

Incidence, Mortality Rate and Rate of Thrombolytic Therapy of Acute Stroke in Northeastern Thailand from 2017-2022

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Background: Stroke is a true medical emergency condition with thrombolytic treatment with recombinant tissue plasminogen activator as the standard treatment. In Thailand, including the Northeast region (Health region 7 to 10), stroke incidence and mortality rate have increased. However, there is no study of stroke incidence, recombinant tissue plasminogen activator (rtPA) access rate, and mortality rate by district in Northeastern Thailand.

Objective: This study aimed to present stroke incidence, access rate of thrombolytic treatment, and acute stroke mortality rates for each district in Northeast Thailand for the 5 years, 2017 to 2022.

Materials and Methods: The study drew from the Thai National Health Security Office's (NHSO) database for 2017 to 2022 and reported using rates per 100,000 population and percentage statistics.

Results: The overall incidence of acute stroke and acute ischemic stroke patients aged over 15 years in Northeastern Thailand were 264.19 to 331.70/100,000 population and 184.57 to 232.82/100,000 population respectively. The rtPA access rate was 6.09 to 8.01% (Main Universal Coverage Scheme) and 6.01 to 7.92% (Referral Universal Coverage Scheme). The mortality rate of acute ischemic stroke patients within 30 days and post-rtPA were 8.80 to 10.43% and 3.65 to 5.67% respectively.

Conclusion: In Northeastern Thailand, stroke incidence has shown an upward trend over the past 5 years. The number of acute ischemic stroke patients receiving rtPA has also been on the rise. The mortality rate in patients with acute ischemic stroke within 30 days declined from 2017 to 2019, then increased from 2020 to 2022. Particularly notable was the increase in the mortality rate among patients with acute ischemic stroke post-intravenous thrombolysis.

Keywords: Incidence; Mortality rate; Stroke; Thrombolytic drug; Northeastern Thailand

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Cerebrovascular disease is a condition that affects cerebral vessels or blood flow, including stroke. Globally, stroke remains the second leading cause of death and the third leading cause of death and disability⁽¹⁾. Stroke is classically characterized as a neurological deficit due to an acute focal injury of the central nervous system by vascular cause⁽²⁾.

Stroke is a true medical emergency condition, and the

standard treatment is reperfusion therapy by recombinant tissue plasminogen activator (rtPA). It is the mainstay standard of care for disabling stroke patients within 4.5 hours from onset⁽³⁾.

Thailand is an upper-middle-income country located in the Southeast Asia, with stroke is the first cause of death among females⁽⁴⁾. Thailand started rtPA treatment in 2008 only in Bangkok. After that it was widespread in 2014 supported by the National Health Security Office's national (NHSO)⁽⁵⁾.

Stroke is a serious health issue in Thailand with mortality rates still increasing over the past 5 years, despite healthcare system improvement⁽⁶⁾. Incidence of all strokes are increasing overall in both Thailand and in the Northeast⁽⁵⁾.

To date, few studies have presented stroke data by district in Northeastern Thailand. Therefore, the present study was designed to contribute to filling this gap, by characterizing individual stroke and stroke services data

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by each district in Northeast Thailand for the period 2017 to 2022. We focused on presenting: stroke incidence, rate of rtPA and mortality rates as a contribution to improving quality of stroke services delivery and future planning.

Materials and Methods

Ethical consideration

This study's protocols were approved by the Khon Kaen University Ethics Committee for Human Research based on the Declaration of Helsinki and the ICH Good Clinical Practice Guidelines (Reference No. HE661179).

Study area

All district in the 20 provinces of Northeastern Thailand were selected for this study. The Thai Ministry of Public Health divides the country into 13 regional health areas for stroke care. This study focused on Northeastern regional health areas numbered 7,8,9 and 10.

Patients

All patients 15 years old or above, in the NHSO 2017 to 2022 database diagnosed with acute stroke with either hemorrhagic or ischemic pathology in each district in Northeast Thailand were included.

Data collection

All data were collected from the NHSO's national

database for 2017 to 2022. This database system consists of imported data from all hospitals in Thailand, both government and private sector. Reports with missing or incomplete data were excluded from the study.

Data analysis

Data was analyzed using descriptive statistics including percentages and rates per 100,000 population.

Results

The incidence of acute stroke patients aged 15 years and over per 100,000 population for provinces in Northeastern Thailand for 2017 to 2022 is shown in Table 1 that indicated steadily increased incidence from 2017 to 2022. In 2022, Buriram having the highest incidence in the Northeastern region with 397.82/100,000 population is shown in Figure 1.

Incidence of acute ischemic stroke patients aged 15 years and over per 100,000 population for provinces in Northeastern Thailand for 2017 to 2022 is shown in Table 2 that several provinces steadily increased over 5 years. And region 9 Health had the highest incidence over the study period.

The last 2 years of study, Buriram had the highest incidence. In 2022, all provinces in Health area 7 had increased incidence and Huai Rat District in Buriram had the highest incidence (Figure 2).

Table 1. Incidence of acute stroke patients aged 15 years and above per 100,000 population for provinces in Northeastern Thailand

Province	2017	2018	2019	2020	2021	2022
	per 100,000	per 100,000	per 100,000	per 100,000	per 100,000	per 100,000
Khon Kaen	246.86	265.4	287.84	301.19	313.04	313.83
Maha Sarakham	235.53	280.81	294.74	308.48	314.88	337.33
Roi Et	263.77	294.45	298.79	296.53	300.95	342.75
Kalasin	240.5	249.35	251.56	253.87	256.91	295.46
Udon Thani	236.38	253.31	259.47	267.36	279.45	302.15
Loei	313.19	339.12	345.89	360.59	357.19	360.7
Sakon Nakhon	225.12	255	255.82	283.16	273.14	295.44
Bueng Kan	214.27	239.81	248.13	251.21	278.26	280.38
Nong Bua Lam Phu	243.89	250.41	278.2	279.37	290.79	278.5
Nong Khai	280.64	273.86	298.62	317.56	327.23	322.4
Nakhon Phanom	210.66	252.97	275.06	294.5	285.59	284.93
Surin	288	329.67	339.63	330.07	339.42	373.58
Chaiyaphum	323.78	333.52	327.86	306.25	313.39	356.38
Nakhon Ratchasima	317.22	369.08	389.33	395.14	394.56	386.94
Buri Ram	284.73	308.17	346.16	380.29	406.33	397.82
Ubon Ratchathani	243.5	264.44	276.9	301.38	305.39	319.81
Yasothon	272.73	307.81	321.18	375.4	386.82	387.17
Mukdahan	210.14	215.64	240.21	255.43	249.92	253.47
Amnat Charoen	300.42	289.87	301.34	351.45	334.77	371.18
Si Sa Ket	244.69	270.79	273.01	279.36	260.69	251.06

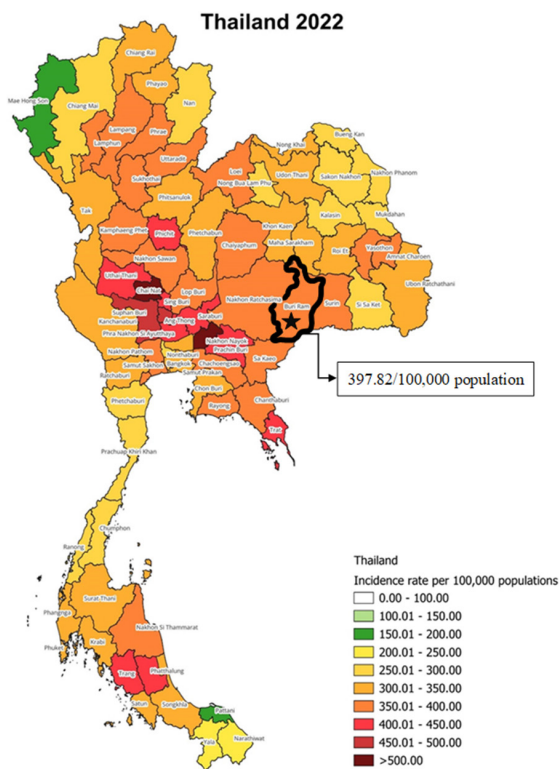


Figure 1. Incidence of acute stroke in each province in Thailand and Buri Ram has the highest incidence in Northeastern region.

Overall, the percentage of Main Universal Coverage Scheme patients with acute ischemic stroke receiving rtPA in Northeastern Thailand increased during 2017 to 2021 and then decreased in 2022 (Table 3). From 2017 to 2021, the percentage increased from 6.09% to 8.01% but decreased to 7.49% in 2022. In Health Area 7, the percentage was highest between 2017 and 2022, except for 2019 when Health Area 10 became the highest.

In the first 5 years of the study, Mukdahan had the highest percentage, but by 2022, Yasothon became the highest (Table 4). During 2022, many districts showed increasing trends such as Yasothon, Roi Et, Surin.

In 2022, Pho Si Suwan in Si Sa Ket had the highest percentage in district level (Figure 3).

Overall, the percentage of Referral Universal Coverage Scheme patients with acute ischemic stroke receiving rtPA in Northeastern Thailand increased during 2017 to 2021 and then decreased in 2022 (Table 5). From 2017 to 2021, the trend of patients receiving rtPA increased (from 6.01% to 7.92%). However, in 2022, the trend decreased to 7.55%. In Health Area 7, the percentage was highest between 2017 and 2022, except in 2019 when Health Area 10 became the highest percentage.

From 2018 to 2021, Mukdahan had the highest percentage. However, by 2022, Yasothon had the highest

percentage (Table 6). During 2022, many districts showed increasing trends such as Yasothon, Roi Et, Surin.

In 2022, Loeng Nok Tha in Yasothon had the highest percentage in district level (Figure 4).

The mortality rates at day 30 post-diagnosis are shown in Table 7 and show an increase from 2021 to 2022. However, mortality rates in the last five years were lower than in 2017. Over the study period, the highest mortality rate was observed in Health Area 7.

From 2018 to 2021, Kalasin had the highest percentage. However, by 2022, Khon Kaen had become the highest (Table 8) and Sang Khom had the highest percentage (Figure 5).

Mortality rates post rtPA, are presented in Table 9. Overall, the trend increased from 3.76% to 5.67% during the period from 2019 to 2022. Throughout the five years, the highest mortality rate in health area 9. In 2022, Si Sa Ket had the highest mortality rate (Table 10).

In 2022, Phimai and Mueang Nakhon Ratchasima had the highest mortality rates post rtPA (Figure 6).

During 2022, Surin and Loei both experienced increased incidence of acute ischemic stroke, rtPA access rates, mortality rate at 30 days post-diagnosis and post rtPA treatment.

Discussion

Our study showed the incidence of acute strokes increased over the period 2019 to 2021 consistent with the study by Nijasri C. Suwanwela⁽⁶⁾. Similarly, Thayabaranathan et al.⁽⁷⁾ had shown that while stroke incidence has declined in high income countries it has been increasing in low to middle income countries over the past 50 years, including Thailand.

In 2022, all health area 7 provinces experienced increased incidence of acute ischemic stroke, to similar levels as central Thailand, such as in Bangkok. Although they have different health facilities and lifestyles, they both face similar climate change, especially air pollution. And rising in stroke incidence can possibly be attributed to environmental factors, such as climate change and long-term exposure to PM2.5⁽⁸⁾.

For 2022, the highest ischemic stroke incidence in each province was typically those with contiguous borders. Potentially interconnected climate and lifestyle factors in these districts could possibly affect the control of underlying factors.

The increased acute ischemic stroke incidence may result from enhanced stroke knowledge from public awareness campaigns such as “BEFAST”. This has led to increased community awareness, prompting symptom recognition and hospital presentation for treatment.

There are now many hospitals capable of providing CT

Table 2. Incidence of acute ischemic stroke patients aged ≥ 15 years per 100,000 population for each province in Northeastern Thailand

Province	2017	2018	2019	2020	2021	2022
	per 100,000	per 100,000	per 100,000	per 100,000	per 100,000	per 100,000
Khon Kaen	172.92	187.55	210.34	225.35	226.96	228.38
Maha Sarakham	208.72	203.2	212.59	218.32	221.8	240.83
Roi Et	208.72	210.52	222.08	211.15	215.91	250.45
Kalasin	208.72	169.7	185.1	177.33	182.26	205.5
Udon Thani	167.06	187.66	189.76	196.18	201.44	213.25
Loei	246.47	263.43	281.99	290.95	276.92	283.26
Sakon Nakhon	208.72	187.02	187.5	207.03	202.61	209.87
Bueng Kan	142.18	165.29	166.09	159.43	184.86	161.22
Nong Bua Lam Phu	134.58	109.14	137.46	162.48	198.18	184.48
Nong Khai	208.72	203.8	241.39	234.13	225.41	221.14
Nakhon Phanom	208.72	164.56	210.55	206.63	205.07	182.65
Surin	191.87	224.57	235.1	230.73	232.04	259.79
Chaiyaphum	232.33	252.42	229.15	201.28	199.6	226.25
Nakhon Ratchasima	227.19	265.21	270.04	280.96	273.73	271.86
Buri Ram	202.1	222.52	260.29	284.97	299.73	295.27
Ubon Ratchathani	172.88	193.25	203.14	205.56	211.25	231.18
Yasothon	169.81	187.67	204.06	263.37	283.39	277.43
Mukdahan	208.72	147.01	176.03	175.43	173.28	198.04
Amnat Charoen	201.78	197.02	197.84	229.45	195.81	259.37
Si Sa Ket	172.35	183.82	192.33	197.41	162.38	151.06

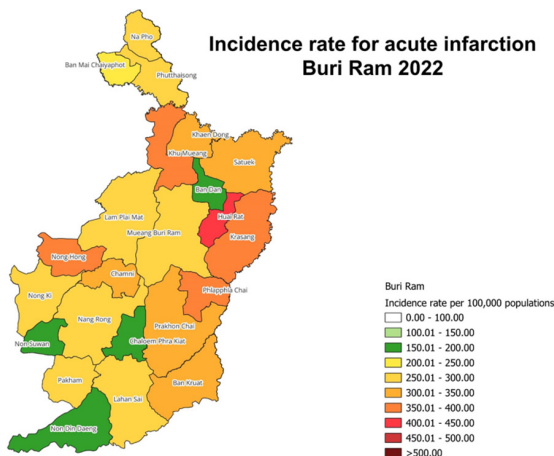


Figure 2. Incidence of acute ischemic stroke in each district in Buri Ram and Huai Rat has the highest incidence in Northeastern Thailand.

scans and standard rtPA treatment in Northeastern Thailand. However, their coverage is not uniform. Many districts with increasing incidence of acute ischemic stroke, but there are no standard node hospitals that can perform CT scans or provide rtPA. Further, these districts are often rural and distant from standard node or tertiary hospitals that can provide such services, for example, Na Chueak or Na Dun hospital in Mahasarakham. Another notable observation is that hospitals providing CT scans and rtPA treatment are mostly established in the capital districts and some

Table 3. rtPA access rate (%) in cerebral infarction (Main Universal Coverage Scheme) in Northeastern Thailand

Area	2017	2018	2019	2020	2021	2022
	%	%	%	%	%	%
Area 7 Khon Kaen	8.04	8.13	8.02	9.95	9.93	9.15
Area 8 Udonthani	5.55	6.76	7.06	6.58	6.58	6.7
Area 9 Nakhon Ratchasima	4.39	4.71	6.2	6.44	7.11	6.7
Area 10 Ubon Ratchathani	7.68	7.67	9.18	9.55	9.33	8.27
Total Northeastern	6.09	6.49	7.37	7.82	8.01	7.49

provinces, such as Mahasarakham, there are no standard node or peripheral hospitals that can perform CT scans or provide rtPA. Meanwhile, the incidence is often higher in the surrounding districts than in the capital district.

For best outcomes, rtPA must be administered within 270 minutes of the onset and number needed to treat depends on the door-to-needle time every 90 minutes⁽⁹⁾. Mortality at 1 year has been shown to increase with every 15-minute increase in door-to-needle duration⁽¹⁰⁾.

Many districts in our study appeared to show little association between the incidence of acute ischemic stroke and rtPA access rates. Many lacked quick access to CT scans and rtPA treatment as they were. These more distant areas had lower rtPA access rates compared to the Mueang districts and their adjacent areas, such as Phayakkhaphum Phisai hospital. Another possible reason is acute minor strokes do

Table 4. rtPA access rate (%) in cerebral infarction (Main Universal Coverage Scheme) in each province of Northeastern Thailand

Province	2017	2018	2019	2020	2021	2022
	%	%	%	%	%	%
Khon Kaen	10.06	8.91	10.16	11.33	9.95	9.87
Maha Sarakham	7.35	8.66	7.1	10.73	11.72	9.79
Roi Et	6.22	6.59	5.99	7.73	8.58	8.65
Kalasin	7.47	8.36	7.74	9.09	9.78	7.64
Udon Thani	8.05	8.44	6.74	5.39	6.76	6.17
Loei	5.28	4.3	5.32	5.96	3.55	6.61
Sakon Nakhon	3.75	6.55	6.21	5.38	5.01	5.78
Bueng Kan	4.26	8.45	7.83	7.87	10.99	6.36
Nong Bua Lam Phu	5.61	6.27	7.67	6.97	4.08	6.37
Nong Khai	5.26	5.19	3	4.31	6.29	5.59
Nakhon Phanom	3.41	7.2	14.06	13.23	12.17	11.44
Surin	4.54	5.69	6.38	6.79	7.83	8.05
Chaiyaphum	4.3	3.99	7.25	7.2	7.51	5.99
Nakhon Ratchasima	4.03	4.48	5.47	5.16	6.44	5.87
Buri Ram	5.01	4.93	6.63	7.9	7.47	7.31
Ubon Ratchathani	3.23	3.52	3.97	3.84	3.72	3.43
Yasothon	6.58	7.55	9.63	6.43	7.32	17.13
Mukdahan	13.96	12.38	17.21	19.68	18.68	9.73
Amnat Charoen	4.13	8.07	7.91	8.15	7.6	5.37
Si Sa Ket	13.53	12.19	14.44	16.8	18.16	12.52

Table 5. rtPA access rate (%) in cerebral infarction (Referral Universal Coverage Scheme) in Northeastern Thailand

Area	2017	2018	2019	2020	2021	2022
	%	%	%	%	%	%
Area 7 Khon Kaen	7.94	8.17	8.08	10.26	10.01	9.62
Area 8 Udonthani	5.55	6.75	7.11	6.34	6.42	6.61
Area 9 Nakhon Ratchasima	4.21	4.64	6.02	6.15	6.91	6.63
Area 10 Ubon Ratchathani	7.69	7.67	9.22	9.58	9.34	8.24
Total Northeastern	6.01	6.47	7.34	7.73	7.92	7.55

Table 6. rtPA access rate (%) in cerebral infarction (Referral Universal Coverage Scheme) in Northeastern Thailand

Province	2017	2018	2019	2020	2021	2022
	%	%	%	%	%	%
Khon Kaen	9.92	9.38	10.36	12.18	10.77	11.17
Maha Sarakham	6.18	7.9	6.49	10.31	10.49	9.29
Roi Et	6	6.57	5.99	7.97	8.62	9.11
Kalasin	7.37	7.96	7.36	8.12	9.18	6.81
Udon Thani	8.18	8.38	6.6	5.07	6.49	5.68
Loei	5.07	3.83	5.27	5.24	3.28	6.68
Sakon Nakhon	3.53	6.58	5.79	5.44	4.6	5.5
Bueng Kan	4.36	8.59	8.56	7.87	11.09	6.61
Nong Bua Lam Phu	5.36	7.44	8.46	6.51	3.7	6.55
Nong Khai	5.71	5.1	3.26	3.99	6.62	5.86
Nakhon Phanom	2.44	7.25	15.74	14.25	12.51	12.25
Surin	3.77	5.73	6.07	6.76	7.87	8.38
Chaiyaphum	4.13	3.53	6.62	6.13	6.34	5.42
Nakhon Ratchasima	3.86	4.38	5.3	4.69	6.3	5.84
Buri Ram	5.1	4.96	6.65	7.92	7.34	7.05
Ubon Ratchathani	2.7	3.08	3.77	3.71	3.57	2.99
Yasothon	6.31	8.1	8.71	3.76	5.53	17.55
Mukdahan	14.43	13.13	19.08	26.09	22.4	10.67
Amnat Charoen	4.24	8.15	7.26	6.98	7.41	4.63
Si Sa Ket	14.44	12.62	14.9	17.14	18.37	13.04

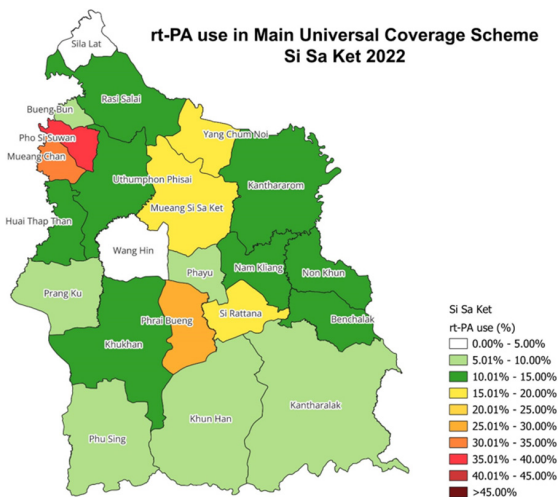


Figure 3. rtPA access rate (%) in each district in Si Sa Ket and Pho Si Suwan has the highest percentage in Northeastern Thailand.

not meet rtPA indications where they constitute the highest incidence among all acute ischemic strokes. For example, Rattanawapi Hospital, had one of the highest incidences of acute ischemic stroke in Nong Khai but a 0% rtPA access rate without mortality, suggesting the incidence of acute ischemic stroke is likely due to mainly non-disabling stroke diagnoses.

While there were hospitals with high incidence and rtPA access rates situated far from standard node or tertiary care

hospitals, such as Chiang Yuen hospital in Mahasarakham. There were also hospitals equipped with CT scans but were unable to administer rtPA, for instance, Suwannaphum hospital in Roi Et. This uneven access to services emphasizes the ongoing need for further development of stroke service systems. For example, these hospitals should be developed into standard node hospitals to ensure faster diagnosis and access to standard rtPA, to improve patients' quality of life and reduce stroke disability rates, consistent with the findings of Kennedy R Lees et al.⁽⁹⁾

Various factors affect mortality, including the disease itself, such as large territory infarction with brain herniation⁽¹¹⁾. Poorly controlled co-morbidities, complications from rtPA, and complications during treatment, such as hospital-acquired infections⁽¹²⁾, also

rt-PA use in Referral Universal Coverage Scheme
Yasothon 2022

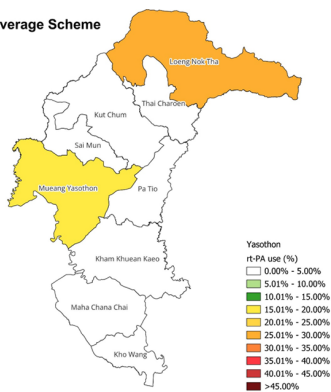


Figure 4. rtPA access rate (%) in each district in Yasothon and Loeng Nok Tha has the highest percentage in Northeastern Thailand.

Table 7. Mortality rate (%) in cerebral infarction within 30 days in Northeastern Thailand

Area	2017	2018	2019	2020	2021	2022
	%	%	%	%	%	%
Area 7 Khon Kaen	12.78	11.1	9.67	10.26	10.69	10.36
Area 8 Udonthani	9.01	8.18	8.58	8.64	8.55	9.02
Area 9 Nakhon Ratchasima	9.85	9.2	8.49	9.67	9.07	9.08
Area 10 Ubon Ratchathani	10.6	10.35	8.61	9.16	9.33	9.72
Total Northeastern	10.43	9.59	8.80	9.45	9.35	9.48

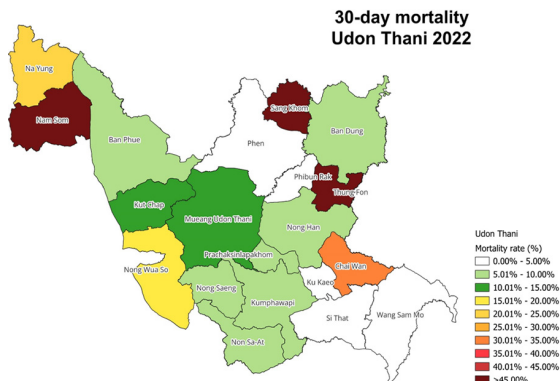


Figure 5. Mortality rate (%) in cerebral infarction within 30 days of each district in Udon Thani and Sang Khom has the highest percentage in Northeastern Thailand.

contribute to mortality. Some district hospitals, such as Thung Khao Luang hospital, exhibited a high incidence of acute ischemic stroke with a low rtPA access rate and a high mortality rate at day 30. This indicates a need for further study to identify the causes of this high mortality and its association with a low rtPA access rate. If there is an association, considerations should be given to stroke service team management, such as increasing the establishment of CT scan centers or improving training for rtPA receiving.

Table 8. Mortality rate (%) in cerebral infarction within 30 days in each province of Northeastern Thailand

Province	2017	2018	2019	2020	2021	2022
	%	%	%	%	%	%
Khon Kaen	14.03	12.33	10.59	11.16	10.68	12.01
Maha Sarakham	12.1	10.04	8.15	8.37	9.92	8.33
Roi Et	11.03	9.35	8.81	8.36	10.03	9.56
Kalasin	13.73	12.6	10.77	13.21	12.84	10.05
Udon Thani	9.88	8.37	9.03	9.23	8.34	10.26
Loei	9.99	7.96	8.9	8.72	8.38	8.56
Sakon Nakhon	7.91	8.42	8.28	8.56	7.26	7.79
Bueng Kan	9.06	7.71	9.77	7.85	10.87	9.27
Nong Bua Lam Phu	12.13	10.42	10.39	8.98	10.77	8.63
Nong Khai	6.96	7.49	8.16	7.68	8.14	8.95
Nakhon Phanom	8.76	7.92	7.2	8.94	9.85	9.88
Surin	9.68	11.11	8.82	10.63	8.86	9.78
Chaiyaphum	11.03	8.63	8.93	10.86	9.35	10.52
Nakhon Ratchasima	9.78	9	8.39	10.23	9.9	9.36
Buri Ram	9.23	8.3	8.13	7.51	7.76	7.27
Ubon Ratchathani	12.31	11.93	8.61	10.1	9.39	9.66
Yasothon	11.53	11.92	9.88	8.5	9.74	10.64
Mukdahan	11.26	8.45	9.69	10.08	8.33	8.51
Amnat Charoen	6.4	10.17	8.5	6.71	7.9	8.27
Si Sa Ket	10	9.04	8.53	9.47	10.65	10.86

In addition, the highest mortality rates were concentrated in the Mueang districts. In contrast, certain districts, such as Phlapphla Chai Hospital, had a high incidence and rtPA access rate, coupled with low mortality rates at day 30, and no mortality post-rtPA. These districts stand as exemplary models for the development of stroke service systems.

Further study is needed to address this study's limitations. Unfortunately, data from the NHSO database was not always complete; some lacked detailed patient information, including age of onset, comorbidities, stroke severity, causes of mortality and other significant details that could be associated with rtPA access rates and mortality rates. Thus, the present study cannot demonstrate a significant association or correlation between all data. However, we suggest our study has importance as a foundational database based on the best, but admittedly, limited data available for Northeastern Thailand stroke service system development. It also provides guidance for further studies on this growing priority issue at both individual stroke patient and service delivery system levels.

Climate change is an important global issue. The current study suggests an association with stroke incidence⁽⁸⁾. Therefore, studying the association between these factors and the incidence of stroke in Northeastern Thailand is one of many interesting issues that should be further studied.

Lastly, mechanical thrombectomy is emerging as a standard treatment in large vessel atherosclerosis. The first

Table 9. Mortality rate (%) in cerebral infarction post-rtPA of Northeastern Thailand

Area	2017	2018	2019	2020	2021	2022
	%	%	%	%	%	%
Area 7 Khon Kaen	2.46	3.65	2.59	2.7	2.78	3.16
Area 8 Udonthani	2.57	1.47	3.16	3.83	4.53	4.26
Area 9 Nakhon Ratchasima	6.99	7.25	5.91	7.01	6.63	7.95
Area 10 Ubon Ratchathani	2.84	3.69	3.12	4.63	5.63	6.87
Total Northeastern	3.65	4.02	3.76	4.53	4.91	5.67

Table 10. Mortality rate (%) in cerebral infarction post-rtPA in each province of Northeastern Thailand

Province	2017	2018	2019	2020	2021	2022
	%	%	%	%	%	%
Khon Kaen	1.94	2.38	2.73	2.44	0	3.87
Maha Sarakham	3.92	1.16	4.05	0.76	3.88	2.99
Roi Et	3.7	7.14	2.06	3.15	7.91	3.43
Kalasin	1.47	5.56	1.35	6.25	2.22	0
Udon Thani	2.99	1.3	2.42	1.74	1.55	4.7
Loei	3.92	0	6.56	4.76	2.63	8.97
Sakon Nakhon	4.65	2.3	5.13	2.53	4.48	1.12
Bueng Kan	0	0	0	0	5.88	6.06
Nong Bua Lam Phu	0	0	0	6.25	8.7	0
Nong Khai	0	0	4	0	6.25	2.27
Nakhon Phanom	0	5.41	2.52	7.69	6.48	4.76
Surin	3.57	10.31	3.92	6.56	4.93	7.28
Chaiyaphum	3.23	1.75	9.38	3.49	2.5	6.86
Nakhon Ratchasima	9.85	9.71	7.91	11.43	9.36	11.81
Buri Ram	7.59	2.35	1.56	3.87	5.85	4.27
Ubon Ratchathani	3.77	1.49	2.35	2.25	10.59	3.57
Yasothon	0	8.7	2	3.13	4.35	1.86
Mukdahan	2.27	0	0	2.94	2.33	6.25
Amnat Charoen	0	2.94	3.23	0	0	7.41
Si Sa Ket	3.45	4.15	4.58	6.58	6	13.14

positive trial published was MR CLEAN⁽¹³⁾. This is also an important subject for further research in Northeastern Thailand.

Conclusion

Our results showed stroke incidence increased over the 5 years in Northeastern Thailand as did the number of acute ischemic stroke patients receiving rtPA. The mortality rate in patients with acute ischemic stroke within 30 days declined from 2017 to 2019, but then increased from 2020 to 2022. Particularly noteworthy is the significant increase in the mortality rate post-rtPA treatment.

What is already known on this topic?

Our study has already shown some correlation

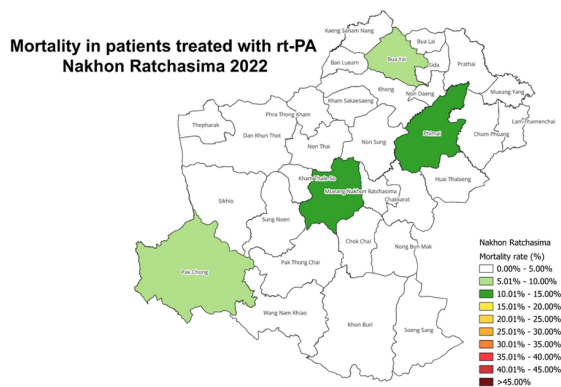


Figure 6. Mortality rate (%) in cerebral infarction post-rtPA of each district in Nakhon Ratchasima and Phimai and Mueang Nakhon Ratchasima had the highest percentage in Northeastern Thailand.

between district region and stroke incidence or rtPA access rate and mortality rate, but these are not statistic association. More importantly, our study has shown importance as a foundational database based on the best. It also provides guidance for further studies on this growing priority issue at both individual stroke patient and service delivery system levels.

What this study adds?

Patient information, including age of onset, comorbidities, stroke severity, causes of mortality and other significant details that could be associated with rtPA access rates and mortality rates.

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Conflicts of interest

The authors declare no conflict of interest.

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