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The Impact of Meteorological Factors on Stroke Incidence in the Transdanubian Region of Hungary

László Horváth [1], Zsófia Verzár [1,2], Tímea Csákvári [3,*], László Szapáry [4], Péter Domján [5], Csaba Bálint [1], Haitham Khatatbeh [6], Amira Mohammed Ali [7] and Annamária Pakai [2]

1 Doctoral School of Health Sciences, Faculty of Health Sciences, University of Pécs, H-7621 Pécs, Hungary
2 Institute of Emergency Care, Pedagogy of Health and Nursing Sciences, Faculty of Health Sciences, University of Pécs, H-7621 Pécs, Hungary
3 Department of Health Economics and Health Care Management, Institute of Health Insurance, Faculty of Health Sciences, University of Pécs, H-7621 Zalaegerszeg, Hungary
4 Department of Stroke, Clinical Centre, University of Pécs, H-7623 Pécs, Hungary
5 Interdisciplinary Applied Health Sciences Program, Doctoral College, Semmelweis University, H-1091 Budapest, Hungary
6 Faculty of Nursing, Yarmouk University, Irbid 21163, Jordan
7 Department of Psychiatric Nursing and Mental Health, Faculty of Nursing, Alexandria University, Alexandria 21544, Egypt
* Correspondence: timea.csakvari@etk.pte.hu

Abstract: Cerebrovascular diseases are the leading cause of death and disability. The epidemiological background and predisposing factors have been the basis of many studies. We aimed to assess the effect of seasonal variability and meteorological factors on stroke incidence in Hungary. National and county-level secondary data were assessed for 2018–2019. We identified stroke with ICD codes I60, I61, I62 (hemorrhagic), I63, I65, and I66 (ischemic). The data were obtained from the University of Pécs Clinical Centre (number of patients per day according to sex and disease subtype, n = 1765). Daily average and maximum wind speed [m/s], precipitation [mm], temperature [°C], and frontal effect [warm/cold/mixed/no effect]) were provided by the Hungarian Meteorological Service. We found that 89.92% of the patients were hospitalized for ischemic and 10.08% for hemorrhagic stroke. We observed a significantly higher number of cases in the other months compared to winter (spring: +35.9%; $p = 0.007$, summer: +59.0%; $p = 0.016$, autumn: +36.5%; $p = 0.01$). In autumn, an increase in temperature increased the incidence of stroke (r = 0.210; $p = 0.004$). Temperature change affected ischemic stroke incidence (r = 0.112; $p = 0.003$). In contrast, the number of hemorrhagic stroke cases showed a mild but significant negative association with daily temperature change (r = −0.073; $p = 0.049$). Overall, a 1 °C temperature change compared to the previous day increased the daily number of admissions by 2.9% ($p = 0.017$). Air pressure change also affected hemorrhagic stroke incidence (r = 0.083; $p = 0.025$). Changes in temperature and frontal effects can increase the incidence of stroke. Modern forecasting technology can help the healthcare system prepare for possible increased workloads during critical periods.

Keywords: stroke; front; meteorology; ischemic; hemorrhagic

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1. Introduction

According to the definition of the American Heart Association/American Stroke Association, stroke is ‘a neurological deficit attributed to an acute focal injury of the central nervous system by a vascular cause’ [1]. Different subtypes are known as cerebral infarction, intracerebral hemorrhage, and subarachnoid hemorrhage [2]. Stroke is the leading cause of disability and the second-leading cause of death globally, according to the World Stroke Organization (WSO). Its incidence was estimated at 16% among people aged 15–49 years and 62% among people under 70 years in 2019, with prevalence rates of 22% and 67%, respectively [1].

Based on the pathomechanism, approximately 80–85% of all stroke events are ischemic, while 15–20% are hemorrhagic [3].

Acute stroke is a condition requiring immediate intervention and hospitalization: the patient's chances of recovery from a stroke and their long-term quality of life can be affected by the availability, speed, and quality of the intervention.

The epidemiological background and predisposing factors of stroke have been the basis of many studies. Environmental (second-hand smoke, lead exposure, meteorological factors, etc.), behavioral (smoking, low physical activity, alcohol use, etc.), and metabolic (high fasting plasma glucose, poor diet, high body mass index, etc.) factors may be responsible for stroke events [4,5]. Other, currently known risk and predisposing factors for stroke include hypertension, age, diabetes, or hyperlipidemia [6–8], but further risk factors may also be involved [9–11], such as colds [12], lack of influenza vaccination [13], air pollution [14], particulate matter [15], or psychosocial factors [16,17].

Several studies are assessing the relationship between the incidence of various diseases, mortality rates, and certain meteorological factors (e.g., phases of the moon, solar flares) [18–21]. It is shown that the number of accidents and ambulance traffic increase during full moons [18]. Meteorological factors have been shown to affect other conditions, such as the increased risk of suicide in certain moon phases [19], short-term temperature changes, and ischemic stroke among women [20].

The influence of meteorological factors on the development of stroke is widely assessed, but little is known about the detailed meteorological factor effect on stroke events. It has been found that the ischemic stroke incidence is lower in the summer, but daily minimum temperatures contribute significantly to its development [22]. However, day-to-day temperature variability may play a major role in hemorrhagic stroke events. When the average temperature was lower than the previous day, the incidence of hemorrhagic stroke was higher [23]. Also, stroke events showed monthly and seasonal variation in southeast China: autumn recorded the highest incidence for both ischemic and hemorrhagic stroke [24].

Climate change has a significant effect on the incidence of acute myocardial infarction as well, especially during the transition from cold to warm weather in March, April, and May [25]. Diurnal temperature has a significant effect on the global mortality for stroke [26]. Overall, the number of environmental health problems is constantly increasing, and there are growing threats to human health [27].

Hungary is located in Central Europe, within the temperate climate zone, characterized by significant temporal variability due to the influences of oceanic, continental, and Mediterranean factors stemming from its geographical position. The country experiences between 1900 and 2000 h of sunshine annually. Precipitation is highly variable both spatially and temporally. Additionally, heatwaves, which are harmful to human health and lead to increased mortality, typically affect the entire country with the exception of one southwestern county (Somogy) [28].

The health status of the Hungarian population is also poorer compared to other European countries [29]. Approximately 18,000 people die of stroke in Hungary every year, and the incidence is estimated at 50,000 [29]. In Hungary, both morbidity and mortality from cardiovascular and cerebrovascular diseases increase with age. Compared to Western European countries, the incidence of stroke in Hungary is two to three times higher, and the average age of patients is 5–10 years lower, making it crucial to increase the effectiveness of prevention and care. The rising rates of myocardial and cerebral infarctions are also striking [28,29].

In Hungary, the Stroke Alliance for Europe predicts an upward trend in incidence (+28%), prevalence (+13%), and mortality (+44%) between 2015 and 2035. The current incidence rate is 127.1/100,000 persons, while the mortality rate is 75.8/100,000 [30].

Baranya County is the 10th most populous county in the southern–southwestern part of Hungary, with 355,315 inhabitants in 2023 [31]. The life expectancies of the population are about the same as the national averages for women ($M_{Baranya}$: 78.12 years, $M_{Hungary}$: 78.38 years) and men ($M_{Baranya}$: 73.03 years, $M_{Hungary}$: 72.55 years), with a slightly higher mean age (women—$M_{Baranya}$: 46.1 years, $M_{Hungary}$: 45.0 years; men—$M_{Baranya}$: 42.1 years, $M_{Hungary}$: 41.0 years), respectively [32]. The largest hospital is the Clinical Centre of the University of Pécs, which is the fourth-largest university hospital in the country and the only inpatient care provider in the Transdanubian Region, representing the leading healthcare provider in Baranya County.

In our study, we aimed to assess the relationship between weather fronts and the number of stroke cases in Baranya County, Hungary, between 2018 and 2019.

2. Materials and Methods

2.1. Study Design

We carried out a quantitative, retrospective, secondary data analysis for the years 2018–2019 for the county of Baranya. The source of patient data was the University of Pécs Clinical Centre, while the Hungarian Meteorological Service provided the meteorological data. A total of 730 days of data were analyzed, during which 1765 patients were treated at the Clinical Centre.

2.2. Sample Characteristics

In our study, the ischemic subtype was identified by ICD codes I63, I65, and I66 and hemorrhagic cases by codes I60, I61, and I62. Patients were selected if the ICD codes were used to code the primary diagnosis for care. The dependent variables were the number of stroke cases by type [ischemic or hemorrhagic] for both males and females. Our data on strokes were collected from the validated databases of the University of Pécs Clinical Centre. According to the inclusion criteria, all stroke cases treated in the Clinical Centre were included in the two years under study (n = 1765).

2.3. Meteorological Data

Meteorological data were provided by the Hungarian Meteorological Service's weather station in Pogány (Lat: 45.9950, Lon: 18.2350), approximately 14 km south of Pécs, where the Clinical Centre can be found. As independent variables, we defined precipitation (mm), front activity [cold front, warm front, mixed front, no front], daily average wind speed and maximum wind speed (m/s), barometric pressure (hPa), and daily mean temperature (°C). The daily averages or sums of weather parameters were derived from 10 min measurement data, as well as the extreme values of certain elements. The data series contains measured and verified data from the station network of the Hungarian Meteorological Service. Based on the available data, we created two new variables: temperature change (°C), which shows the number of degrees Celsius change in the daily average temperature compared to the previous day, and barometric pressure change (hPa), which shows the amount of change in barometric pressure compared to the previous day.

2.4. Statistical Analysis

The data were analyzed by descriptive statistical indicators (mean, standard deviation). In addition, we tested normality using the Shapiro–Wilk test and then examined differences and correlations between variables using the Mann–Whitney U, Kruskal–Wallis test, Spearman rank correlation, and regression analysis. Results were considered significant at $p < 0.05$ [33].

A Poisson regression analysis was also performed, where the dependent variable was the total number of cases, as well as separately the number of ischemic and hemorrhagic stroke cases. The independent variables included the season, front effects (1 = cold front, 2 = warm front, 3 = mixed front, 4 = no front), daily average temperature compared to the seasonal average temperature (1 = below average, 2 = above average, 3 = average), changes in the front compared to the previous day (1 = no, 2 = yes), atmospheric pressure (hPa), changes in atmospheric pressure compared to the previous day (hPa), daily average wind speed (km/h), daily precipitation (mm), daily average temperature (°C), and daily average temperature change compared to the previous day (°C).

Calculations were performed using SPSS 26.0 software.

2.5. Ethical Considerations

The data used for this research are all secondary; they do not contain any information suitable for patient identification. Our analysis were conducted in compliance with all relevant guidelines, data protection rules, and the Declaration of Helsinki. We had ethical approval granted by the University of Pécs in 2020 (8085 PTE2020).

3. Results

Between 1 January 2018 and 31 December 2019, during the 730 days examined, a total of 1765 cases were treated in Baranya County, of whom 834 were women (47.25%) and 931 were men (52.75%). Among the sample, 89.92% of the patients were hospitalized for ischemic stroke and 10.08% for hemorrhagic stroke. Overall, ischemic strokes were much more frequent, with males experiencing slightly higher frequencies. Seasonal variation was more pronounced in ischemic strokes, with the highest number of cases occurring in spring (n = 420) and the lowest in winter (n = 363) (Figure 1).

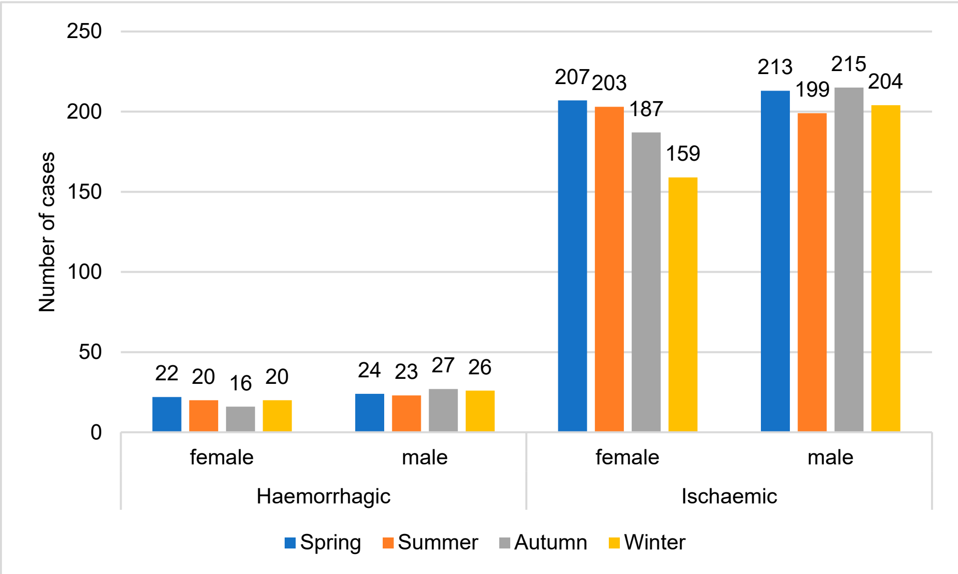
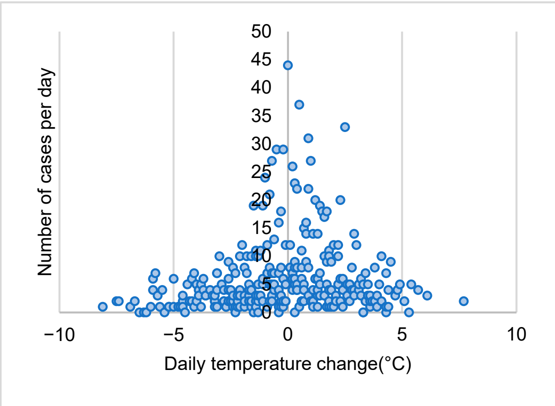


Figure 1. Number of stroke events in Baranya County, Hungary between 2018 and 2019.

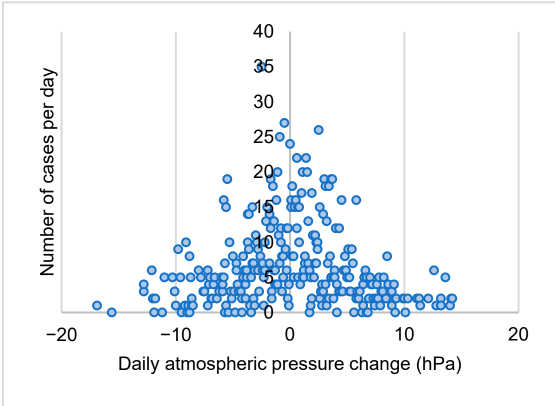
We examined the relationships between the dependent variables (case counts) listed in Figure 1 and seasons, front types, and daily mean temperature, but found no significant differences ($p > 0.05$).

The relationship between daily temperature variation, air pressure, and the total number of cases per day is shown in Figure 2. For daily temperature changes, a higher proportion of cases occurred on days when the daily average temperature had increased compared to the previous day. We also found a weak positive significant relationship with temperature change for the number of ischemic strokes in men (r = 0.088, $p = 0.018$) and for the total number of ischemic strokes (r = 0.112; $p = 0.003$). In contrast, the number of hemorrhagic strokes, although weak, showed a significant negative relationship with daily temperature change (r = −0.073; $p = 0.049$). The change in atmospheric pressure showed a weak positive correlation with the number of hemorrhagic stroke cases (r = 0.083; $p = 0.025$).

In addition, we showed that the day on which the frontal effect changed from the previous day had a higher mean daily incidence of female ischemic stroke (M: 1.13, SD: 1.04) than when the frontal effect did not change (M: 0.95, SD: 1.02, $p = 0.010$). Also, frontal change may significantly increase ischemic stroke events during the summer. A more detailed description can be seen in Table 1.



(**a**)



(**b**)

Figure 2. The relationship of (**a**) daily temperature variation and (**b**) air pressure with the total number of cases per day.

Table 1. Stroke incidence and changes in frontal effect in different seasons.

Subtype	Front Change			No Front Change			*p*
	Number of Cases (Mean per Day)	SD	Total Number of Cases	Number of Cases (Mean per Day)	SD	Total Number of Cases	
Spring (n = 466)							
Hemorrhagic (female)	0.16	0.36	14	0.09	0.32	8	0.366
Hemorrhagic (male)	0.12	0.36	11	0.14	0.35	13	0.858
Hemorrhagic (total)	0.28	0.54	25	0.22	0.47	21	0.723
Ischemic (female)	1.02	1.07	92	1.22	1.03	115	0.907
Ischemic (male)	1.10	1.25	99	1.21	1.02	114	0.994
Ischemic (total)	2.12	1.60	191	2.44	1.35	229	0.620
Total	2.40	1.68	216	2.66	1.41	250	***0.622***
Summer (n = 445)							
Hemorrhagic (female)	0.11	0.31	13	0.11	0.31	7	0.372
Hemorrhagic (male)	0.12	0.33	14	0.14	0.35	9	0.133
Hemorrhagic (total)	0.23	0.46	27	0.24	0.47	16	0.150
Ischemic (female)	1.08	1.15	127	1.15	1.01	76	0.534
Ischemic (male) *	1.12	1.06	132	1.02	0.90	67	0.016
Ischemic (total) *	2.19	1.45	259	2.17	1.41	143	0.041
Total *	2.42	1.57	286	2.41	1.56	159	***0.022***
Autumn (n = 445)							
Hemorrhagic (female)	0.14	0.35	13	0.03	0.18	3	0.128
Hemorrhagic (male)	0.11	0.31	10	0.20	0.50	17	0.700
Hemorrhagic (total)	0.24	0.46	23	0.23	0.54	20	0.702
Ischemic (female)	0.91	0.92	86	1.16	1.11	101	0.382
Ischemic (male)	1.22	1.22	116	1.14	1.00	99	0.250
Ischemic (total)	2.13	1.50	202	2.30	1.57	200	0.925
Total	2.37	1.56	225	2.53	1.67	220	0.886

Table 1. *Cont.*

Subtype	Front Change			No Front Change			*p*
	Number of Cases (Mean per Day)	SD	Total Number of Cases	Number of Cases (Mean per Day)	SD	Total Number of Cases	
				Winter (n = 406)			
Hemorrhagic (female)	0.11	0.31	8	0.12	0.32	12	0.562
Hemorrhagic (male)	0.20	0.43	15	0.11	0.31	11	0.495
Hemorrhagic (total)	0.30	0.52	23	0.22	0.44	23	0.458
Ischemic (female)	0.71	0.83	54	1.00	1.02	103	0.756
Ischemic (male)	1.26	1.12	96	1.04	1.10	107	0.914
Ischemic (total)	1.97	1.41	150	2.04	1.42	210	0.865
Total	2.28	1.48	173	2.26	1.48	233	0.867

*: statistically significant

However, there was no significant difference in how the front changed—only in the number of ischemic cases among women in autumn did we see the presence of a front effect that changed to a mixed or warm one, increasing the number of cases on the day of the event (p = 0.030).

The results of the Poisson regression model can be seen in Table 2. There is a significant result regarding the season when considering the total number of cases, indicating that we observed a significantly higher number of cases in the other months compared to winter (spring: +35.9%; p = 0.007, summer: +59.0%; p = 0.016, autumn: +36.5%; p = 0.01). If the daily average temperature is lower than the seasonal average, a 19.9% reduction in the number of cases is expected compared to days with above-average temperatures (p = 0.024). The amount of precipitation also significantly influences the expected number of cases (p = 0.038), while a 1 °C increase in daily average temperature reduces the number of cases by 2.1% (p = 0.020), whereas a 1 °C temperature change compared to the previous day increases it by 2.9% (p = 0.017). When breaking down the stroke case numbers by subtype, we found additional significant associations in ischemic cases, again concerning season and temperature; however, no correlation is visible between the dependent and independent variables for hemorrhagic cases.

The indicators were also examined separately by season. We found that there are essentially no significant differences between stroke incidence and meteorological characteristics in spring and summer, with the exception that in spring, changes in atmospheric pressure are slightly positively correlated with hemorrhagic stroke events (r = 0.156; p = 0.034), as well as wind speed (r = 0.150, p = 0.041). However, in autumn, the number of ischemic cases increases when the temperature varies more from one day to the next (r = 0.255, p = 0.002), and this relationship is also observed for the total number of cases (r = 0.211, p = 0.004).

In the summer, changes in barometric pressure can significantly increase the number of strokes, with an increase in air pressure increasing the likelihood of stroke occurrence. Changes in the atmospheric pressure significantly predicted the total number of strokes (β = −0.168, [95%CI: −0.972–−0.075], p = 0.022), with the number of male ischemic events (β = −0.0145, [95%CI: −0.583–−0.001] p = 0.049) also increasing at this time of year.

In autumn, an increase in temperature increases the incidence of stroke (r = 0.210; p = 0.004). Within this, the association is slightly stronger for ischemic cases (r = 0.225; p = 0.002; female: r = 0.148; p = 0.046, male: r = 0.163; p = 0.028). In men, however, the risk of ischemic stroke is increased by a fall in air pressure (r = −0.183; p = 0.013).

Table 2. Results of the Poisson regression model.

Independent Variables		Total		Ischemic		Hemorrhagic	
		Exp(B) (95%CI)	p	Exp(B) (95%CI)	p	Exp(B) (95%CI)	p
Season (ref: winter)	Spring	1.359 (1.088–1.698)	0.007	1.371 (1.084–1.734)	0.009	1.296 (0.652–2.576)	0.460
	Summer	1.590 (1.089–2.319)	0.016	1.613 (1.082–2.404)	0.019	1.444 (0.447–4.658)	0.539
	Autumn	1.365 (1.076–1.731)	0.010	1.387 (1.079–1.784)	0.011	1.193 (0.577–2.468)	0.633
Front (ref: no front)	Warm	0.960 (0.832–1.108)	0.575	0.944 (0.810–1.099)	0.454	1.112 (0.724–1.706)	0.628
	Cold	0.976 (0.831–1.145)	0.763	0.968 (0.818–1.146)	0.709	1.052 (0.634–1.745)	0.844
	Mixed	0.906 (0.775–1.059)	0.216	0.922 (0.783–1.086)	0.331	0.748 (0.437–1.279)	0.288
Mean daily temperature compared to seasonal average (ref: average)	Below average	0.801 (0.661–0.971)	0.024	0.778 (0.634–0.954)	0.016	1.008 (0.571–1.779)	0.978
	Above average	1.124 (0.953–1.324)	0.164	1.111 (0.934–1.321)	0.233	1.262 (0.751–2.120)	0.379
Front changed? (ref: yes)		0.942 (0.850–1.045)	0.258	0.924 (0.829–1.030)	0.155	1.125 (0.816–1.551)	0.472
Air pressure (hPa)		1.002 (0.994–1.010)	0.591	1.000 (0.992–1.008)	0.990	1.020 (0.995–1.045)	0.114
Air pressure change from previous day (hPa)		1.003 (0.992–1.013)	0.624	1.002 (0.991–1.014)	0.665	1.003 (0.970–1.037)	0.847
Wind speed (km/h)		0.978 (0.915–1.044)	0.499	0.953 (0.889–1.022)	0.181	1.184 (0.973–1.441)	0.092
Precipitation (mm)		1.009 (1.000–1.018)	0.038	1.009 (0.999–1.018)	0.068	1.014 (0.987–1.041)	0.302
Daily average temperature (°C)		0.979 (0.963–0.997)	0.020	0.979 (0.961–0.997)	0.024	0.983 (0.932–1.038)	0.547
Daily average temperature change from previous day (°C)		1.029 (1.005–1.054)	0.017	1.035 (1.010–1.062)	0.007	0.982 (0.912–1.057)	0.627

4. Discussion

In our analysis, we examined the number of patients admitted to a university clinic with a diagnosis of stroke in light of certain meteorological factors. We found that although storm and wind intensity do not greatly influence the incidence of the disease, the daily temperature variation—and, in some cases, changes in air pressure and frontal effects—may increase the incidence of stroke in the region. For example, Guan et al. describe how changes in barometric pressure affect hospital admissions due to stroke among older men. Similar to our research, they identified decreasing barometric pressure and rising temperature as risk factors in their study [34]. Regarding weather fronts, Shimomura et al.'s study confirmed that changes in the front from one day to the next increase the number of ischemic stroke cases [35]. In a systematic review, Danh et al. also states that both high and low ambient temperature can increase the stroke risk in patients with other cardiovascular comorbidities [36]. Qian et al. linked both extremely high and low temperatures to an increase in the number of ischemic stroke cases, and they demonstrated that within 5 days of the temperature change, the number of hospital admissions significantly rises [37]. However, there is less strong evidence for hemorrhagic stroke, as Helsper et al.'s research demonstrated the independence of the two variables [38]. In our analysis, we found similar relationships—or lack thereof—which align with these studies, even considering the relatively shorter time series and smaller sample size we used. We also observed that these meteorological factors affect the prevalence of the disease between seasons.

In addition to mean values, it would be worth considering the maximum and minimum temperature indicators as well. However, according to Ikefuti et al., daily average temperature provides more reliable results and reduces the likelihood of potential distortions from measurement errors [39]. Although we did not have data on minimum and maximum temperatures, it is likely that these are also influencing factors. In the study by He et al., nighttime peak temperatures increased the risk of ischemic stroke [40].

The risk of ischemic stroke is influenced by various factors, including blood pressure, atherosclerosis, diabetes, and other cardiovascular diseases. Environmental factors, such as temperature and atmospheric pressure variation, also play a significant role in increasing stroke risk. For example, warm weather can increase blood viscosity and blood pressure fluctuations [41], which may elevate the risk of thrombosis and ischemic events.

Knowing the epidemiology and risk factors for diseases are crucial for several reasons. First, eliminating or minimizing risk factors may ensure longer healthy life years for individuals. Although environmental factors such as meteorology are less preventable than lifestyle factors, other means can be used to prepare for potential adverse effects, which is key for individuals who are older or already suffering from other underlying conditions. Efficiently working systems have already been developed to reduce the negative effects of meteorological factors on health [42,43], which can contribute significantly to reducing the number of acute and chronic conditions such as asthma, allergic reactions [44], and infectious diseases [45], in addition to cardiovascular and cerebrovascular diseases.

Secondly, disease prevention yields significant benefits not only for individuals but also for society at large. Enhanced population health improves workforce productivity and economic participation longevity. Therefore, we strongly recommend that policymakers consider our findings and integrate them into preventive health strategies [46].

Third, prevention has also been shown to help reduce the burden on the healthcare and health insurance system. Active inpatient care has been shown to be the most expensive and resource-intensive form of care and should ideally be used only when justified and unavoidable. Reducing the number of avoidable cases should therefore be fought for from a healthcare perspective, so that those resources can be used in other levels of healthcare. Reducing the number of acute, ambulatory cases will also help to reduce the burden on healthcare workers, which is crucial to maintaining their ability to work effectively [47,48].

Our results can therefore benefit the individual, the state, and the health sector and contribute to a healthier life and a sustainable society and care system.

The strength of our research is that the observed case numbers and the meteorological data presented are from the same region. Patients treated in the healthcare provider we studied most likely to come from nearby due to the need for acute care of the pathology, while the Hungarian Meteorological Service monitoring station where the data are obtained from is only 14 km away from the provider. In addition, we examined a total of six dependent variables by sex and stroke subtype, taking into account nine different independent variables of a meteorological nature.

As a limitation of our analysis, we highlight that our results are not national, only county-level, based on data from only two years (2018–2019). Considering the results obtained and the fact that climate change has been proven to have an impact on other diseases as well, it will be important in the future to analyze the incidence of stroke over a longer time period in light of climatic factors. We also did not look at mortality indicators, which may also be worth investigating in terms of the independent variables listed above. Moreover, we did not have other information on the patients, but presumably their age and the presence of other diseases could have influenced the daily case numbers. For example, a lower mean daily temperature was associated with a better quality of life for patients discharged to hospital than for patients with warmer days. However, it has been suggested that humidity as a meteorological factor may also affect the incidence of stroke [24], for which we also had no data.

The effects of climate change are also being felt in Hungary, where global warming is changing the weather. Frontal activity is increasing, and storms and sudden temperature changes have a major impact on the human body.

Our study fills an important gap in the literature by focusing on the influence of meteorological factors on stroke incidence in a region that has been underexplored in such research—Baranya County, Hungary. Our findings that daily temperature variation—and, in some cases, changes in air pressure and frontal effects—can increase the incidence of stroke in the region provide new insights that can inform regional public health strategies. This study is among the first to examine the connection between weather fronts and stroke incidence in Hungary, offering evidence that can lead to more tailored, region-specific prevention and resource management efforts.

Our research aimed to confirm that certain meteorological factors can increase the incidence of stroke in Hungary. During the summer months, it may be particularly important to enhance preventive measures to reduce the risk of stroke. Medical professionals should consider the impact of temperature and atmospheric pressure variations and provide appropriate advice to patients, especially those who already belong to high-risk groups. Our results may be of use for decision-makers, as our findings could be generalized to other groups or populations living in a geographical area with similar meteorological conditions. Modern forecasting technology can also help the healthcare system to prepare for possible increased workloads during critical periods when the number of cases increases. Although the human resource situation in the country is challenging, it is still a way of ensuring that patients receive adequate care, to ensure that they can recover with as few complications as possible and return home as soon as possible.

5. Conclusions

In conclusion, we observed that the seasonal variation in stroke incidence was most prominent in ischemic cases, particularly in spring. Meteorological factors, such as daily temperature changes and atmospheric pressure, were found to have weak but significant correlations with stroke incidence. Specifically, a rise in daily temperature was associated with an increased risk of ischemic strokes, particularly in men, while a drop in air pressure increased the likelihood of stroke events, especially during autumn. There is also fluctuation between the seasons, with the number of hospital admissions due to stroke being lower in winter and higher in the warmer seasons.

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