Original Article

The prevalence and patterns of use of point-of-care ultrasound in Newfoundland and Labrador

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Abstract

Introduction: Point-of-care ultrasound (POCUS) is used for diagnostic and procedural guidance by physicians in Newfoundland and Labrador (NL). POCUS use is largely limited to urban locations and the training is variable amongst physicians. The primary aim of this study was to determine the prevalence of POCUS devices in NL and the secondary aim was to characterise the patterns of POCUS use amongst physicians in NL.

Methods: This is a mixed-methods cross-sectional study. We determined the prevalence of POCUS devices from purchase records and the patterns of POCUS use through theme-based interviews. The interviews were transcribed, coded and analysed using standardised qualitative methods.

Results: Ten physicians (3 females, 5 rural) participated in the interviews. The overall prevalence of POCUS devices in NL was 12.5/100,000 population. Participants in urban areas had more access to POCUS training and devices. Participants used POCUS on a daily or weekly basis to rule in or out life-threatening conditions and improve access to specialist care. The benefits of POCUS included expedited investigations, decreased radiation and increased patient satisfaction. The barriers to using POCUS were lack of training, time, devices, image archiving software, difficulty generating and interpreting images and patient body habitus.

Conclusion: This is the first study to our knowledge to report the prevalence of POCUS devices in Canada. Physicians who practise in rural NL have limited access to POCUS devices and have identified barriers to POCUS training. Connecting physicians in rural areas with POCUS experts through a province-wide POCUS network may address these barriers and improve healthcare access.

Keywords: Competency framework, continuing medical education, point-of-care testing, rural health services, ultrasound

Résumé

Introduction: L'échographie ciblée est utilisée par les médecins de Terre-Neuve-et-Labrador (T.-N.-L.) pour guider le diagnostic et certaines

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interventions. L'échographie ciblée est grandement limitée aux régions urbaines et la formation des médecins sur son utilisation est variable. Cette étude visait en premier lieu à déterminer la prévalence des appareils d'échographie ciblée à T.-N.-L. et en deuxième lieu, à caractériser les habitudes d'utilisation de l'échographie ciblée chez les médecins de T.-N.-L. **Méthodes:** Il s'agit d'une étude transversale à méthodes mixtes. Nous avons déterminé la prévalence des appareils d'échographie ciblée à partir de registres d'achat, et les habitudes d'utilisation de l'échographie ciblée à partir d'entrevues thématiques. Dix médecins (3 de sexe féminin, 5 de régions rurales) ont participé aux entrevues. Les entrevues ont été transcrites, codées et analysées à l'aide de méthodes qualitatives standardisées.
Résultats: La prévalence générale des appareils d'échographie ciblée à T.-N.-L. était de 12.5/100 000 populations. Les participants des régions urbaines avaient un meilleur accès à la formation sur l'échographie ciblée et aux appareils. Les participants utilisaient l'échographie ciblée tous les jours ou toutes les semaines pour inclure ou éliminer les affections potentiellement mortelles et améliorer l'accès aux spécialistes. Les bienfaits de l'échographie ciblée étaient l'accélération des examens, la réduction des rayonnements et une meilleure satisfaction des patients. Les obstacles à l'échographie ciblée étaient l'absence de formation, de temps, d'appareils et de logiciel d'archivage des images, la difficulté à générer et à interpréter les images, et les caractéristiques physionomiques du patient.
Conclusion: À notre connaissance, il s'agit de la première étude à avoir rapporté la prévalence des appareils d'échographie ciblée au Canada. Les médecins qui pratiquent dans les régions rurales de T.-N.-L. ont un accès limité aux appareils d'échographie ciblée et ont identifié des obstacles à la formation sur l'échographie ciblée. Pour faire tomber ces obstacles et améliorer l'accès aux soins de santé, il serait utile de relier les médecins des régions rurales à des spécialistes d'échographie ciblée dans un réseau provincial d'échographie ciblée.

Mots-clés: Échographie, examen ciblé, services de santé ruraux, formation médicale continue, cadre de compétences

INTRODUCTION

Point-of-care ultrasonography (POCUS) is a portable ultrasound technology that physicians can use at the patient's bedside to diagnose a disease or guide a procedure.[1] POCUS has been integrated into many clinical areas including emergency departments and outpatient clinics in both urban and rural settings.[2,3] It has become a valuable tool in the recent COVID-19 pandemic as physicians can rapidly assess a patient's lungs, volume status and cardiac function at the bedside.[4]

The province of Newfoundland and Labrador (NL) is home to approximately 500,000 people distributed across 405,000 km^2. A combination of geography and inclement weather often makes transportation of patients to secondary and tertiary centres difficult, and physicians practising in many of the province's isolated communities often have little in the way of technological or personnel support. The largely rural population in NL may benefit from having physicians and nurses trained in POCUS connected together to mentor one another. POCUS is ideally suited for locations with limited resources, including war zones and on board the International Space Station.[2] Most emergency departments in Canada use POCUS and the Canadian Association of Emergency Physicians has published guidelines on the use of POCUS.[5] In addition, POCUS has been introduced into undergraduate medical education in Canada[6] and is well established in many postgraduate residency programmes.[7-9] In NL, physicians and nurses have been using POCUS in their practice increasingly for the past 20 years.[10]

Despite the increased use of POCUS in clinical practice, its prevalence has never been reported in Canada to our knowledge. Knowing where and how POCUS is used in NL is important if we want to plan healthcare services and educational programmes that respond to the health needs of our aging population. The purpose of this study was to determine the prevalence of POCUS

devices in NL. The secondary objective of the study was to understand the patterns of POCUS use amongst physicians who use it regularly in NL. Finally, our research group also wanted to explore physician attitudes about a province-wide network for POCUS training and practice.

METHODS

Data were collected in 2 phases with a combination of quantitative and qualitative methods.

In the first phase, we determined the prevalence of POCUS devices in NL using purchase orders obtained under the Access to Information and Protection of Privacy Act (ATIPPA) from the 4 provincial regional health authorities (RHA). The total number of POCUS devices within the geographic limits of the 4 RHAs was cross verified through E-mail or telephone with respective administrative officers. For the purposes of this study, we excluded all Statistics Canada Census Agglomerations and Census Metropolitan Areas from the rural category. This excluded the communities of St. John's, Gander, Grand Falls-Windsor and Corner Brook.[11,12]

In the second phase, we studied the patterns of POCUS use amongst physicians practising in NL in 2 steps. First, we developed a questionnaire for physicians to rate their level of confidence in using POCUS during regular clinical practice on a 5-point Likert scale. Second, we recruited physicians who use POCUS in NL to participate in an interview to discuss the patterns of POCUS use in their clinical practice. We used a combination of purposive and convenience sampling to reflect diversity in gender, rural and urban healthcare settings, clinical training, experience and years of POCUS use. Research team members (AJD and CC) who had no prior training or knowledge about POCUS conducted semi-structured theme-based interviews. The interviews were conducted using an interview guide through telephone. The interviews were audio recorded, transcribed verbatim, anonymised and coded by key aspects of the conversations. They were analysed using an interpretive paradigm to identify emerging themes. The code words were operationally defined during the data extraction process to reflect the essence of the data and were consistently applied. The codes were placed into broader themes as they emerged based on their conceptual properties.

Two assessors (AJD and CC) extracted data from the interview recordings for each participant separately. After interviewing the first 3 participants, a peer debriefing with research team members who had experience using POCUS (GS) and who had qualitative method expertise (MN) determined the emergence of common codes or tentative themes. The preliminary themes were refined and revised by collapsing and consolidating codes in consultation with the research team members. A similar iterative process was carried out after coding the sixth and the tenth participants to determine whether saturation was reached. To ensure no further sampling was necessary, recruitment was continued until no new themes emerged over 2 consecutive interviews. The qualitative data analyses of the interviews were performed using NVIVO software package (version 12, QSR International, Doncaster, Victoria, Australia). In an effort to include the patient's perspective on POCUS use in NL, we engaged with a patient partner throughout the study, from data collection to manuscript preparation.

This was a cross-sectional, mixed-methods study approved by the NL Health Research Ethics Board (Reference # 2019.084).

RESULTS

Prevalence of point-of-care ultrasonography devices

The overall prevalence of POCUS devices in NL was 12.5 per 100,000 population [Table 1]. The prevalence of POCUS devices in Western, Labrador-Grenfell, Central and Eastern health

Table 1: The prevalence of point-of-care ultrasound devices in Newfoundland and Labrador

Location	Population*	Devices per region	Devices per 100,000
NL, total	519,716	65	12.5
Western	77,687	12	15.4
Labrador-Grenfell	36,072	14	38.8
Central	92,690	4	4.3
Eastern	313,267	35	11.2

*Statistics Canada. 2016 Census Profile. NL: Newfoundland and Labrador

authorities in NL was 15.4, 38.8, 4.3 and 11.2 per 100,000 population, respectively [Table 1]. The POCUS devices were used in both urban (n = 4) and rural (n = 19) geographic locations in NL. The urban locations included the city of St. John's, the towns of Gander and Grand Falls-Windsor and the city of Corner Brook. The rural locations included Carbonear, Old Perlican, Burin, Clarenville, Bonavista, Twillingate, Baie Verte, Fogo Island, Botwood, Stephenville, Port Saunders, Norris Point, St. Anthony, Happy Valley-Goose Bay, Labrador City, Postville, Nain, Flower's Cove and Roddickton. The prevalence of POCUS devices in urban centres in NL was 20.0 devices per 100,000 versus 12.6 per 100,000 in rural NL.

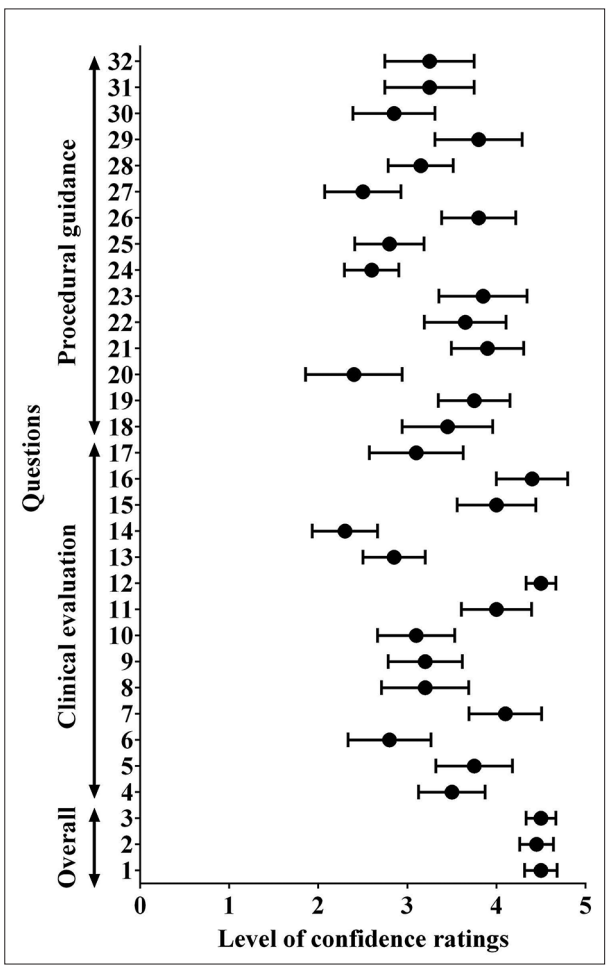

Figure 1: Level of confidence in using point-of-care ultrasonography. X-axis represents average scores of the level of confidence rated on a 5-point Likert scale: 1 – disagree, 2 – mostly disagree, 3 – neutral, 4 – mostly agree and 5 – agree. Y-axis represents items from the level of confidence questionnaire. For questions 1–32 on Y-axis, please refer to Table 3.

Descriptive characteristics of interview participants

The characteristics of the 10 participants (3 females, 5 rural) in this study are listed in Table 2. Nine participants were trained in family medicine or family medicine with special competence in emergency medicine and only one participant was a specialist.

Level of confidence in using point-of-care ultrasonography

All of the participants were confident in their overall ability to acquire and interpret images, and operate the ultrasound device [Table 3]. The self-reported level of confidence for using POCUS to evaluate clinical conditions and perform procedures varied widely [Figure 1].

Participants were least comfortable overall with diagnosing testicular torsion, pneumonia and deep vein thrombosis (average scores <3.0) [Table 3]. Participants were most comfortable using POCUS to perform Focused Assessment with Sonography in Trauma, early pregnancy assessment and to diagnose pneumothorax, aortic aneurysm and ascites (average scores of 4.0 or greater) [Table 3]. Participants were least confident conducting ultrasound-guided procedures such as pericardiocentesis, peripheral nerve blocks, peritonsillar abscess drainage, lumbar puncture and peripherally inserted central catheter (PICC) line insertion (average scores of <3.0) [Table 3]. Participants felt most confident performing central

Table 2: Participant characteristics

Participant characteristics	**Mean (SD) or *n***
Age	47.8 (10.3)
Gender (male/female)	7/3
Practice setting (rural/urban)	5/5
Level of education (generalist/specialist)	9/1
Total years of clinical practice	18.9 (11.4)
Total years of POCUS practice	7.8 (6.2)
Number of hours of POCUS training	
<50 h	5
≥50 h (but<100 h)	2
≥100 h	3
POCUS use during clinical practice	
Daily	3
At least once a week	7

SD: Standard deviation, POCUS: Point-of-care ultrasound

Table 3: The level of confidence in using point-of-care ultrasound

Areas of expertise	Level of confidence ratings (1–5)									
Location of practice	R	U	U	R	R	R	U	U	R	U
I am confident in general image acquisition skills	4.5	5	5	4	4	4	3.5	5	5	5
I am confident in general image interpretation skills	5	5	5	4	4	4	3.5	4	5	5
I am confident in machine operations	5	5	5	5	4	4	4	4	5	4
I am confident in evaluation skills for:										
Cardiac systolic function	4	4	3	4	3	3	1	3	5	5
Inferior vena cava	4.5	4	5	4	4	3	1	2	5	5
Deep vein thrombosis	4	1	4	3	1	4	1	2	3	5
Pneumothorax	5	4	5	5	4	3	1	4	5	5
Pulmonary oedema	5	2	3	5	3	3	1	1	4	5
Cholecystitis	3	1	4	4	3	4	1	4	3	5
Hydronephrosis	4	1	4	4	2	3	1	4	3	5
Aortic aneurysm	4	4	5	5	4	4	1	3	5	5
Ascites	5	4	5	5	4	4	4	4	5	5
Pneumonia	4.5	2	2	3	2	3	1	4	3	4
Testicular torsion	3	1	1	2	2	3	1	2	4	4
Early pregnancy assessment	4.5	5	5	5	4	2	1	5	4	4.5
Focussed abdominal sonography in trauma	5	5	5	5	4	4	1	5	5	5
Retinal detachment	4	1	4	4	4	2	1	1	5	5
Procedural guidance										
Arterial line placement	5	1	2	3	4	4	4.5	1	5	5
Peripheral intravenous line placement	5	1	3	3	4	4	4.5	3	5	5
Peripherally inserted central catheter	5	1	2	1	1	4	1	1	3	5
Central line	5	2	3	5	3	4	5	2	5	5
Thoracocentesis	5	1	4	5	2	4	4.5	2	4	5
Paracentesis	5	1	4	5	4	4	4.5	1	5	5
Pericardiocentesis	3	1	3	3	2	3	3	1	3	4
Peripheral nerve block	4	1	3	3	2	4	1	2	4	4
Abscess drainage (general)	5	3	4	5	3	4	1	3	5	5
Peritonsillar abscess drainage	4	1	3	3	2	2	1	1	3	5
Foreign body detection	4	2	3	4	2	3	1	4	4	4.5
Jugular vein pulse assessment	5	1	4	4	4	4	5	1	5	5
Lumbar puncture	4.5	1	3	4	2	2	1	2	4	5
Fracture reduction	4	1	4	5	2	2	1	4	5	4.5
Joint aspiration	5	1	3	5	2	3	1	3	5	4.5

R: Rural, U: Urban

lines, arterial lines, peripheral intravenous lines, paracentesis, thoracocentesis, abscess drainage and jugular venous pressure assessment (average scores of 3.5 or more) [Table 3].

Themes

A word frequency analysis of interview transcripts showed training, patterns of use, barriers, benefits, limitations and network as the 6 main themes of POCUS in participants' clinical practice.

Thirty subthemes and 491 codes also emerged from the interviews.

Point-of-care ultrasound training

This study found that participants completed their POCUS training at formal courses offered through professional societies such as the Canadian Point of Care Ultrasound Society, at academic conferences such as the Canadian Association of Emergency Physicians Conference or in medical school or residency. Some participants also used online POCUS content to supplement their training. While the duration of formal POCUS courses is about 100 h, participants believed it took a total of 300–400 h to become competent in using POCUS.

Since all participants had similar types of POCUS training, we did not identify any differences in interview attitudes amongst them. Participants were aware of the recommendations about the use of POCUS within their own discipline but highlighted the need for continuing education to learn about new applications of POCUS.

The challenges to POCUS training included travel costs, difficulty getting time off work, a lack of institutional support and a lack of available POCUS devices. Participants from rural settings could not access enough physicians who were competent in POCUS with 'Independent Practitioner Status' to mentor them to become certified in POCUS. Rural participants had difficulty acquiring the number of ultrasound images required to obtain and maintain competence. In addition, there was little institutional support or financial incentives for POCUS training.

Patterns of use

Participants used POCUS on a daily or weekly basis to rule in or out life-threatening conditions, guide procedures and improve access to diagnostic imaging or specialist consultation. Participants shared several clinical scenarios to explain their patterns of POCUS use. Participants thought archiving POCUS images would be a valuable addition to the patient's chart as it can provide 'a huge amount of information' for consultants. Participants stated that patients were very receptive to POCUS, noting that it provided 'peace of mind'. To improve the quality of care, participants supported the use of POCUS according to clinical practice guidelines and suggested there be a 'well-developed quality control programme' for POCUS use.

Benefits of use

Participants described POCUS as an 'essential' part of patient care. Benefits for patients included expediting investigations, decreased radiation and increased patient satisfaction. Most participants highlighted patient safety and comfort as further benefits of POCUS, especially when it was used for procedures like PICC lines. Additional benefits for patients included timely access to a correct diagnosis, especially in rural areas where technicians must be called in after hours for formal diagnostic imaging. A number of participants highlighted the potential cost savings for patient care in rural and remote communities by lowering the cost to the system by not having to call in a technician. Furthermore, all participants reported that none of their patients declined the use of POCUS during clinical assessments.

Barriers to use

Participants in the early stages of learning POCUS stated that image generation and interpretation were difficult for them. Participants stated that 2 patient factors, body habitus and perceived patient discomfort, impeded image generation or interpretation with POCUS. Several participants stated that lack of access to an ultrasound machine prevented them from using POCUS. One participant had purchased their own portable ultrasound device to address this problem. However, we did not include this POCUS device in our calculations, as the purpose of this study was to estimate the prevalence of POCUS units purchased and used within the public healthcare settings in NL. At 1 urban centre, physicians were denied access to an endocavitary probe because they could not access their institution's sterilisation equipment.

Participants who were emergency physicians described the pressure on them to maintain adequate patient flow as a barrier to POCUS use. One emergency physician described lack of compensation as a barrier. Another physician described situations where the POCUS image was not adequate to make a diagnosis, necessitating appropriate formal diagnostic imaging.

Participants described an overall lack of familiarity with clinical practice guidelines related to POCUS as a barrier to its use. One participant who was familiar with the guidelines felt they were already outdated. The final barrier to POCUS use was a lack of image-archiving software which allows users to store POCUS images and share them with other clinicians.

Limitations of point-of-care ultrasonography use

Ultrasound image generation and interpretation is dependent on the training and proficiency of the operator. Participants described acquiring these

skills as a limitation to using POCUS. Participants also saw POCUS leading to more diagnostic imaging. Some participants felt POCUS increased the cost of care for patients. While others, who practised in rural settings, thought POCUS saved time and money by preventing unnecessary travel to and from urban hospitals. Finally, 1 participant recalled a negative cardiac POCUS scan during a trauma that in their view delayed a thoracotomy. However, the participant described the importance of knowing their own limitation with respect to interpreting POCUS images and discussing the limitations of POCUS with patients to avoid false or implied reassurance.

Point-of-care ultrasonography network

Participants of this study supported the idea of a province-wide network, where a community of experts would mentor physicians. A major concern for participants was the importance of setting standards for POCUS training both in terms of quality assurance and patient safety. They felt it was important to build on other POCUS courses already in place instead of creating new training standards. Some were particularly interested in short and intensive courses that teach advanced skills and suggested delivering this content in the form of weekend seminars, online courses or conferences with oversight from advanced POCUS users and specialists.

Participants listed resident physicians, physician POCUS experts, specialists, ultrasound technicians, hospital administrators and nurses as potential stakeholders in a POCUS network. One participant reported that nurses on the coast of Labrador have been generating images with ultrasound for many years with a physician interpreting images via telemedicine. While some physicians felt it was outside the scope of practice for a nurse to interpret their own POCUS images, the majority of physicians felt that nurses and, in particular, nurse practitioners had a lot to offer by using POCUS. Furthermore, they wanted to see support from generalists and specialists in the development and maintenance of the network.

DISCUSSION

The objectives of this study were to determine the prevalence and patterns of POCUS use in NL. To our knowledge, this study is the first to report the number of POCUS devices available within a provincial public healthcare setting in Canada. By accessing purchase records, we found that there were 12.5 POCUS devices per 100,000 population in NL, Canada. When asked to explain the patterns of POCUS use during routine clinical practice, participants reported the benefits, barriers and limitations of POCUS through theme-based interviews.

In this study, participants who were physicians in NL listed several benefits of using POCUS compared to other portable technologies such as diagnostic ultrasound or portable X-rays. Several protocols have been developed using POCUS in recent years to improve diagnostic accuracy in a range of diseases. For example, the Bedside Lung Ultrasound in Emergency protocol has been demonstrated to have a diagnostic accuracy of 90% for determining the causes of respiratory failure in patients admitted to critical care units.[13] In this study, physicians were aware of the recommendations about the use of POCUS within their own discipline but highlighted the need for continuing education to learn about new applications of POCUS.

Adherence to clinical guidelines and technological advancements

Despite the increasing use of POCUS, there was a general lack of awareness of clinical guidelines and recent developments related to POCUS amongst participants. For instance, even though lung POCUS performs better than chest X-rays for the diagnosis of heart failure, emergency physicians do not use lung POCUS regularly.[14,15] Critics of POCUS point out that its use in the breathless patient is operator dependent and that there is a lack of general consensus or an evidence-based approach to how lung ultrasound is conducted.[16] It is essential that a group of experts comprised of experienced POCUS users keep track of these developments in order to keep pace with rapid technological advancements, and we suggest that a province-wide training network could possibly help with dissemination of knowledge and skills related to POCUS use within the public health system in NL.

Potential solution through training network

The concept of a network of teaching hospitals and clinics working together with a university-based department to provide specialty training for physicians has existed since the early 1900s in Canada.[17] At the turn of the 21st century, training initiatives such as the Multi-Specialty Community Training Network (MSCTN) were established using competency-based frameworks such as 'Canadian Medical Education Directives for Specialists' (CanMEDS) in Ontario. [18] The MSCTN network, which involves 10 medical school departments and 7 rural communities, provided an excellent learning experience for specialty residents who opted to improve their rural competence.[19] In this study, most participants identified the need to set up a similar training network for POCUS education. Participants were also interested in setting up an online network to facilitate the sharing of POCUS knowledge, similar to the successful virtual communities of practice in Australia.[20] In a complex healthcare system with ever-increasing challenges, it is essential for physicians who are experts in a specific domain to engage in stewardship through teaching and training. Telemedicine has been used to deliver healthcare and education in NL for many years.[10,21] While teleguidance for ultrasound mentoring is in its infancy, it may eventually provide a solution for training rural practitioners in POCUS and needs further investigation.[22,23] Implementing POCUS training by engaging both rural and urban centres using competency-based frameworks such as CanMEDS may provide excellent learning experiences for residents and nurse practitioners in NL.

Limitations

We estimated the prevalence of POCUS devices in NL using information requested from ATIPPA.

We may have over- or underestimated the prevalence of POCUS devices in NL as the authorities in 1 RHA reported fewer POCUS devices during cross verification of the purchase orders. Informal discussions with physicians in another RHA, outside of the study protocol, revealed that 2 more POCUS machines were in use that were not described in the purchase orders.

Due to the nature of the data collection method, using theme-based interviews, there were threats to external validity and reliability of findings. Although we employed strategies to recruit physicians with diversity in gender, rural and urban practice, clinical training, experience and years of POCUS use, we were unable to recruit an adequate number of female physicians and specialists. Furthermore, the Western RHA was not represented amongst our participants. The exclusion of Western RHA might skew the findings from this study. Finally, there was a lack of adequate focus on the analysis of negative consequences of using POCUS. In order to better understand the benefits of setting up a POCUS training network in NL, pragmatic studies engaging potential stakeholders with systematic *a priori* considerations of threats to external validity are necessary.[24]

CONCLUSION

In this study, we are, to our knowledge, the first to report the prevalence of POCUS devices in Canada. The prevalence of POCUS devices in NL was 12.5 per 100,000 population. The majority of the POCUS equipment is located in urban locations. In our interviews with physicians, we found that there were significant barriers in training and acquiring competence in POCUS, especially for rural physicians. The majority of physicians in NL described the importance of POCUS training, especially for emergency physicians, and for continuing medical education as it relates to POCUS. The physicians in this study endorsed the idea of developing a province-wide POCUS network. Finally, physicians described the importance of being able to share their POCUS images with other healthcare providers to ensure safe patient care

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