The Canadian Journal of Neurological Sciences (2025), 1–11
doi:10.1017/cjn.2025.10460

Canadian Journal of Neurological Sciences
Journal Canadien des Sciences Neurologiques

Original Article

The First Eight Years of the Manitoba TeleStroke Program: An Observational Study

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ABSTRACT: ***Background:*** Rural areas are often challenged in delivering time-sensitive hyper-acute stroke care. TeleStroke can improve access to time-sensitive reperfusion therapies. We aimed to evaluate our experience with TeleStroke and to explore if it facilitates reperfusion therapy in patients with acute ischemic stroke (AIS). ***Methods and analysis:*** The Manitoba TeleStroke Program was rolled out across seven sites between November 2014 and January 2019. We retrospectively included consecutive patients with suspected AIS within 4.5 hours of onset, between November 2014 to December 2022. Demographic data, process metrics, and outcome measures were collected. The primary outcome was safety and efficacy measured in terms of 90-day modified Rankin score (mRs). A descriptive and analytical analysis was performed. ***Results:*** Of the 1,748 TeleStroke patients (median age 71 years, female 810 [46.3%]), 696 (39.8%) were identified as AIS. Of these, 265 (38.1%) received intravenous thrombolysis. Ninety-day mortality was 53 (20.0%) among those receiving thrombolysis and 117 (44.2%) had a favorable outcome of mRs≤2. Among patients receiving thrombolysis, nine (3.4%) had a symptomatic intracranial hemorrhage. Arrival by ambulance occurred in 1115 (63.8%) cases, median last-seen-normal-to-door time was 121 minutes, and median door-to-needle time was 55 minutes. When comparing "AIS-without thrombolysis" and "AIS with thrombolysis," the median last-seen-normal-to-door was 210 versus 90 minutes ($p < 0.001$); and the median door-to-CT scanner was 24 versus 22 minutes ($p = 0.009$). ***Conclusion:*** Intravenous thrombolysis for patients with AIS was found to be effective and safe in the Manitoba TeleStroke Program. Lessons learnt from our study will help improve the TeleStroke program in Manitoba and beyond.

RÉSUMÉ: Les huit premières années du programme TeleStroke au Manitoba : résultats d'une étude d'observation. ***Contexte :*** Les régions rurales font souvent face à la nécessité de fournir de toute urgence des soins à des patients en phase critique pour des accidents vasculaires cérébraux (AVC). Le programme TeleStroke permet d'améliorer l'administration sans délai de traitements de reperfusion. L'étude visait à évaluer l'expérience du programme TeleStroke, et à examiner si celui-ci facilitait le traitement de reperfusion chez les patients ayant subi un AVC ischémique aigu. ***Méthode et analyse :*** Le programme TeleStroke au Manitoba a été mis sur pied dans 7 centres, entre novembre 2014 et janvier 2019. Ont été sélectionnés de manière rétroactive des patients consécutifs, chez qui était soupçonnée la présence d'un AVC ischémique aigu, dans les 4,5 heures suivant l'apparition des symptômes, et ce, de novembre 2014 à décembre 2022. Ont été recueillis des données démographiques, des indicateurs de processus et des mesures de résultats. Le principal critère d'évaluation était la sûreté et l'efficacité des interventions, mesurées en fonction du score sur l'échelle de Rankin modifiée (ERM) au bout de 90 jours. L'équipe de recherche a procédé à une analyse descriptive et analytique. ***Résultats :*** Sur 1748 patients traités dans le cadre du programme TeleStroke (âge médian : 71 ans; femmes : 810 [46,3 %]), 696 (39,8 %) avaient subi un AVC ischémique aigu. De ce nombre, 265 (38,1 %) ont été soumis à la thrombolyse intraveineuse. La mortalité au bout de 90 jours chez ces derniers était de 53 (20,0 %), et 117 (44,2 %) ont connu une issue favorable, leur score sur l'ERM étant ≤ 2. Parmi les patients soumis à la thrombolyse, 9 (3,4 %) ont subi une hémorragie intracrânienne symptomatique. Par ailleurs, 1115 patients (63,8 %) sont arrivés en ambulance, le temps médian écoulé entre la dernière fois où les patients avaient été vus dans un état normal et l'arrivée au service des urgences (SU) était de 121 minutes, et le temps médian écoulé entre l'arrivée au SU et l'injection du thrombolytique était de 55 minutes. Dans les comparaisons entre les « AVC ischémiques aigus sans thrombolyse » et les « AVC ischémiques aigus avec thrombolyse », le temps médian écoulé entre la dernière fois où les patients avaient été vus dans un état normal et l'arrivée au SU était de 210 minutes contre [c.] 90 minutes ($p < 0{,}001$) et le temps médian écoulé entre l'arrivée au SU et la tomodensitométrie était de 24 minutes c. 22 minutes ($p = 0{,}009$). ***Conclusion :*** La thrombolyse intraveineuse administrée dans le cadre du programme TeleStroke au Manitoba chez des patients ayant subi un AVC ischémique aigu s'est révélée sûre et efficace. Les leçons tirées de l'étude aideront à améliorer le programme TeleStroke au Manitoba, voire plus loin.

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Cite this article: Alcock S, Ayroso M, Leung YS, Blackwood B, Marin R, Huang B, Alcock A, Trivedi R, Ghrooda E, Singh N, Trivedi A, McMillan D, and Shankar J. The First Eight Years of the Manitoba TeleStroke Program: An Observational Study. *The Canadian Journal of Neurological Sciences*, https://doi.org/10.1017/cjn.2025.10460

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Keywords: stroke; tissue plasminogen activator; quality of care

(Received 17 May 2025; final revisions submitted 3 September 2025; date of acceptance 9 October 2025)

Highlights

- Intravenous thrombolysis for acute ischemic stroke was found to be effective with acceptable safety.
- The Manitoba TeleStroke Program played an important role in identifying patients eligible for intravenous thrombolysis and endovascular thrombectomy.
- We hope more experience with TeleStroke will further facilitate best practice stroke care in our program.

Introduction

In Canada, stroke is the leading cause of adult disability, with approximately 878,000 Canadians living with the effects of stroke.[1] A stroke occurs every five minutes in Canada, which highlights the magnitude of stroke and the need for organized care.[2] Hyperacute stroke care addresses the critical first steps to deliver timely reperfusion therapy, which includes intravenous thrombolysis (tissue plasminogen activator [tPA] and tenecteplase [TNK]) and endovascular therapy (EVT). The mantra "time is brain" guides care during this phase. Although organized stroke systems have revolutionized acute stroke care, geographical disparities remain in Canada. TeleStroke programs can help narrow this gap.

TeleStroke is a system of care that links a referring site and consulting site to provide real-time assessment and management of stroke patients. TeleStroke uses telecommunication technology in the form of real-time video conferencing and rapid transmission of brain CT images. A TeleStroke stroke-neurologist provides guidance in patient stabilization and eligibility assessment for thrombolysis and EVT. The onsite TeleStroke team implements the best practice hyperacute stroke care[1] at the referring site, which includes pre-hospital protocols, by-pass protocols, stroke protocols for the emergency department (ED), and time-driven protocols for diagnostic services.

The safety, feasibility, and efficacy of TeleStroke have been well established.[3–7] Studies[8–11] have found no increased risk of mortality or symptomatic intracranial hemorrhage (sICH) associated with TeleStroke when compared to in-person care, and stroke guidelines[1,12,13] endorse its use. In Canada, Ontario was the first province to utilize TeleStroke in 2002.[14] The Manitoba TeleStroke Program was initiated in 2014, and the aim of our study was to evaluate the process metrics and outcomes of this program.

Methods

The study was approved by the institutional research ethics board (HS25492[H2020:163]), the hospital research office (SH2022:092), and the provincial health research privacy committee (P2022-89).

Research design

This study used a retrospective cohort design. We hypothesize that the implementation of the Manitoba TeleStroke Program provided safe and effective best practice stroke care in the Province of Manitoba.

Manitoba TeleStroke program implementation

Our province is largely rural with one provincial comprehensive stroke center (CSC) (Figure 1) and eight CT scanner-capable hospitals in rural areas, with a distance range of 68 to 760 km from the CSC. In 2011, the provincial stroke strategy was created to establish TeleStroke at every CT scanner-capable rural hospital. Under a hub and spoke model, seven TeleStroke sites were established in rural Manitoba over the span of five years.

Seven TeleStroke sites were implemented between 2014 and 2019, by using the Donabedian structure-process-outcome framework, which suggests that the three domains are linked and should be evaluated as a whole[15] (Figure 2). Structure elements included equipment needed for TeleStroke, written stroke protocols and education, which primarily affect processes of care. The process domain, which relies on structural elements to provide the necessary resources for quality care, focused on measuring the stroke care delivered at the TeleStroke site and used key quality indicator process metrics.[16] Outcomes, which are linked to structures and processes of care, focused on evaluating patient and system outcomes.

The Manitoba TeleStroke Program is comprised of a *hub* (the provincial CSC) and seven *spokes* (TeleStroke sites) (Figure 1). The Hub started with six (now ten) neurologists with stroke expertise who are on call 24/7. At the CSC, the neurologist uses a Telehealth laptop after hours to perform a neurological consultation. All TeleStroke sites utilized the same implementation process. The steps are described in Table S1.

Stroke protocol

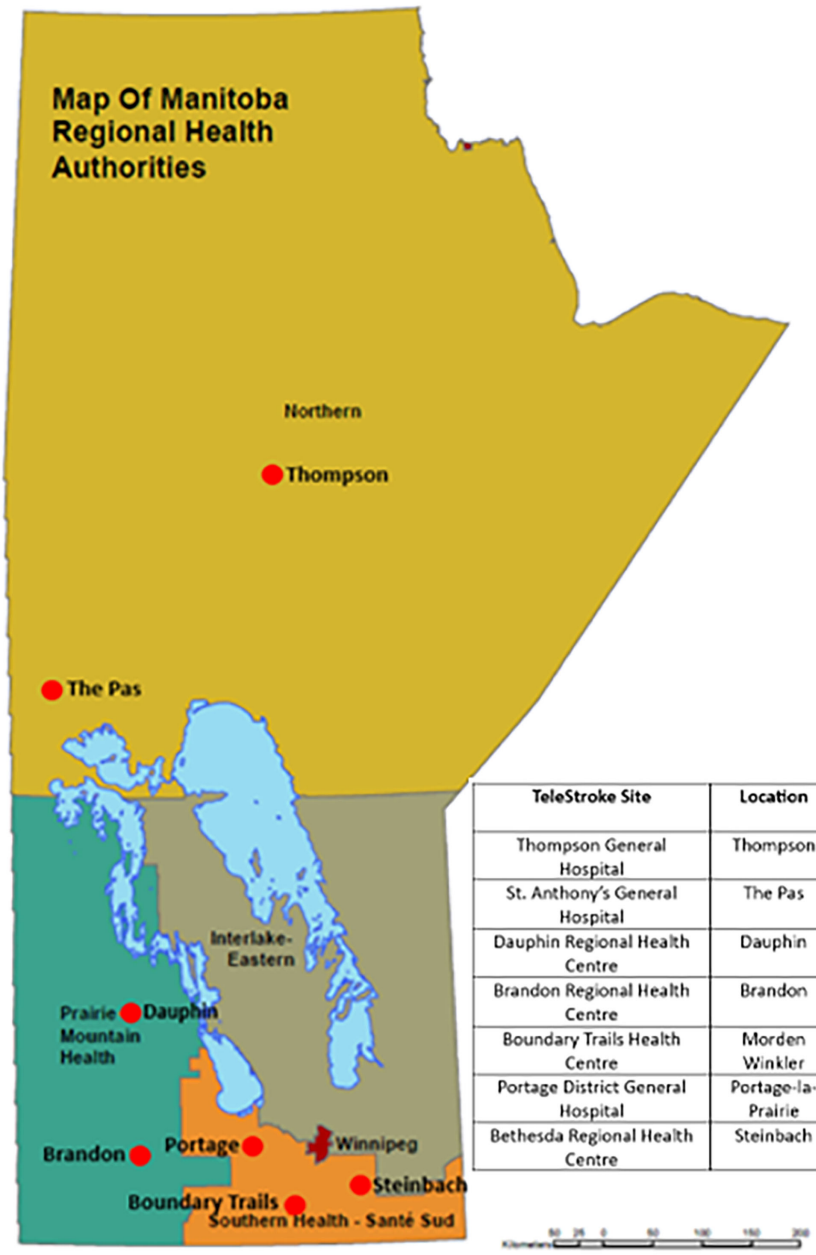
A detailed operational process of the stroke protocol pathway is illustrated in Figure 3. The process typically began with EMS (paramedic services) pre-notifying the TeleStroke center (triage nurse) about the patient's estimated time of arrival. This pre-notification is a critical step in the management of stroke patients, as it allows the receiving medical facility time to prepare for the arrival of the patient, ensuring that resources such as the stroke team and equipment are ready. Video conferencing between the site and the TeleStroke neurologist's laptop was facilitated over a secure VPN network managed by MBTelehealth.

Data collection

Clinical data were collected from the TeleStroke Consultation form and missing data were collected from the patient electronic medical record when available. All imaging times (including CT and CTA start time) were gathered from the provincial picture archiving and communication system.

Demographic variables included site, index event, last seen normal (LSN) time, age, sex, where the stroke occurred, if the participant arrived by EMS (yes/no), stroke risk factors (hypertension, atrial fibrillation, obesity, excess alcohol use, migraine, diabetes, congestive heart failure, sleep apnea, smoking, hypocoagulable state, hyperlipidemia, coronary artery disease, carotid disease, peripheral vascular disease and prior stroke or transient ischemic attack [TIA]), median blood pressure on arrival, arrival

https://doi.org/10.1017/cjn.2025.10460 Published online by Cambridge University Press



TeleStroke Site	Location	Distance to HSC	TeleStroke start date
Thompson General Hospital	Thompson	760 km	November 2014
St. Anthony's General Hospital	The Pas	623 km	April 2015
Dauphin Regional Health Centre	Dauphin	327 km	May 2016
Brandon Regional Health Centre	Brandon	214 km	August 2016
Boundary Trails Health Centre	Morden Winkler	119 km	January 2019
Portage District General Hospital	Portage-la-Prairie	86 km	January 2019
Bethesda Regional Health Centre	Steinbach	68 km	January 2019

Figure 1. Manitoba TeleStroke program site map with regional health authorities and TeleStroke sites.

National Institute of Health Stroke Scale (NIHSS) when found on the consultation form and reason thrombolysis was not given for patients who did not receive thrombolysis.

To evaluate the transactional practitioner/patient interaction that occurred when providing care, process metrics were collected.[17] This could identify gaps between expected care and actual care. Several time points were collected to obtain stroke process metrics: 1) door to consult, time interval between ED arrival to consult start time; 2) door to CT, time interval between ED arrival to first slice of CT; 3) CT to CTA, time interval between first slice of CT and first slice of CTA; 4) CT to needle, time interval between first slice of CT to time of tPA bolus; 5) door to needle (DTN), time interval between ED arrival to tPA bolus time; 6) LSN to door, time interval between patient LSN to ED arrival; 7) LSN to needle, time interval between LSN to tPA bolus time and 8) LSN to consult, time interval between LSN and consult start time).

The proportion of patients who received a CT scan within 15 minutes of arrival and the proportion of patients who received tPA within 30 minutes of arrival (DTN $\leq$ 30 minutes) and within 60 minutes of arrival (DTN $\leq$ 60 minutes) were calculated. To better understand process metrics, we also compared all process metrics between patients with AIS who received tPA [AIS with tPA] versus patients with AIS who did not receive tPA [AIS without tPA].

Outcome measures evaluated both system outcomes and patient outcomes. System outcomes included access to care, such as TeleStroke consultation volumes and the proportion of

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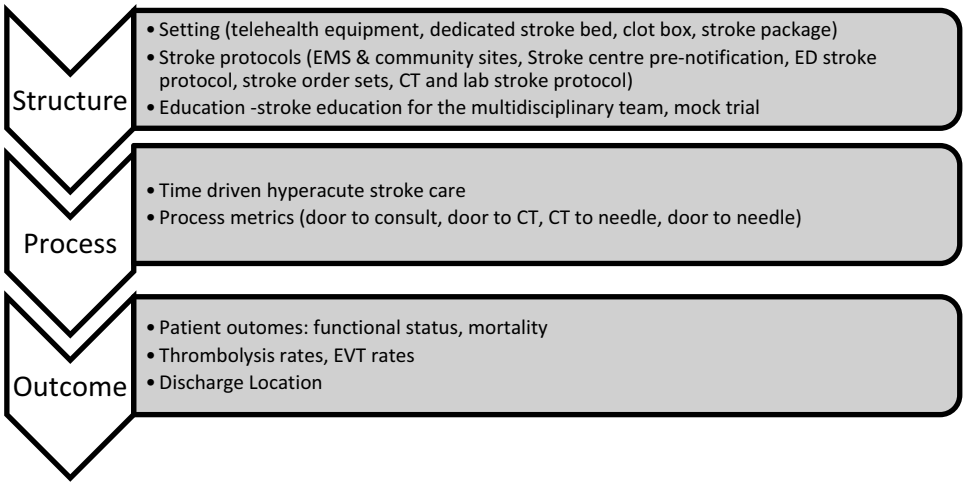


Figure 2. Adapted structure, process and outcome framework for the Manitoba TeleStroke program for each of the TeleStroke sites.

confirmed acute ischemic stroke (AIS) patients treated through TeleStroke who received tPA and or EVT. Patient outcomes, which reflect a change in health status, were assessed using 90-day mRs, mortality, sICH rate (as reported in the patient electronic record) and discharge location from the TeleStroke site.

Statistical analysis

The data parameters included demographic data, patient evaluation data, comorbidities, process metrics and outcome metrics. Demographic data were analyzed using descriptive summary statistics. Discrete variables, such as sex, and the presence/absence of various stroke risk factors were reported with frequency distributions and percentages. Continuous data, such as age and patient treatment time intervals, were reported by median and inter-quartile range. All variables were compared between AIS patients who *did* or *did not* receive tPA. Pearson's chi-square test for independence was used to analyze differences between groups, and Mann–Whitney U tests were conducted to non-parametrically compare continuous variables.

The Mann-Kendall test (null hypothesis equaling no monotonic change over time) was used to determine if process metrics changed over the study period. When the data were not normally distributed, a nonparametric test was used to assess for a monotonic trend. A significant p-value ($p < 0.05$) indicates the presence of a statistically significant monotonic trend. All[18] statistical analyses were conducted using R (version 4.3.2 in RStudio using the tidyverse package).

Results

A total of 1,748 TeleStroke consultations occurred between November 2014 and December 2022 (see Table 1). Demographic and clinical characteristics can be found in Table 1, along with a between-group comparison of those who did and didn't receive tPA. There were 696 cases (39.8%) identified as AIS, 296 cases (16.9%) identified as TIAs and 129 as hemorrhagic strokes (7.4%). The median age of patients evaluated by TeleStroke was 71 years, and 46.3% were female. "AIS with tPA" had a significantly higher median baseline NIHSS as compared to "AIS without tPA" (8[6–14] vs. 4[2–8], $p < 0.001$). The most common comorbidity among all patients was hypertension (1092, 62.3%). Although the numbers are small, those with a history of hypertension, diabetes and previous stroke or TIA were more likely not to receive thrombolysis. Most strokes occurred in the community (1618, 92.6%); however, (98, 5.6%) occurred in hospital. Most patients (1115, 63.8%) arrived by ambulance. A significantly longer median LSN-to-door time was found in the "AIS without tPA" group versus the "AIS with tPA" group (210mins [104–482] vs. 90mins [50–140], $p < 0.001$). Only 26.5% of TeleStroke consultations occurred during business hours (0800-1700 Monday–Friday). The three most common reasons among all study patients for not receiving tPA were as follows: 1) minor deficits (28.7%); 2) out of window (18.6%) and 3) not a stroke (17.0%). The two most common stroke mimics were seizures (6.3%) and migraine headache (4.8%) (S2).

Figure 4 illustrates the proportion of cases of "AIS with tPA," the proportion of "AIS without tPA" and the proportion of non-AIS within the study population.

Process metrics (Table 2)

The median door-to-CT time was reduced by 9 minutes for those who arrived by EMS as compared to those who self-presented (22[16–33] vs. 31[21–46], $p < 0.001$). Longer door-to-CT was observed in the "AIS without tPA" cohort as compared to the "AIS-with-tPA" cohort (22[15–31] vs. 24[18–34], $p = 0.009$). There was also a significantly longer median CT-to-CTA time for "AIS with tPA" versus "AIS without tPA," (7[3–44] vs. 5[3–23], $p = 0.014$.

The proportion of cases with a door-to-CT ≤ 15 minutes was significantly less than in the "AIS-without-tPA" cohort as compared to the "AIS-with-tPA" cohort (60[22.6] vs. 70[16.2], $p = 0.035$.

The proportion of patients who received tPA within 30 minutes of arrival (DTN ≤ 30 minutes) was 7.4%, and within 60 minutes of arrival, it was 58.4%, see Table 2. Compared to patients who self-presented, when patients arrived by EMS, the median DTN was reduced by 12 minutes. For those AIS patients who were transferred to HSC for EVT ($n = 55$), the median door-in-door-out time was 2 hours 8 minutes.

Outcomes metrics

The number of TeleStroke consultations that received tPA and EVT is shown in Figure 5a, and the number of AIS who received tPA or received EVT is shown in Figure 5b.

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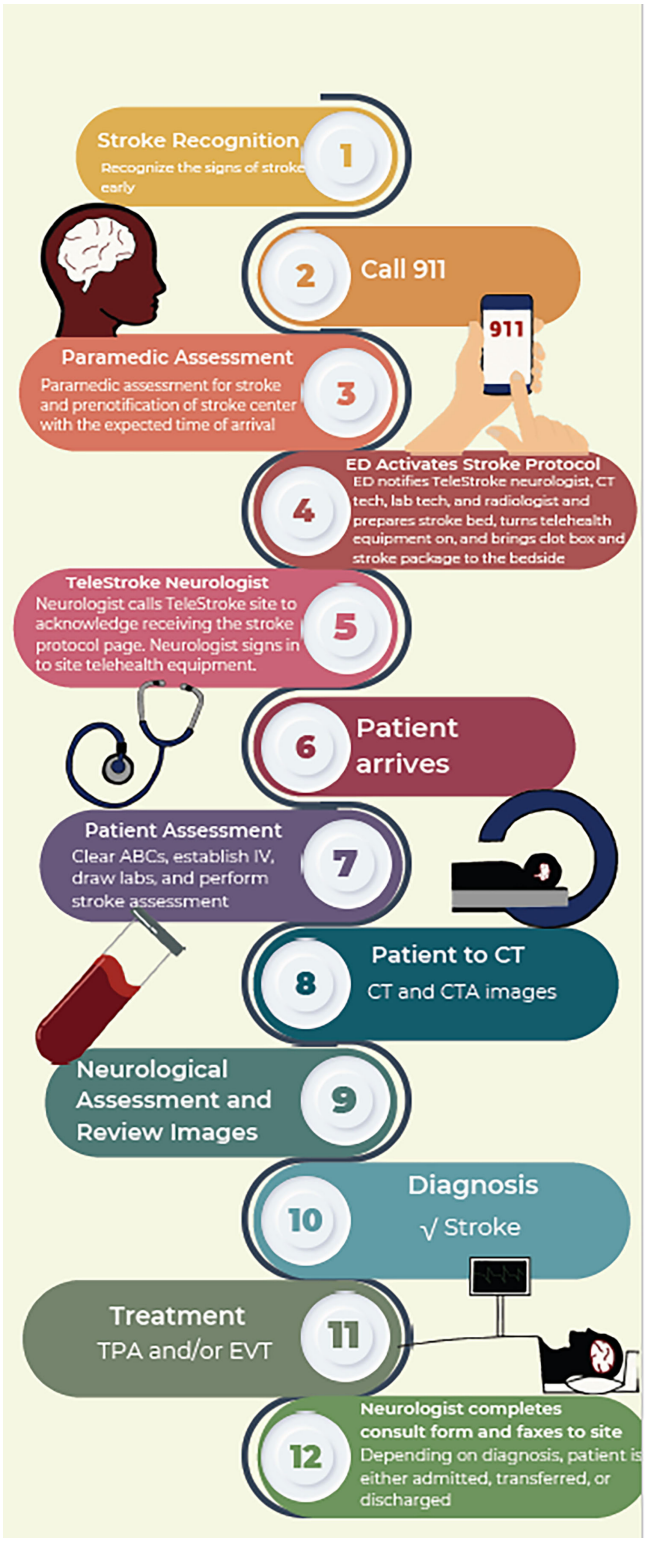


Figure 3. TeleStroke site stroke protocol workflow.

The median length of stay at the TeleStroke site was 7 hours and 55 minutes, with 877 (50.2%) being discharged home, and 167 (9.6%) transferred to our CSC for further stroke treatment or other types of tertiary care (Table 3).

The 90-day mortality among all TeleStroke consults was 12.5%, whereas the 90-day mortality among "AIS with tPA" was 20.0%, and the 90-day for "AIS without tPA" was 16.0%.

The sICH rate for those who received tPA was 3.4%.

TeleStroke consult volumes increased progressively during 2015 to 2022 ($p = 0.002$), as did treatment rates for tPA administration ($p = 0.003$) and EVT procedures ($p = 0.027$) (Figures 6 and 7). Furthermore, arrival by ambulance significantly increased over time ($p = 0.001$) (Figure 7). Interestingly, process metrics did not significantly change over time (Figure 7).

Discussion

Our study found that intravenous thrombolysis for AIS within the context of the Manitoba TeleStroke Program was effective with an acceptable safety profile. Furthermore, the number of patients cared for by the TeleStroke program significantly increased over time (Figure 6); this was expected as more centers joined the network and more healthcare workers were aware of stroke and the TeleStroke service. Additionally, the significant increase in tPA rates, EVT rates and EMS arrival also reflected the overall improvement of care through the TeleStroke program (Figure 7). Even though treatment rates plateaued, as consult rates continued to rise, this was felt to be a positive outcome. TeleStroke has not just improved care for the acute ischemic stroke patients, but for all patients with neurological complaints in rural Manitoba by streamlining their referral to the neurological specialties.

Among the 265 patients who received tPA, the 90-day mortality rate was recorded at 20.0%. This was similar to what has been reported by the Ontario TeleStroke Program 22.0%[19] and by the Northern Alberta TeleStroke Program 22.5%.[20] In patients who received tPA ($n = 265$), a favorable outcome (mRs 0–2) was achieved in 44.2%. This outcome aligns closely with findings from other studies[19,20] and could be due to careful patient selection by the TeleStroke neurologist.

Regarding safety, the sICH in those who received intravenous thrombolysis was 3.4%. This is consistent with rates reported by others[19,20] as TeleStroke is reported not to be associated with an increase in sICH rate when compared to in-person evaluation by a neurologist.[8–10]

Discharge location can provide additional insight into outcomes. "Home" was the discharge location for 50.2% of TeleStroke consults. Interestingly, significantly more "AIS without tPA" (41.8%) were discharged home compared to "AIS with tPA" (27.2%), likely due to the lower severity of strokes in the non-tPA cohort. Overall, these findings underline the effectiveness and safety of the Manitoba TeleStroke Program in managing acute stroke patients.

Identifying eligible tPA and EVT patients

The Manitoba TeleStroke Program played an important role in identifying patients eligible for tPA and EVT in rural Manitoba. Among all TeleStroke consultations, 15.2% received tPA and 2.7% EVT, whereas among AIS patients seen by TeleStroke, 38.1% received tPA and 6.9% had EVT at our CSC. Furthermore, over time, treatment rates for tPA and EVT significantly increased. Our study provides valuable insight into TeleStroke program treatment rates since comparative data are sparse across Canadian provinces.

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Table 1. Demographics and clinical characteristics of total TeleStroke patients and of acute ischemic stroke patients who received tPA as compared to those who did not receive tPA during the study period (November 2014 to December 2022)

	Total ($n = 1748$)	AIS with tPA ($n = 265$)	AIS without tPA ($n = 431$)	*P* value
Female, *n* (%)	810 (46.3)	116 (43.8)	181 (42.0)	0.645
Age[a], median (IQR1-3), *y*	71 (58–81)	72 (61–80)	74 (63–82)	0.105
18–64 (%)	646 (37.0)	89 (33.6)	117 (27.1)	0.071
65–80 (%)	648 (37.1)	112 (42.3)	181 (42.0)	0.944
80+ (%)	452 (25.9)	64 (24.2)	133 (30.9)	0.056
Stroke occurred in:				
Community, *n* (%)	(1747) 1618 (92.6)	253 (95.5)	398 (92.3)	0.096
In hospital, *n* (%)	(1747) 98 (5.6)	8 (3.0)	28 (6.5)	0.043
Another hospital, *n* (%)	(1747) 31 (1.8)	4 (1.5)	5 (1.2)	0.736
Transfer from:				
Community hospital, *n* (%)	(1744) 189 (10.8)	(264) 29 (11.0)	47 (10.9)	0.967
Nursing station, *n* (%)	(1744) 17 (1.0)	(264) 1 (0.4)	6 (1.4)	0.202
Clinic, *n* (%)	(1744) 13 (0.7)	(264) 1 (0.4)	4 (0.9)	0.445
Personal care home, *n* (%)	(1744) 48 (2.8)	(264) 5 (1.9)	18 (4.2)	0.100
No transfer, *n* (%)	(1744) 1477 (84.7)	(264) 228 (86.0)	356 (82.6)	0.236
Arrived by EMS, *n* (%)	1115 (63.8)	191 (72.1)	285 (66.1)	0.101
On hours 0800–1700 (M-F) *n* (%)	464 (26.5)	71 (26.8)	118 (27.4)	0.866
LSN-to-Door, median (IQR), min	121 (65–214)	90 (50–140)	210 (104–482)	<0.001
Comorbidities				
Hypertension, *n* (%)	1092 (62.5)	163 (61.5)	298 (69.1)	0.040
AFib, *n* (%)	264 (15.1)	49 (18.5)	99 (23.0)	0.159
Obesity, *n* (%)	297 (17.0)	50 (18.9)	80 (18.6)	0.922
Excess ETOH, *n* (%)	49 (2.8)	8 (3.0)	14 (3.2)	0.883
Migraine, *n* (%)	71 (4.1)	9 (3.4)	8 (1.9)	0.216
Diabetes, *n* (%)	451 (25.8)	57 (21.5)	135 (31.3)	0.005
CHF, *n* (%)	98 (5.6)	20 (7.5)	35 (8.1)	0.775
Sleep apnea, *n* (%)	36 (2.1)	10 (3.8)	13 (3.0)	0.567
Smoking, *n* (%)	200 (11.4)	26 (9.8)	62 (14.4)	0.077
Hypocoagulable state, *n* (%)	7 (0.4)	1 (0.4)	2 (0.5)	0.850
Hyperlipidemia, *n* (%)	560 (32.0)	85 (32.1)	155 (36.0)	0.294
CAD/MI, *n* (%)	286 (16.4)	57 (21.5)	84 (19.5)	0.524
Carotid disease, *n* (%)	51 (2.9)	7 (2.6)	22 (5.1)	0.109
PVD, *n* (%)	1 (0.1)	1 (0.4)	0	0.189
Prior stroke or TIA, *n* (%)	254 (14.5)	29 (10.9)	82 (19.0)	0.005
Baseline NIHSS, median (IQR1-3)	(1579) 2 (0–7)	(247) 8 (6–14)	(400) 4 (2–8)	<0.001
Systolic BP, median (IQR1-3)	(1683) 155 (139–175)	(264) 154.5 (138–174)	(417) 156 (139–178)	0.354
Diastolic BP, median (IQR1-3)	(1682) 85 (76–95)	(264) 85 (78–96)	(417) 85 (77–94)	0.470
Systolic BP > 185, *n* (%)	(1683) 288 (17.1)	(264) 34 (12.9)	(417) 74 (17.7)	0.090
Diastolic BP > 110, *n* (%)	(1682) 99 (5.9)	(264) 20 (7.6)	(417) 20 (4.8)	0.133

(*Continued*)

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Table 1. Demographics and clinical characteristics of total TeleStroke patients and of acute ischemic stroke patients who received tPA as compared to those who did not receive tPA during the study period (November 2014 to December 2022) (*Continued*)

	Total ($n = 1748$)	AIS with tPA ($n = 265$)	AIS without tPA ($n = 431$)	*P* value
Discharge Diagnosis from Emergency Stroke *n* (%)				
TIA	295 (16.9)	1 (0.4)	0	
AIS	696 (39.8)	265 (100)	431 (100)	
ICH	102 (5.8)	0	0	
SAH	10 (0.6)	0	0	
SDH	12 (0.7)	0	0	
IVH	5 (0.3)	0	0	

[a]Two study participants were less than 18 years of age during index TeleStroke consult date; LSN = last seen normal; AFib = atrial fibrillation; CHF = congestive heart failure; CAD = coronary artery disease; PVD = peripheral vascular disease; TIA = transient ischemic attach; AIS = acute ischemic stroke; NIHSS = National Institute of Health Stroke Scale; BP = blood pressure; ICH = intracranial hemorrhage; SAH = subarachnoid hemorrhage; SDH = sub dural hemorrhage; IVH = intraventricular hemorrhage.

Table 2. Process metrics of total TeleStroke patients and of acute ischemic stroke patients who received tPA as compared to those who did not receive tPA during the study period (November 2014 to December 2022)

	Total ($n = 1748$)	AIS with tPA ($n = 265$)	AIS without tPA ($n = 431$)	*P* value
Door-to Consult, median (IQR), minutes[a]	(1085) 11 (5–25)	9 (4–20)	12 (5–30)	0.0515
Neurologist present on patient arrival (%)	524 (30.0)	90 (34.0)	128 (29.7)	0.239
Door-to-CT, median (IQR), minutes	(1378) 24 (17–37)	22 (15–31)	24 (18–34)	0.009
CT-to-CTA, median (IQR), minutes	(1419) 5 (3–15) (0–1305)	7 (3–44)	5 (3–23)	0.014
Door-to-CT time ≤15 minutes %	284/1378 (20.6)	60 (22.6)	70 (16.2)	0.035
CT-to-Needle, median (IQR), minutes	–	34 (24–48)	–	
Door-to-Needle, median (IQR), minutes	–	55 (43–77)	–	
Door-to-Needle time ≤30 minutes %	–	17/231 (7.4)	–	
Door-to-Needle time ≤60 minutes %	–	135/231 (58.4)	–	
LSN-to-Door, median (IQR), minutes	(1242) 121 (65–214)	90 (50–140)	210 (104–482)	<0.001
LSN-to-Consult, median (IQR), minutes	(1257) 125 (72–203)	100 (60–152)	156 (92–285)	<0.001
LSN-to-Needle, median (IQR), minutes	–	160 (120–215)	–	
DIDO, median (IQR), minutes	–	(55) 128 (99–157)	–	

[a]Two study participants were less than 18 years of age during index TeleStroke consult date; tPA = tissue plasminogen activator; AIS= acute ischemic stroke; IQR = inter-quartile range; CT = brain computed axial tomographic; CTA = CT angiogram; LSN = last seen normal; DIDO = door-in-door-out.

Longer LSN-to-door impact

We observed that patients with AIS with longer LSN-to-door times were less likely to receive tPA. Our median LSN-to-door was 121 minutes. This is similar to what was reported by Khan et al. in Northern Alberta[20] and likely reflects transport challenges associated with largely remote geography. We also found a significantly longer median LSN-to-door time for "AIS without tPA" (210 minutes) versus "AIS with tPA" (90 minutes), suggesting that patients who arrive late in the 4.5-hour thrombolytic window are less likely to receive tPA. This reflects the need for faster in-hospital processing for AIS patients presenting late in the thrombolysis window.

Longer door-to-CT time challenges

Longer door-to-CT times remain challenging, highlighting the need for improved workflow. Unfortunately, our median door-to-CT (24 minutes) was longer than the recommended 15 minutes[1] and we also found a significantly longer median door-to-CT time for "AIS without tPA" (24 mins) versus "AIS with tPA" (22 mins). Additionally, the proportion of patients with a door-to-CT within 15 minutes of arrival was significantly smaller (16.2% versus 22.6%) in the "AIS without tPA" cohort. By shortening the door-to-CT time, more AIS patients may potentially be eligible for thrombolysis. The median CT-to-CTA time was 5 minutes (range of 0–1305 minutes). The wide range of CT-to-CTA was attributed

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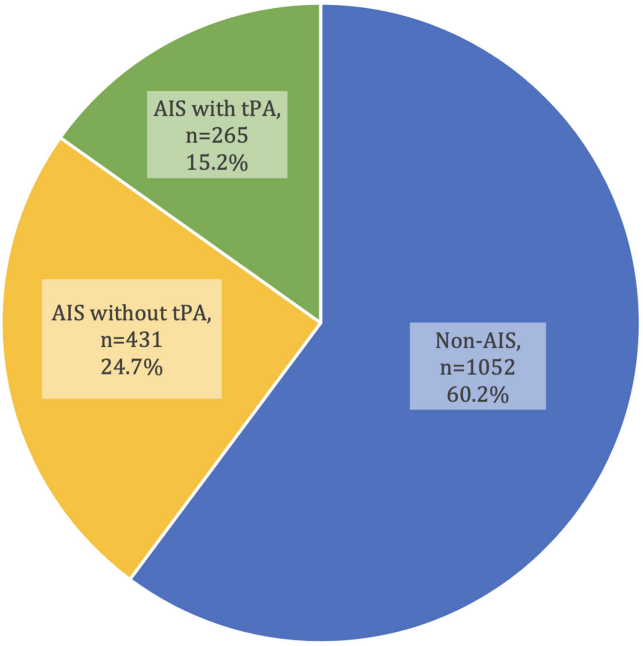


Figure 4. Proportion of "AIS with tPA," of "AIS without tPA" and of "non-AIS" within the study population.

to several factors: firstly, TeleStroke was initially used for assessing tPA eligibility only, and adoption of the program for EVT is evolving. Secondly, 26.5% of TeleStroke consultations occurred outside normal business hours when staffing for CT scanners becomes challenging. We hope that the identification of these challenges and more experience with TeleStroke will enhance best practice stroke care in our program and improve these gaps.

Door-in-door-out

Disparities between urban and rural access to EVT for stroke have been previously identified in our Province.[21] Door-in-door-out is an important metric for patients eligible for EVT. Our median door-in-door-out time was 2 hours 8 minutes for the 55 patients transferred to the CSC for EVT. The long door-in-door-out times for patients transferred to the CSC for EVT highlight ongoing challenges in optimizing access to stroke treatment, especially in rural areas. The debate about bypassing TeleStroke centers closer to the CSC is essential to continue improving workflow efficiency, decision-making processes and coordination between the TeleStroke sites and our EVT center.

Limitations

Due to the retrospective nature of the data collection, not all data variables were collected on all patients. The NIHSS evaluation was not always completed by the treating neurologist. Another study limitation is that the final ED diagnosis was sometimes unknown or unclear as to whether the patient actually had a stroke or not. This uncertainty could have impacted the final classification of cases as stroke or non-stroke diagnoses.

Conclusion

Intravenous thrombolysis for AIS patients was found to be effective with acceptable safety in the Manitoba TeleStroke Program. While the Manitoba TeleStroke Program has consistently increased access to best practice stroke care for patients in rural Manitoba, it has also improved general neurology care in rural Manitoba and lessons learned from our study will help improve the TeleStroke program in Manitoba and beyond.

Supplementary material. The supplementary material for this article can be found at https://doi.org/10.1017/cjn.2025.10460.

Acknowledgements. Financial support for this research was received from Heart and Stroke Foundation, Manitoba, Canada.

Author contributions. JS and SA – conceptualized the study, monitored the study conduct, analyzed the data and reviewed the final draft; SA – wrote the first draft of the study; MA and YSL – analyzed the data and reviewed the final manuscript; BB, RM, BH, AA and RT – collected data and reviewed the final manuscript; EG, NS, AT and DM – monitored the conduct of the study and reviewed the final manuscript.

Competing interests. JS has received grant as PI from Medtronic Canada, HSC Foundation, Heart and Stroke Foundation and CIHR. DM has received grant from HSC Foundation. Others – None.

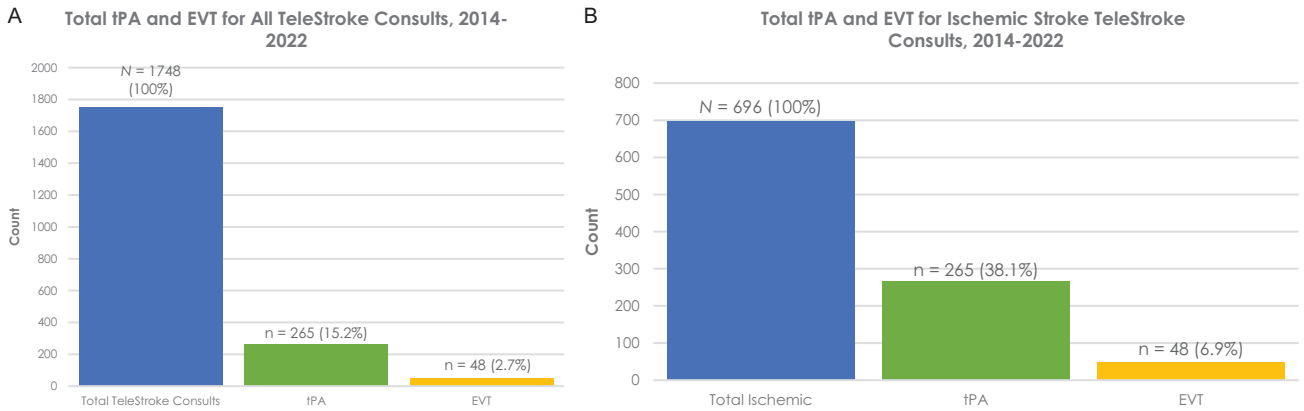


Figure 5. a) tPA administration and EVT procedures among all patients seen by TeleStroke and b) tPA administration and EVT procedures among acute ischemic stroke patients seen by TeleStroke.

Table 3. Outcomes of total TeleStroke patients and of acute ischemic stroke patients who received tPA as compared to those who did not receive tPA during the study period (November 2014 to December 2022)

	Total (*n* = 1748)	**AIS with tPA (*n* = 265)**	**AIS without tPA (*n* = 431)**	***P* value**
Access to Care:				
tPA cases, *n* (%)	265 (15.2)	265 (100)	N/A	–
EVT cases, *n* (%)	48 (2.7)	27 (10.2)	21 (4.9)	0.007
Patient Outcomes:				
Length of Stay, TeleStroke site, median (IQR), days	0.33 (0.11–2.72)	1.17 (0.09–4.76)	0.78 (0.13–6.18)	
Length of Stay, TeleStroke site, median (IQR), hr:min	7:55 (2:38–65:17)	28:05 (2:10–114:14)	18:43 (3:07–148:19)	0.091
Discharge Home from TeleStroke site, *n* (%)	877 (50.2)	72 (27.2)	180 (41.8)	<0.001
Transfer to HSC, *n* (%)	167 (9.6)	55 (20.8)	54 (12.5)	0.004
In hospital mortality, *n* (%)	114 (6.5)	28 (10.6)	35 (8.1)	0.275
7-day mortality, *n* (%)	119 (6.8)	30 (11.3)	31 (7.2)	0.061
90-day mortality, *n* (%)	218 (12.5)	53 (20.0)	69 (16.0)	0.179
sICH, *n* (%)	–	9 (3.4)	–	–
90-day mRs (fixed)				
0–2, *n* (%)	–	117 (44.2)	–	–
3–5, *n* (%)	–	64 (24.2)	–	–

AIS = acute ischemic stroke; tPA = tissue plasminogen activator; EVT = endovascular therapy; IQR = inter-quartile range; HSC = Health Sciences Centre (Winnipeg, Manitoba); sICH = symptomatic intracranial hemorrhage; mRs = modified Rankin scale.

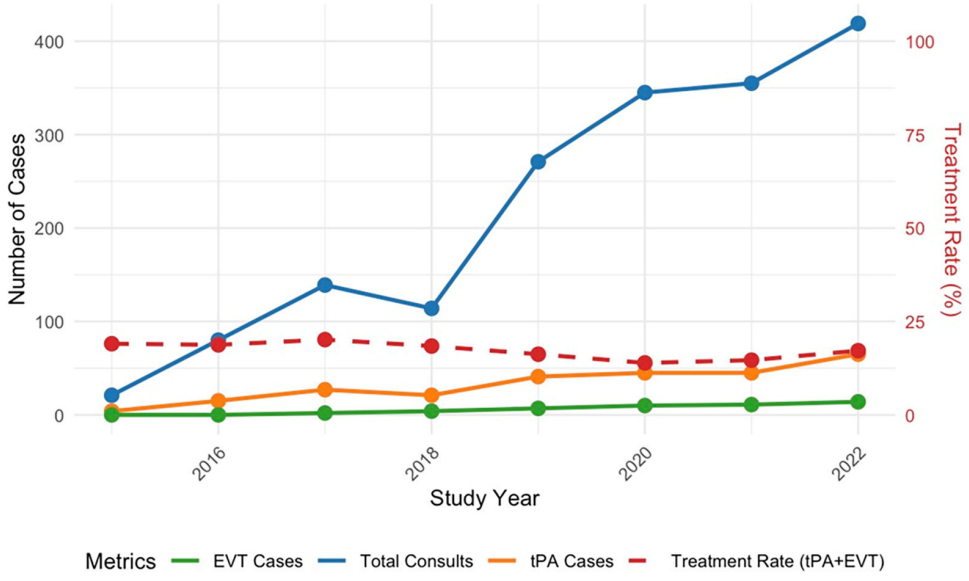


Figure 6. TeleStroke consult volumes and treatment rates over the study period.

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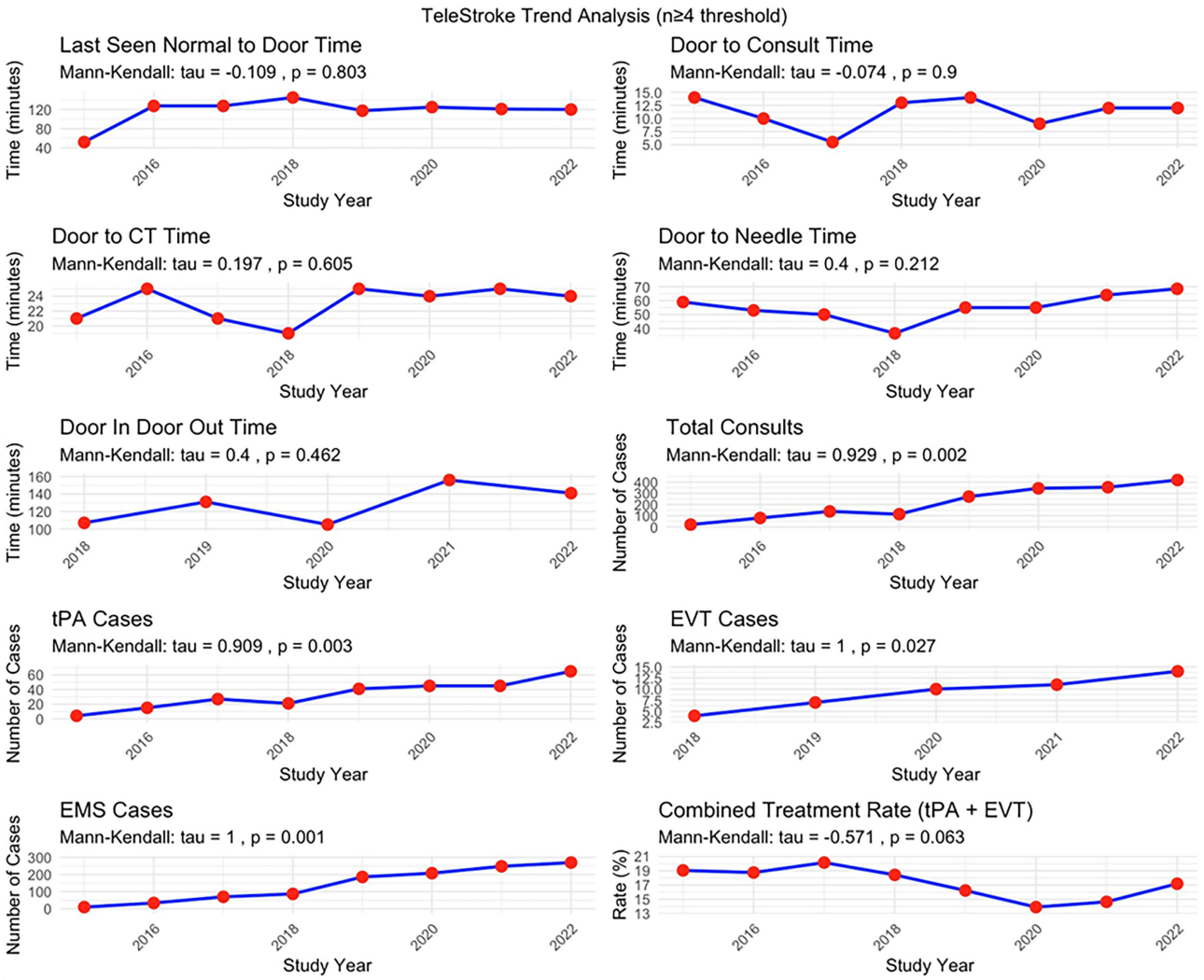


Figure 7. TeleStroke trend analysis of process metrics and treatment rates.

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