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Original Article

Exploring Differences in Stroke Treatment Between Urban and Rural Hospitals: A Thematic Analysis of Practices in Canada

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ABSTRACT: ***Background:*** Treatment of acute ischemic stroke is highly time dependent, which relies heavily on each hospital's ability and capacity. Designated stroke centers have been established across Canada, but there is still a divide between urban and rural hospitals. This study aims to understand the similarities and differences in their stroke treatment process workflow, incorporation of best practices and data collection. ***Methods:*** Interviews were conducted with clinicians in stroke centers across Canada to identify similarities and differences between provinces and hospital treatment capability. Semi-structured interviews were completed from September 15 to November 3, 2023, with clinicians and stroke coordinators using snowball and purposive sampling techniques. The interviews were analyzed using thematic analysis. ***Results:*** Fourteen participants were interviewed with representatives from four primary stroke centers and three comprehensive stroke centers across five provinces. Five primary themes were identified: 1) management of resources, 2) standardization of tasks, 3) data collection, 4) tool integration into workflow and 5) teamwork and experience. Participants in primary centers described limited resources to follow the patient through the entire treatment process, reliance on pre-notification times to prospectively search necessary patient information, using software to aid in calculating National Institute of Health Stroke Scale and being more cautious toward treating thrombolytics. Both center types discussed challenges with complete and accurate data collection. ***Conclusions:*** The overall stroke treatment process and information required across primary and comprehensive centers are similar. However, differences occur in the process due to limitations in resources, pre-arrival notification time, completeness and accuracy of data collected and comfort in treating with thrombolytics.

RÉSUMÉ : Explorer les différences dans le traitement des AVC entre les hôpitaux urbains et ruraux: une analyse thématique des pratiques au Canada. ***Contexte :*** Le traitement des AVC ischémiques en phase aiguë dépend fortement des délais d'accès à des soins, ainsi que de l'expertise et de la capacité de traitement de chaque hôpital. Des centres désignés pour les AVC ont été mis en place partout au Canada, mais il existe toujours un fossé entre les hôpitaux urbains et ruraux. Cette étude vise donc à comprendre les similitudes et les différences dans le flux opérationnel (*workflow*) qui concerne les trajectoires de traitement des AVC, mais aussi l'incorporation de meilleures pratiques et la collecte de données. ***Méthodes :*** Des entretiens ont été menés avec des cliniciens dans des centres de traitement des AVC dans l'ensemble du Canada afin d'identifier les similitudes et les différences entre les provinces et la capacité de traitement des hôpitaux. Des entrevues semi-structurées ont été réalisées du 15 septembre au 3 novembre 2023 avec des cliniciens et des coordonnateurs de l'AVC à l'aide de techniques d'échantillonnage en boule de neige et d'échantillonnage raisonné. Ajoutons aussi que les entretiens ont été analysés au moyen d'une analyse thématique. ***Résultats :*** Au total, quatorze participants ont été interrogés. Il s'agissait de représentants de quatre centres de soins primaires pour les AVC et de trois centres de soins complets pour les AVC présents dans cinq provinces. Cinq thèmes principaux ont été identifiés : 1) la gestion des ressources, 2) la normalisation des tâches, 3) la collecte de données, 4) l'intégration des outils dans le flux opérationnel et 5) le travail d'équipe et l'expérience. Les participants des centres primaires ont fait état de ressources limitées pour suivre les patients tout au long des trajectoires de traitement, du recours à des délais de pré-notification pour rechercher de manière prospective des renseignements nécessaires sur les patients, de l'utilisation d'un logiciel pour faciliter le calcul du *National Institutes of Health Stroke Scale* (NIHSS) et d'une plus grande prudence dans les traitements thrombolytiques. Les deux types de centres ont également évoqué des difficultés liées à la collecte de données complètes et précises. ***Conclusions :*** Les trajectoires générales de traitement des AVC et les renseignements requis dans les centres de soins primaires et les centres de soins complets sont similaires. Cependant, des différences apparaissent dans les trajectoires en raison de contraintes liées aux ressources, de délais de notification avant l'arrivée des patients, de l'exhaustivité et de l'exactitude des données collectées et de l'aisance à offrir des traitements thrombolytiques.

Keywords: comprehensive stroke centre; data collection; primary stroke centre; resource management; rural

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Highlights

- Primary stroke centers (PSCs) have fewer resources than comprehensive stroke centers (CSCs), which leads to variable workflow.
- There is variation in the collection of data across Canada, which leads to incomplete and inaccurate data.
- There is a gap in stroke knowledge at PSCs, which leads to hesitancy in treating patients.

Introduction

Health systems across Canada have recognized the need for structured acute stroke systems of care to ensure timely access to stroke treatment. The development of acute stroke systems of care ensures that suspected stroke patients are directed by ambulance services to designated stroke centers that are capable of treatment with thrombolysis[1–3] and treatment with endovascular thrombectomy (EVT).[4] Both treatments are highly time dependent,[5–7] which makes timely access to hospitals with adequate capability and expertise to provide treatment especially critical. Establishment of primary stroke centers that are capable of thrombolysis treatment and comprehensive stroke centers that are capable of EVT[3] (primary stroke centers [PSCs] and comprehensive stroke [CSCs], respectively) are key to designing stroke systems of care.

Despite the creation of designated stroke hospitals, disparity in acute ischemic stroke (AIS) treatment between rural and urban areas stands as a pervasive issue,[8] reflecting broader challenges in healthcare accessibility and delivery. Urban centers typically benefit from more robust healthcare infrastructure, including specialized stroke centers, advanced imaging capabilities and readily available medical expertise and trainees. In contrast, rural regions often face limited resources, including fewer healthcare facilities, sparse access to specialized care, longer travel distances to reach medical facilities and the need to urgently transfer patients to receive higher level of treatment such as EVT.[8,9] This study aims to better understand the differences in the clinical workflow processes for acute stroke treatment across PSCs and CSCs. The objectives for the study are as follows: 1) to understand the similarities and differences in the stroke treatment process workflow, 2) to investigate how variations between PSCs and CSCs impact their incorporation of best practices and 3) to explore how data is collected and prioritized during acute stroke treatment and how it impacts clinical decision-making.

Methods

This study employed a qualitative approach utilizing semi-structured interviews to explore the thrombolysis treatment process for AIS in urban and rural hospital settings at designated stroke centers across Canada. The methodology was designed to gather rich insights from healthcare professionals directly involved in stroke care, encompassing their perspectives, experiences and perceptions regarding stroke treatment.

Ethical considerations

Prior to data collection, ethical approval was obtained from the Dalhousie University Research Ethics Board, ensuring adherence to ethical guidelines and principles throughout the research process. The study protocol, with the REB file number 2023-6753, was approved by the Board.

Table 1. 18 Semi-structured interview topics

#	Topic
1	Participants professional experience and expertise
2	Stoke treatment practice over the last year
3	Stoke treatment process tasks and responsibilities
4	Changes within participant task performance
5	Standardization and deviation of tasks within the stroke treatment process
6	View on stroke treatment process standard practices
7	Pre-arrival versus in-hospital task preparation for treatment
8	Critical information and documentation within treatment process
9	Eligibility for treatment
10	Issues with availability and accessibility of patient information
11	Treatment process time tracking means
12	NIHSS calculation methods/practices
13	Information shared between clinicians of different roles
14	Forgotten versus recovered information and impact on outcome
15	Preparedness and use of tools in stroke response
16	Utilization and preferences of software applications in practice
17	Key insights on stroke treatment awareness
18	Final thoughts and future engagement

NIHSS = National Institute of Health Stroke Scale.

Data collection

Data was collected from September 15, 2023, to November 3, 2023. Participants were contacted via email and provided with a consent letter outlining the study's objectives, procedures and confidentiality measures. Semi-structured interviews were scheduled, and then upon obtaining informed consent verbally, the interviews were conducted virtually using the Microsoft Teams. Interviews were conducted in private with only one of the authors (AF) and an individual participant present.

A standardized interview guide was developed, consisting of 18 questions to delve into a spectrum of topics ranging from workflow processes to treatment practices to pretreatment preparations. An overview of the interview topics is provided in Table 1.

Each participant underwent the same structured interview process, fostering consistency and comparability across responses. Prior to the data collection, mock interviews were conducted to refine the interview guide and ensure the clarity and relevance of the questions.

Participant identities were coded to ensure their confidentiality, and permission was received to directly quote the participants' responses during the interview sessions throughout this study. Additionally, participants were assured of their right to withdraw from the study at any point without repercussion. There was no compensation provided to any participants.

Recruitment strategy

The sampling strategy employed a combination of non-probability snowball sampling and purposive sampling techniques.[10] An initial invitation was sent to participants based on their expertise and direct involvement in stroke care, ensuring a diverse representation of perspectives across different healthcare roles and settings. After

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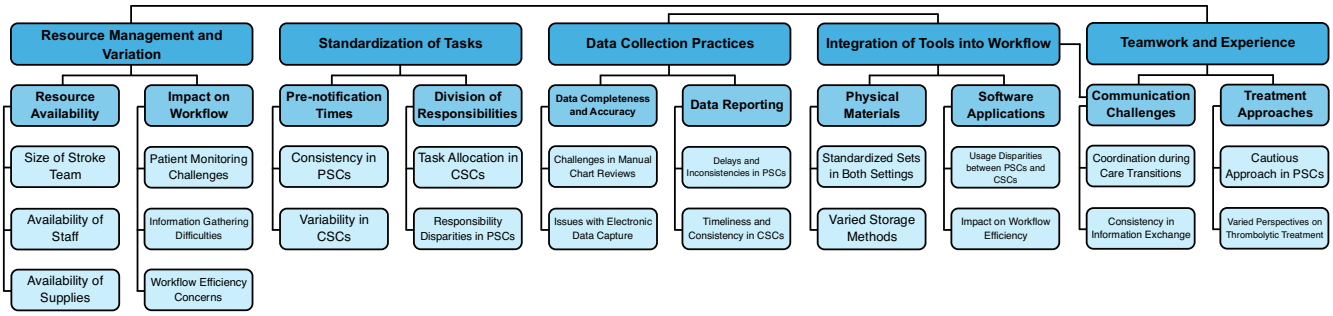

Figure 1. Affinity diagram of stroke treatment processes.

completing the interviews, participants were asked if they would be willing to reach out to colleagues involved in the stroke treatment process who would be interested in being interviewed. There were no additional screenings for eligibility, as the pool of diverse participants and perspectives allowed for the most breadth of insight.

Qualitative analysis

The qualitative data collected through semi-structured interviews underwent a thematic analysis to explore and interpret the complexities of stroke care delivery in diverse healthcare settings across Canada. This methodological approach facilitated a nuanced understanding of healthcare professionals' perspectives, experiences and challenges in administering treatment for AIS patients.

The steps involved in the thematic analysis were as follows:

1. The interviews were transcribed using the Microsoft Teams live transcription feature to capture participants' responses. The transcripts were manually reviewed and edited to ensure accuracy, allowing for thorough analysis.
2. Each transcript was systematically analyzed line by line. AF applied descriptive labels or codes to segments of text representing key concepts or ideas. Coding was conducted inductively, allowing for the identification of emergent themes without predetermined categories.
3. AF and AS compared and refined the codes, grouping them into overarching themes after coding several transcripts. These themes were iteratively developed and defined, ensuring they accurately represented the content of the data.
4. The established thematic framework was applied to the remaining transcripts, with each segment of text coded according to the predefined themes. This systematic approach ensured consistency and reliability in the analysis process.
5. The final stage involved interpreting the data within the context of the research objectives. AF and AS examined the relationships between themes, identified patterns and variations and compiled the results of key similarities and variations identified between the interviews.

Results

An initial invitation was sent to 27 clinicians, 9 of which agreed to participate in the interviews. From snowball sampling, 10 colleagues of the interviewees were contacted, and half of them agreed to an interview, which resulted in 5 additional clinicians being recruited. A total of 14 participants took part in the study, as the codes and themes identified had reached a saturation point and no new themes or subthemes were emerging.[11]

The sample population recruited comprised five doctors (three stroke neurologists in CSCs, one neurologist in a PSC and one emergency physician in a PSC), seven nurses (two nurses working in CSCs and five in PSCs) and two stroke coordinators (both representing PSCs) spread across seven hospitals (three CSCs and four PSCs) in five provinces in Canada. The interviews took between 60 and 90 min.

Through thematic analysis, five themes emerged, each encompassing a range of subthemes. These five themes were 1) resource variation and management, 2) standardization of tasks, 3) data collection, 4) tools integrated into workflow and 5) teamwork and experience. Additionally, a total of 13 subthemes were identified. A description of the themes with illustrations is provided in Figure 2.

An affinity diagram of stroke treatment processes is showcased in Figure 1, categorizing the findings into the five key themes and their subthemes. *Resource management and variation* encompasses *resource availability* and *its impact on workflow*, highlighting challenges in patient monitoring and information gathering due to resource constraints. *Standardization of tasks* explores consistency in *pre-notification times* and *role responsibilities*, revealing differences between settings in advance preparation time and task division disparities. *Data collection* delves into *documentation modalities, data reporting* practices and *data completeness and accuracy* issues. *Integration of tools into workflow* explores how existing tools are used by clinicians to aid them throughout the treatment process using *physical materials* and *existing software*. Finally, *teamwork and experience* address the importance of both *interdisciplinary collaboration* and *training* in stroke treatment and *hospital culture* toward providing thrombolytic treatment.

Theme 1: Resource variation and management

Table 2 summarizes the main similarities and differences that emerged from the interviews with respect to stroke treatment related to *resource variation and management*. The primary subthemes are *the size of the stroke team*, *the availability of staff* and *the availability of needed supplies*. Frequently reoccurring codes concerning *the available resources* were the required balance between other emergency department (ED) patients with stroke patients, capability of having the same stroke care providers throughout the process and limited access to care beds with cardiac monitoring.

One key difference described by the participants in PSCs and CSCs was the members of the stroke team, as PSCs have fewer resources than the CSCs. While participants in both PSCs and CSCs consistently mentioned paramedics, radiologists, CT technologists and an emergency nurse as members of the stroke team, PSCs often only had an emergency physician (with a

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Theme	Symbol	Description
Resource Variations and Management		Concerns the number of clinicians, equipment and skills involved in the centers stroke treatment process and how they optimize and adapt based on their resources available to provide the best care.
Standardization of processes		Identifying practices and strategies to improve the flow of patient care, then implementing protocols to facilitate the execution of best practices for all stroke team members involved.
Data Collection		Practices used in stroke treatment centers to collect demographic, process, and outcome data to report the key performance measurements to the stroke team to identify patterns and areas of improvement.
Integration of Tools into Workflow		The use of materials (physical or digital) during the stroke treatment process to aid in streamlining the workflow in various aspects. Examples include the use of reference tools, timekeeping aids, and documentation checklists.
Teamwork & Experience		Development of formal and informal practices between clinicians to facilitate confidence in the team that all information is known, everyone is aware of their responsibilities and what task must be completed next given the treatment path.

Figure 2. Theme descriptions.

Table 2. "Resource variation and management" theme and subthemes

			Variations	
Main theme	**Subtheme**	**Similarities**	**PSC**	**CSC**
Resource variation and management	Stroke team size	The stroke team always has two paramedics, the diagnostic imaging team and an emergency nurse	An emergency physician and potentially a second emergency nurse are part of the stroke team	A neurologist, fellow, resident, stroke nurse and interventional radiology team are part of the stroke team
	Availability of staff		The emergency physician sends the patient to imaging and then receives a report from radiology on the scan results	The neurologist and at least one nurse will stay throughout the whole treatment process
			There can be challenges with assigning nurses to monitor the patient after treatment is given	
	Availability of supplies	The CT scanner is always reserved for a stroke patient if the hospital is notified	A nurse is tasked with freeing a bed for the patient	There is a trauma bed reserved for incoming stroke patients

PSC = primary stroke center; CSC = comprehensive stroke center.

neurologist accessible via telestroke) and potentially a second emergency nurse as additional stroke team members. In CSCs, the additional stroke team members listed included a neurologist, neurology fellow, neurology resident, a specialized stroke nurse and the interventional radiology team.

A variation discussed with the participants from PSCs concerning the stroke team size was that in three of the PSCs interviewed, the emergency physician and nurse(s) may be unable to follow the patient to diagnostic imaging. Due to the fewer resources, the staff may be required to stay in the ED to care for other patients:

> The physician does not necessarily go down with the patient to the CT scanner because we are a single coverage department. So, if we leave the [emergency] department for 15–20 min, sometimes it is an issue. (Participant 7, PSC 1)

Additional challenges were discussed concerning the inability to follow the patient throughout the treatment process, since the emergency physicians in PSCs have to manage multiple patients at one time and they may be required to redirect their attention between multiple patients during a stroke code:

> If the patient leaves [the emergency department for imaging], mentally the physicians are going "that is done for the moment, I am being asked to do something else" then they must reorient back when they arrive back in the department. (Participant 5, PSC 2)

An additional variation discussed concerned the diagnostic imaging interpretation process. In CSCs, the neurologist follows the patient through the entire stroke process, so they attend imaging and interpret the results primarily independently. However, six of the participants in three of the PSCs discussed how, because the physician often remains in the ED, the radiologist must interpret the imaging and communicate their findings to the physician. This creates an additional potential for delays if there is no communication system in place, as discussed:

> It used to be that our radiologist would review the CT and CTA, then dictate a report, then the doctor would look [the report] up on their computer, but the doctor would not get a notification of the report, so that was leading to significant delays. Now the radiologist looks at the CT and they immediately call the emergency doctor with a verbal report before they even look at the CTA. So that has helped to cut down our times. (Participant 4, PSC 2)

Finally, five of the PSC participants discussed there can be additional considerations of whether there is staff available to monitor the patient when they are going to receive a thrombolytic. When thrombolytics are administered, two nurses must be present to help administer the thrombolytics and monitor the patient. Four CSC participants stated that there is at least one (typically two) nurse following the patient throughout the process, but PSC participants

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Table 3. "Standardization of tasks" theme and subthemes

Main theme	Subtheme	Similarities	Variations	
			PSC	CSC
Standardization of tasks	Timing of tasks	Task structure is similar across all sites: pre-arrival, emergency department, imaging, treatment	Smaller sites often relied on longer pre-notification times to know patient history pre-arrival	Pre-notification times were often described as shorter and inconsistent
	Role responsibilities	Emergency department and diagnostic imaging team are always pre-notified of incoming strokes	The emergency physician completes family discussions and searches patient history, while the radiologist completes imaging review	CSCs had residents and often a fellow along with the neurologist, and they would divide their tasks (imaging review, family discussion, searching medication history)

PSC = primary stroke center; CSC = comprehensive stroke center.

Table 4. "Data collection" theme and subthemes

Main theme	Subtheme	Similarities	Variations	
			PSC	CSC
Data collection	Documentation modality	Sites had a combination of paper and electronic data collection methods	Data would be manually reviewed through paper and e-charts and recorded retrospectively	Sites often had a nurse specifically dedicated to charting and documenting
	Data completeness and consistency	Sites reported frequent issues regarding the completeness of data collected	PSCs often had issues with people not documenting certain information such as NIHSS	Discussed issues with discrepancies in duplicated data
	Data reporting		Data reporting was seen as inconsistent and dependent on if they had a person available to complete chart reviews	Data on stroke treatment metrics would typically be reported biweekly or monthly

PSC = primary stroke center; CSC = comprehensive stroke center; NIHSS = National Institute of Health Stroke Scale.

discussed that they would often need to ensure they had nurses available to help treat the patient:

> An important part [of treatment] is how we are going to manage them: do we have the resources? Often, our nurse that is taking care of them has three other patients besides them. It takes a lot of resources for one person. (Participant 14, PSC 1)

Theme 2: Standardization of tasks

Table 3 highlights the main similarities and variations between PSCs and CSCs in terms of standardization of tasks. The subthemes concern the *timing of tasks* and *role responsibilities*. Frequently reoccurring codes were the amount of pre-notification time before the patient arrived, the tasks clinicians would complete during the imaging process and how tasks were assigned between each role.

Overall, the workflow of the stroke treatment process described was similar between PSCs and CSCs in terms of who is notified of the incoming stroke, methods clinicians used to complete their tasks and the treating physician's considerations when treating a patient. The primary difference discussed between participants in three of the PSCs compared to participants in two of the CSCs is the consistency of pre-notification times that were seen as more consistent and earlier for PSCs than CSCs, likely due to CSCs being in urban areas with unpredictable factors affecting transport times:

> Sometimes the ETA [estimated time of arrival] is off. Sometimes they say, "hey, we are 10 min out" and then they show up 3 s later. Or they are like, "I am 10 min out" and they show up 30 min later. (Participant 2, CSC 1)

The shorter pre-notification time discussed by three CSC participants impacts what tasks they can complete pre-arrival:

> It [pre-notification] is usually 3 min of heads up. When you get the page, you just drop what you are doing, go down, and get ready. (Participant 12, CSC 2)

This contrasts with five participants from PSCs who discussed using pre-notification time to search the patient's history to review their potential eligibility for treatment:

> While they are on route, sometimes we get a patch 40 min out, so you have lots of time to look up history: if they had a recent stroke or recent bleed. You also can look up their drugs on the information system. (Participant 7, PSC 1)

The other subtheme within the standardization of tasks is *role* responsibilities, where the results showed variation between PSCs and CSCs. CSCs are often teaching hospitals, which provide residents and fellows to work alongside the attending neurologist. With a larger neurology team, four CSC participants discussed the ability to divide tasks within the team. In PSCs, six participants explained that most tasks in the treatment process are the emergency physician's responsibility. Participant 9 in a CSC described an example of how their neurology team can divide tasks to retrieve required information in the process:

> Maybe you are in the scanner and realize "Oh, I did not ask if they [the patient] are on any blood thinners," I will tell the resident. "Can you quickly look in the system [to see] if they are on any medications that we should be aware of?" (Participant 9, CSC 3)

Theme 3: Data collection

Table 4 presents the main similarities and variations that emerged from the *data collection* theme. The subthemes were *documentation modality*, *data completeness and consistency* and *data*

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Table 5. "Tools integrated into workflow" theme and subthemes

			Variations	
Main theme	**Subtheme**	**Similarities**	**PSC**	**CSC**
Tools integrated into workflow	Software used	Clinicians used phone applications for either calculators, reference tools or to communicate with their team	Both physicians and nurses use applications primarily for calculators and reference tools	Less consistently used phone applications
				More often used applications for communication
	Physical materials	Standard forms were prepared before patient arrival		

PSC = primary stroke center; CSC = comprehensive stroke center.

reporting. Frequently reoccurring codes included how high ED capacity affected the ability to capture data, how data was reported to provide feedback to the stroke teams and who were responsible for data collection.

Participants' views on data collection in both CSCs and PSCs were that there were existing issues concerning how data was collected. Participants agreed that the key data they want to collect includes the last seen normal time, if onset of symptoms was witnessed, timestamps of in-hospital processes (time of arrival, imaging, thrombolytic treatment and EVT/transfer time) and National Institute of Health Stroke Scale (NIHSS) assessment times and scores. Participants discussed combining electronic data capture through electronic medical records as well as having paper forms they would document and review after treatment was completed. However, a similarity between participants in PSCs and CSCs was they discussed issues concerning data completeness and accuracy.

A noted challenge with data collection in CSCs was the reliability of documenting the treatment process. Four CSC participants discussed they often would have a nurse responsible for documentation during the stroke process, but it was not guaranteed and depended on whether a nurse was available. When asked about what the stroke team does if there is no nurse available to document the process, a participant responded as follows:

> You do the best you can. Usually documentation suffers, because you are doing all the tasks you need to do, and then you document. But that happens when it is crazy busy. (Participant 1, CSC 3)

Additional challenges were discussed with documenting data accurately as the clinician is often unable to record concurrently with the treatment process. In CSCs, five participants discussed often having a nurse or resident dedicated to documenting, but if they must complete tasks during the process, they often delay documenting until they have downtime:

> Our stroke nurses have a paper form that they will fill out often when we go to the Angio Suite. But the only time that gets done is at the end when there is downtime. (Participant 12, CSC 2)

Participants also discussed retrospective data collection, which is required for local registries and other quality assurance programs. In PSCs, five participants who conducted retrospective reviews discussed their method of data collection primarily through conducting manual chart reviews. There was a discussion of how the degree of data completeness was often clinician dependent:

> Some physicians do write the (NIHSS) score on there (the patient chart), we have it on our stroke protocol sheets to write the score on, but I do not routinely see every physician writing it. (Participant 14, PSC 1)

> I would say their notes are very well written, but to know which chart to go into is sometimes difficult, So, you have to look at a lot of things [documentation] before we can get a full picture. (Participant 8, PSC 2)

Finally, an issue discussed by four PSC participants was the lag time between stroke treatments and when the data was reported back to the stroke team. As the data from treatment is reported weeks or even months after treatment has happened, participants discussed that the lag time reduces the value of the data as a feedback mechanism:

> We often do not get our data until six to nine months after it has been collected, which is not really useful when we are trying to tell the team "We need to work on this," but they say, "that was nine months ago. We have changed since then." (Participant 4, PSC 2)

Theme 4: Tools integrated into workflow

Table 5 shows the similarities and variations of *tools integrated into clinical workflow*. The main subthemes are *software used* and *physical materials*. The frequently reoccurring codes were how and when people would use software applications during workflow and the preparation of physical materials (such as order sets) before the patient arrived.

Participants in both PSCs and CSCs had tools integrated into the workflow to aid their processes. The primary similarity discussed was that both types of centers had standard pre-prepared sets of physical materials including forms, medications and reference sheets. The physical materials discussed used during the treatment process varied in terms of being stored in either a dedicated stroke box, a dedicated trauma room or printed in advance of the patient's arrival. However, the materials themselves were similarly described in that they contained order sets, treatment forms and the inclusion-exclusion criteria for treatment.

The biggest variation in terms of tools integrated into the workflow was four PSC clinicians interviewed discussed using software applications or physical forms for calculation and reference tools (such as the NIHSS assessment) more often than participants from CSCs (of which, one participant discussed regularly using software applications). Typically, the more experienced neurologists would not use software tools for reference because they had the required assessments memorized. The situations participants in CSCs would use software applications would be if they were using it to train residents or if they were treating a patient after regular hours:

> I have the NIHSS in my head. Now, for residents, I ask them to use MD Calc, so they all use MD Calc. (Participant 9, CSC 3)

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Table 6. "Teamwork and experience" theme and subthemes

Main theme	Subtheme	Similarities	Variations	
			PSC	CSC
Teamwork and experience	Interdisciplinary collaboration	Participants discussed the importance of interdisciplinary collaboration with all people involved in the process	Challenges with communication between different clinicians through the treatment process	Challenges associated to communication between different clinicians in relation to transfers and in-hospital strokes
	Importance of training		Challenges with keeping clinicians trained in the stroke protocol	Clinicians are experienced in stroke protocol
	Hospital culture	Sites discussed keeping a closed loop communication standard of practice	Often would take caution when considering treating patients with thrombolysis	Less hesitant approach to consider treating patients with thrombolysis

PSC = primary stroke center; CSC = comprehensive stroke center.

> If I am tired and I cannot do the NIHSS, in my head, then I sometimes open and use the Neuro Toolkit app. (Participant 12, CSC 2)

Participants in PSCs discussed using the software more regularly in their practice for tools to aid in the workflow:

> I do the NIHSS on MD Calc. And even when I know the score is going to be in a range that they are going to be eligible for thrombolytics, I do it so I can document on the chart what the score was. (Participant 7, PSC 1)

Theme 5: Teamwork and experience

Table 6 highlights the similarities and variations of *teamwork and experience* in stroke treatment. The subthemes include *interdisciplinary collaboration*, *importance of training* and *hospital culture*. Frequently occurring codes in this theme were the specific use of terminology between roles, the importance of a culture of improvement and methods to reduce repeating information.

Participants frequently discussed the importance of closed-loop communication among the team. They discuss that even though different roles require different information, they develop standards so everyone can get information at the same time:

> I won't let the paramedics start the story until I have the nurse present, because otherwise they will have to repeat it. (Participant 12, CSC 2)

The importance of training and educating clinicians was emphasized by eight participants in both PSCs and CSCs. The main variation was PSC participants discussed more difficulties in keeping their teams trained in the stroke protocol:

> One of our challenges is to make sure that people are aware of the protocols and have the training that they need and feel comfortable doing that [thrombolysis] delivery. (Participant 5, PSC 2)

An additional variation between PSCs and CSCs is clinicians' confidence toward administering thrombolytic treatment. Five PSC clinician participants discussed having a more cautious approach when administering thrombolysis, while three clinician participants in CSCs felt more confident to treat with thrombolytics after gathering the essential information:

> We are pretty cautious about it, and I think we always get concerned, like "should we give this to such a minor thing?" we are all worried about giving thrombolytics and causing bleeds. (Participant 7, PSC 1)

> If the patient looks well enough, onset time was under four-and-a-half-hours ago, they were from home, they are not on blood thinners, and the scan looks like a stroke, I treat the patient. (Participant 9, CSC 2)

An additional aspect of the cautious approach toward administering thrombolytics applied to receiving consent to treat the patient. Four participants (three from PSCs, one from a CSC) discussed there can be longer discussions to receive consent to treat a stroke:

> Some of our staff are still struggling with the consent piece. That is still sometimes, explained more than perhaps necessary. (Participant 5, PSC 2)

An overview of the process differences identified between PSCs and CSCs is showcased in Table 7.

Discussion

This qualitative study reveals clear differences between stroke treatment processes in Canadian PSCs and CSCs, highlighting disparities in different stroke centers across Canada. This study found that there are various causes that can lead to gaps in the care and treatment being provided to stroke patients who arrive first at a PSC compared to a CSC. Our study found that PSCs often have limited resources compared to CSCs, which have neurologists (often specializing in stroke), medical trainees and stroke nurses, whereas PSCs have emergency physicians and ED nurses, who have to manage all patients in the ED. Previous studies have shown stroke team management is strongly associated with improvement in stroke processes,[9,12] but PSCs often have smaller, less specialized stroke teams.[13,14]

The results of this study highlight the unique impacts on the flow of stroke treatment processes with fewer available staff. The literature has noted that in smaller centers, the emergency physician does not always accompany the patient to imaging[13–15] but have not discussed how it impacts the workflow compared to CSCs, primarily with regard to gathering information from Emergency Medical Services (EMS) throughout treatment, mentally balancing the needs of multiple patients at once and the additional coordination required between radiologists, CT technicians and emergency physicians.

To accommodate the resources and lack of specialized staff in PSCs, telestroke is regularly used across Canada to assist PSCs with the acute management of stroke patients in the ED.[16] While this provides access to stroke expertise, it adds additional work to their existing workflow that includes the management and care of other patients in the ED, and the emergency physician at PSCs also has to manage discussions with family and other tasks that are often done by a team of clinicians and trainees at the CSC.[17] However, well-implemented telestroke programs have been shown to reduce treatment times in rural areas significantly, and it is regarded as a critical component in improving stroke treatment in rural and remote areas.[18,19] Studies have also shown the importance of

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Table 7. Process differences between PSCs and CSCs

Process differences	PSC	CSC
Roles involved in treatment process	Paramedics, triage nurse, emergency physician, emergency nurse, radiologist, CT technologist	Paramedics, triage nurse, attending neurologist, neurology resident, neurology fellow, stroke nurse, emergency nurse, radiologist, CT technologist
Gathering patient information	Completes as much as possible through the hospital computer system pre-arrival	Completes some pre-arrival through the computer system and the rest when the patient arrives
Pre-notification consistency	Common to receive pre-notification about 30 min pre-arrival	Consistent for transfer patients, often inconsistent and received less than 10 min pre-arrival
Software application use	Consistently used for reference tools and calculators	Inconsistently used
Data collection frequency	Often delayed and relies on retrospective chart reviews	Consistent, but either relies on chart reviews or a team member dedicated to data collection
Data collection accuracy	Often missing information	May miss information or contain discrepancies
Experience and comfort in treatment	Less experienced in stroke protocol, cautious approach to treatment	Experienced in stroke protocol, less cautious toward treatment

PSC = primary stroke center; CSC = comprehensive stroke center.

standard metrics in contacting telestroke, as delayed telestroke alert times were associated with longer treatment times.[20]

Our study also revealed that there is a significant variation in data collection between all the centers interviewed. There is no standardization around data collection prospectively, which makes retrospective quality reviews rife with incomplete and inaccurate data. This study revealed a significant opportunity with the acute stroke process to standardize data collection and look at ways to integrate a standard data collection tool into clinical practice. Research in health informatics reveals the need for standardized and accurate data collection to ensure successful quality improvement programs.[21,22] Furthermore, studies have associated the use of stroke registries with improved patient outcomes, highlighting the importance of consistent data collection practices and prompt data feedback.[12,23,24]

Critically, there is a gap in the prerequisite knowledge about stroke treatment at PSCs in comparison to CSCs. PSC clinicians interviewed in this study often use software tools to help them. Additionally, PSC participants found staff were less experienced in the stroke protocol and challenges persisted from lack of awareness. Hesitancy to treat with thrombolytics persists at several PSCs interviewed, which suggests that patients who present to PSCs may have poorer access to treatment, given the staff's level of training and confidence. The importance of training and education has been reported extensively in other studies with respect to improved treatment times and higher thrombolytic rates.[13,25–27] This hesitancy also applies when getting consent from the patient to administer thrombolytics, as thrombolytic treatment is considered an urgent situation in which emergency consent procedures may be taken.[28,29] This signifies the importance of well-established protocols to ensure PSC clinicians can be confident when treating stroke.

Limitations and future directions

Some limitations need to be considered regarding the results of this study. First, while there was representation from five provinces and seven hospitals, recruiting additional participants in rural centers was challenging since snowball sampling more often led to recruiting participants in larger centers. Second, additional clinician roles, such as paramedics and radiologists, were not represented in the interviews. Finally, the representation of PSCs could be further subdivided based on their capabilities and resources; for example, some PSCs might have a neurology team or a stroke unit, and this will affect the capability of the PSC. Although the four PSCs represented in this study had different capabilities, we could not further divide the centers into more than PSC and CSC due to the sample size.

Future directions of this study should include a deeper analysis of the differences between PSCs and CSCs and compare stroke treatment variations in different countries. Even though studies analyzing stroke treatment processes have been conducted in different countries, further investigation should be done comparing the practices of centers in different countries.[26,30] Exploring the different PSC settings based on location sizes and capabilities, such as having in-house neurology and a dedicated stroke unit, compared to PSCs that must rely on telestroke will further recognize potential variations in stroke treatment. Additionally, prospective data collection should be focused on for future studies since our study identified variations in data collection processes, reliability and accuracy. Finally, a wider spanning analysis of similarities and variations should include additional healthcare experts such as paramedics and radiologists since it can help understand the totality of the potential variations in stroke treatment across the system.

Conclusion

This study aimed to highlight the similarities and differences in acute stroke treatment across PSCs and CSCs in Canada. Key disparities included the lack of a dedicated stroke team to follow the patient through the treatment process, limited availability of staff and level of experience and training in stroke treatment. This study investigated the causes of gaps in treatment processes in PSCs and CSCs and how these gaps can be addressed through development and training in stroke protocols and leveraging existing technologies such as telestroke. Regardless of PSCs or CSCs, there was a challenge in complete and accurate data collection throughout the treatment process in centers interviewed, and data is often reported weeks or months after treatment has

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happened, creating an ineffective feedback mechanism for clinicians. A follow-up study will be conducted to identify the design requirements of a prototype software application that can aid in data collection during the clinical workflow of the acute stroke treatment process to better understand clinicians' needs to effectively collect accurate data required during stroke treatment.

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