1-2):53-7.