

Education

Point-of-care ultrasonography adoption in Canada: using diffusion theory and the Evaluation Tool for Ultrasound skills Development and Education (ETUDE)

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ABSTRACT

Objective: Point-of-care ultrasonography (PoCUS) first appeared in the 1980s in North America, but the extent of the diffusion of its adoption is unknown. We characterized early PoCUS adoption by emergency physicians in Canada and its barriers to use using Rogers' diffusion of innovations theory.

Methods: We developed a questionnaire based on a pilot study and literature review to assess past, current, and potential use of PoCUS and potential barriers to adoption. A Dillman technique for electronic surveys was used for dissemination. Using Rogers' diffusion of innovations theory, we developed and validated the Evaluation Tool for Ultrasound skills Development and Education (ETUDE). ETUDE scores allowed categorization of respondents into innovators, early adopters, majority, and nonadopters. Descriptive statistics, correlations, and χ^2 statistics were used to analyze the data.

Results: The 296 respondents (36.4% of 814 surveyed) had a median age of 40 and were 72.5% male. Adoption scores using ETUDE revealed nonadopters (18.8%), majority (28.7%), early adopters (34.5%), and innovators (18.0%). Respondents endorsed "always" using PoCUS currently and in the future for focused assessment with sonography in trauma (FAST) (current 41.8%/future 88.4%), first trimester pregnancy (current 23.3%/future 73.7%), suspected abdominal aortic aneurysm (current 32.7%/future 92.6%), basic cardiac indications (current 30.7%/future 87.5%), and central venous catheterization (current 17.0%/future 80.3%). Several barriers to PoCUS were identified for part-time emergency physicians and those working in inner-city/urban/suburban settings.

Conclusion: This is the first study to determine the state of adoption and barriers to the introduction of PoCUS in Canadian emergency medicine practice. The novel validated ETUDE instrument should be used to evaluate the uptake of PoCUS over time.

RÉSUMÉ

Objectif: L'échographie pratiquée au point de service (EPS) est d'abord arrivée en Amérique du Nord, dans les années 1980, mais on ne connaît pas l'étendue de son adoption. L'étude visait donc à caractériser l'adoption précoce de l'EPS par les urgentologues, au Canada, ainsi que les obstacles à son utilisation à l'aide de la théorie de la diffusion de l'innovation de Rogers.

Méthodes: Nous avons conçu un questionnaire reposant sur une étude pilote et sur un examen de la documentation dans le but d'évaluer l'utilisation passée, présente, et future de l'EPS ainsi que les obstacles possibles à son adoption. La technique de Dillman pour les enquêtes par voie électronique a été appliquée pour la diffusion. L'équipe a élaboré, à l'aide de la théorie de la diffusion de l'innovation de Rogers, puis validé un outil d'évaluation de l'acquisition des habiletés et de la formation en échographie (Evaluation Tool for Ultrasound skills Development and Education [ETUDE]). Les résultats ETUDE ont permis de classer les répondants en différentes catégories: les innovateurs, les adoptants précoces, la majorité, et les non-adoptants. Des statistiques descriptives, des corrélations, et des variables aléatoires khi-carré ont servi à analyser les données.

Résultats: Les répondants (296 sur 814 sondés; 36.4%) avaient un âge médian de 40 ans et se composaient d'hommes à 72.5%. Les résultats ETUDE relatifs à l'adoption de l'EPS se répartissaient comme suit: les non-adoptants (18.8%), la majorité (28.7%), les adoptants précoces (34.5%), et les innovateurs (18.0%). Les répondants ont indiqué «toujours» en ce qui concerne l'utilisation de l'EPS, présente et future, dans l'évaluation ciblée des cas suivants: les traumatismes (FAST) (actuellement: 41.8%; à l'avenir: 88.4%), le premier trimestre de grossesse (actuellement: 23.3%; à l'avenir: 73.7%), l'anévrisme présumé de l'aorte abdominale (actuellement: 32.7%; à l'avenir: 92.6%), l'exploration cardiaque (actuellement: 30.7%;

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This article has been peer reviewed.

à l'avenir: 87.5%), et la pose d'un cathéter veineux central (actuellement: 17.0%; à l'avenir: 80.3%). Plusieurs obstacles à l'utilisation de l'EPS ont été relevés chez les urgentologues à temps partiel et parmi ceux qui travaillent en milieu urbain ou suburbain et dans les quartiers centraux de ville.

Conclusion: Il s'agit de la première étude à avoir déterminé l'étendue de l'EPS, et les obstacles à son utilisation, en

médecine d'urgence au Canada. L'évaluation de l'adoption de l'EPS au fil du temps devrait se faire à l'aide du nouvel instrument validé ETUDE.

Keywords: emergency medicine, point-of-care ultrasonography, survey

Point-of-care ultrasonography (PoCUS) is defined as the use of bedside ultrasonography by the treating clinician to answer focused questions relating to the patient's condition.¹⁻³ After its introduction in Europe and Japan in the 1980s, PoCUS started to appear in the United States.⁴⁻⁶ Although emergency physicians led the use of PoCUS in North America, it has rapidly expanded to other aspects of medicine.³ It has been found to be essential to diverse specialties and has been incorporated into many medical schools in the United States and Canada, with some medical educators believing that it will replace the stethoscope.^{7,8} In 2006, the Canadian Association of Emergency Physicians (CAEP) published its first position statement, which was later updated in 2012, endorsing the availability of PoCUS 24 hours per day and 7 days per week.²

Despite these rapid advancements, the state of initial adoption in Canada has not previously been investigated. We set out to determine the state of early PoCUS adoption by emergency physicians in Canada as of 2007. The spread of innovations in populations is often described using a model developed by Rogers in 1962. Rogers' diffusion of innovations theory categorizes adoption of innovations based on a normal distribution, divided into groups of innovators, early adopters, early majority, later majority, and nonadopters.⁹ Using this validated approach, we developed the novel Evaluation Tool for Ultrasound skills Development and Education (ETUDE) to help characterize the diffusion of PoCUS. Our secondary objective was to determine the barriers to PoCUS adoption by emergency physicians in Canada. By studying the diffusion of PoCUS and barriers to adoption, further initiatives can be instituted to enhance use. This is the first study to determine the state of PoCUS adoption in Canada using the ETUDE tool.

MATERIALS AND METHODS

Survey development and study setting

The instrument was derived from items identified on a literature review and from experts in PoCUS. It

was designed to assess demographics; level of training; and past, current, and potential use of PoCUS by emergency physicians. These included the primary indications focused assessment with sonography in trauma (FAST), confirmation of intrauterine first trimester pregnancy abdominal aortic aneurysm, identification of asystole or pericardial effusion, and ultrasonography-guided central venous catheterization (CVC), as well as other indications listed in Table 1. Barriers to adoption were also explored.

The survey was pilot tested with all 46 emergency physicians at The Ottawa Hospital in 2006. Research ethics was approved by the Ottawa Research Ethics Board (OHREB protocol #2007573-01H). Funding was provided by the Department of Emergency Medicine at the University of Ottawa, and a \$400 random draw was provided as an incentive to complete the survey.

The survey was distributed to members of the CAEP email database. The CAEP is the national specialty

Table 1. List of other PoCUS indications on the survey and performed by emergency physicians

Suspected gallbladder disease
Renal colic
Abscess identification
US-guided thoracentesis
US-guided paracentesis
US-guided suprapubic catheterization
US-guided cutaneous abscess drainage
US-guided lumbar puncture
US-guided pericardiocentesis
Retinal detachment
Optic nerve sheath diameter for intracranial pressure
Cardiac wall motion
Cardiac ejection fraction
Other (identified by respondents)
Fracture identification and reduction
Foreign body identification and removal
Intraosseus insertion
Ovarian cysts
Deep vein thrombosis
Testicular torsion

PoCUS = point-of-care ultrasonography; US = ultrasonography.

society for emergency physicians in Canada. All emergency physicians, excluding residents, medical students, and pediatric emergency physicians, with valid email addresses in the database were sent an invitation to a Web-based survey using *Survey Console* software (Survey Analytics, Seattle, WA).

A Dillman technique was used, and the study was conducted for the period of September 2007 to November 2007, with reminders sent every 2 weeks for a total of four contacts.^{10,11}

Data analysis

Based on Rogers' diffusion of innovation theory,⁹ we defined a series of patterns to categorize respondents into innovators, early adopters, majority, and non-adopters. We combined the early majority and late majority categories originally described by Rogers. *Innovators* were defined as those who had introductory and advanced training, were very comfortable using PoCUS for four indications, had expanded its use in many different areas as listed in Table 1, and have also taught and wanted to teach others in the future. *Early adopters* were defined as those who had introductory training, were credentialed (not necessarily with advanced training), indicated a desire to get more training, already performed some more specialized applications, and had a desire to teach others. The *majority* category had taken an introductory course but may not have taken PoCUS any further, felt somewhat comfortable with primary indications, still wanted to get more training, and have not used PoCUS for other applications. Some emergency physicians in this category could still be in the process of obtaining credentialing. *Nonadopters* may have taken an introductory course but did not use PoCUS and generally felt uncomfortable with primary indications.

Based on these defined categories, a scoring and weighting system was developed based on current and future experience and use of PoCUS. Three external experts in PoCUS validated this system (Table 2). Questions pertaining to respondents' familiarity, confidence, and current use were assigned points based on their global responses, as well as for each of the five primary indications that resulted in the maximum of 18 points. Points were then assigned to each respondent, and based on their score, they were categorized as an innovator (75–100 points), early adopter (50–74 points), majority (25–49 points), or nonadopter (0–24 points).

Table 2. ETUDE content and weighting system

Current experience and use (maximum 72 points)
How familiar are you with using PoCUS in the primary indications? (maximum 18 points)
<input type="radio"/> Not familiar = 0 points
<input type="radio"/> Somewhat familiar = 1 point
<input type="radio"/> Generally familiar = 2 points
<input type="radio"/> Very familiar = 3 points
How confident are you with using PoCUS in the primary indications? (maximum 18 points)
<input type="radio"/> Not confident = 0 points
<input type="radio"/> Somewhat confident = 1 point
<input type="radio"/> Generally confident = 2 points
<input type="radio"/> Very confident = 3 points
Current use of PoCUS for primary indications (maximum 18 points)
<input type="radio"/> Little, if any = 0 points
<input type="radio"/> Seldom as appropriate = 1 point
<input type="radio"/> Usually as appropriate = 2 points
<input type="radio"/> Always as appropriate = 3 points
Training (maximum 10 points)
<input type="radio"/> No formal training = 0 points
<input type="radio"/> Introductory training = 2 points
<input type="radio"/> Credentialed = 5 points
<input type="radio"/> Advanced training = 10 points
Other indications
<input type="radio"/> None = 0 points
<input type="radio"/> Less than 5 = 1 point
<input type="radio"/> 5 or more = 3 points
Current teaching
<input type="radio"/> No = 0 points
<input type="radio"/> Yes = 5 points
Future experience and use (maximum 28 points)
Do you plan on using PoCUS for primary indications? (maximum 18 points)
<input type="radio"/> Not interested = 0 points
<input type="radio"/> Mildly interested = 1 point
<input type="radio"/> Very interested = 2 points
<input type="radio"/> Extremely interested = 3 points
Do you plan on teaching others? (maximum 5 points)
<input type="radio"/> No = 0 points
<input type="radio"/> Yes = 5 points
Do you plan on obtaining more training? (maximum 5 points)
<input type="radio"/> No = 0 points
<input type="radio"/> Yes = 5 points

ETUDE = Evaluation Tool for Ultrasound skills Development and Education; PoCUS = point-of-care ultrasonography.

A single data abstractor was used to enter all data into a Microsoft *Excel* 2008 database (Microsoft Corporation, Redmond, WA). All responses were anonymous, and the data were reported in aggregate only. We used descriptive, correlation, and χ^2 statistics to analyze the data.

RESULTS

Responses were obtained from 36.3% (296 of 814) of emergency physicians. The median age of respondents was 40 years old, and 72.5% were male. Most respondents were certified with the CCFP(EM) designation (52.3%), followed by FRCP(EM) (29.3%), and 18.4% had other certifications, including CCFP and ABEM. Most (80.1%) of the respondents reported working full time in the emergency department (ED) versus 19.9% part time. More than half of the respondents had less than 10 years in practice. Figure 1 describes the distribution of respondents across Canada, and Figure 2, Figure 3, and Figure 4 provide a demographic summary. Figure 5 illustrates the availability of PoCUS over time. Emergency physicians reported that PoCUS was first available in 1989 and progressed rapidly throughout the years. By 2004, 53.5% of respondents indicated that PoCUS was available in their ED. Figure 6 describes the differences in the level of training. A formal credentialing program was available 41.9% of the time, and only 32.2% of respondents were required to have credentialing to use PoCUS in their ED. Figure 7 depicts the current and future use of the primary indications for PoCUS. Figure 8 compares the actual category versus the respondents' perceived category of adoption for PoCUS based on their self-categorization. Correlation was found to be moderate, with an $r = 0.53$.

Respondents practicing in inner-city/urban/suburban settings were more likely to endorse heavy clinical workload as a barrier to using PoCUS versus small town/rural/remote EDs ($p < 0.05$). Female respondents felt that "not enough training" was a barrier ($p < 0.05$). Respondents older than 42 years of age felt that easy access to computed tomographic (CT) scans was a barrier ($p < 0.05$). Part-time physicians reported more

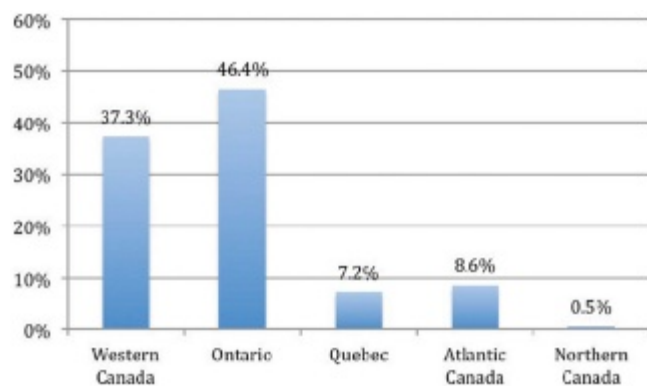


Figure 1. Distribution of respondents across Canada.

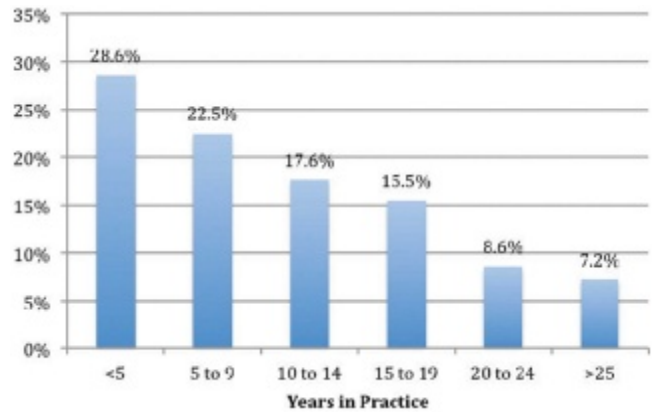


Figure 2. Distribution of respondents based on number of years in practice.

barriers compared to full-time physicians ($p < 0.05$), including clinical workload, difficulty recording scans, inadequate access to formal training, supervision and review of findings with credentialed staff, and inability to complete 200 scans in a timely manner. The following were not considered barriers by the respondents: consultant attitudes, lack of impact on patient management, and the ease of getting a radiology-performed sonogram.

DISCUSSION

This study describes the rise of PoCUS in Canadian emergency medicine. Although PoCUS was first available to respondents in this study in 1989, there was a rapid rise in the availability starting from 1998 up to the level of 76% in 2007 at the time of the survey. The rapid rise in the availability of PoCUS may be a result of the lack of access to radiology-performed ultrasonography^{12,13} and technological advances with

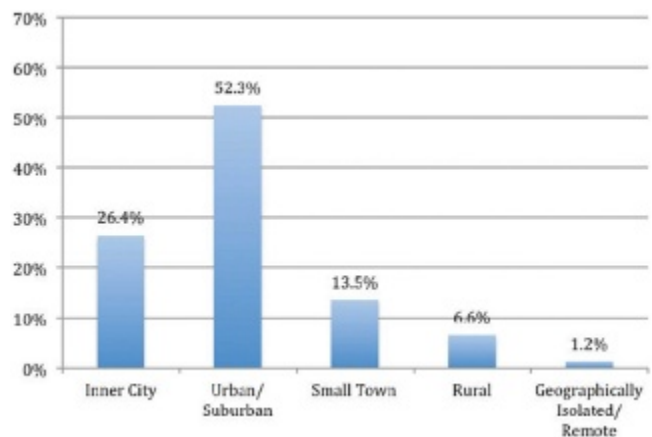


Figure 3. Distribution of respondents based on area of practice.

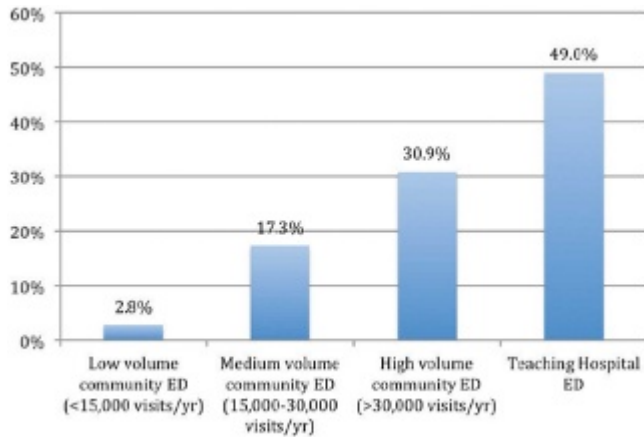


Figure 4. Distribution of respondents based on number of emergency department (ED) visits/year.

more portable and affordable ultrasound units. In addition, several Canadian courses were introduced and offered during this period.

Since this study was undertaken, PoCUS has been established as a core competency in both adult residency training pathways to emergency medicine in Canada. It was first established in 2008 for the Royal College – Emergency Medicine (RC-EM) program followed by the College of Family Physicians – Emergency Medicine (CFP-EM) program in 2010.^{14,15} In 2012, 100% of RC-EM programs and 88% of CFP-EM programs had PoCUS as a formal part of their residency program.¹⁶

At the time of this study in 2007, 21% of respondents had no formal training, and there was only a low level of use for the primary indications of PoCUS. However, respondents projected a rate of over 80% use in the future. With PoCUS a core competency requirement and almost all graduating EM residents having formal training, it is likely that the primary and extended uses will increase. Notably, although only 6% of respondents reported advanced training in 2007, 18% of respondents were classified as innovators on the ETUDE score.

Interestingly, the use of PoCUS for CVC insertion was the lowest of the primary indications despite national guidelines supporting its use.^{17,18} This may reflect a lack of training opportunities for using PoCUS for CVC insertion.

The development of the ETUDE has allowed the categorization of PoCUS adoption according to Rogers' diffusion of innovation.⁹ There was moderate correlation ($r = 0.54$) between when ETUDE was applied to the answers of respondents in comparison with the category the respondents assessed themselves and when not given the definitions of the ETUDE categories. In 2007, the diffusion of PoCUS adoption demonstrated a normal distribution. If a critical mass of PoCUS users is obtained, the adoption will be self-sustaining.⁹ ETUDE scores allowed characterization of the state of PoCUS adoption in 2007 and could be used in future to

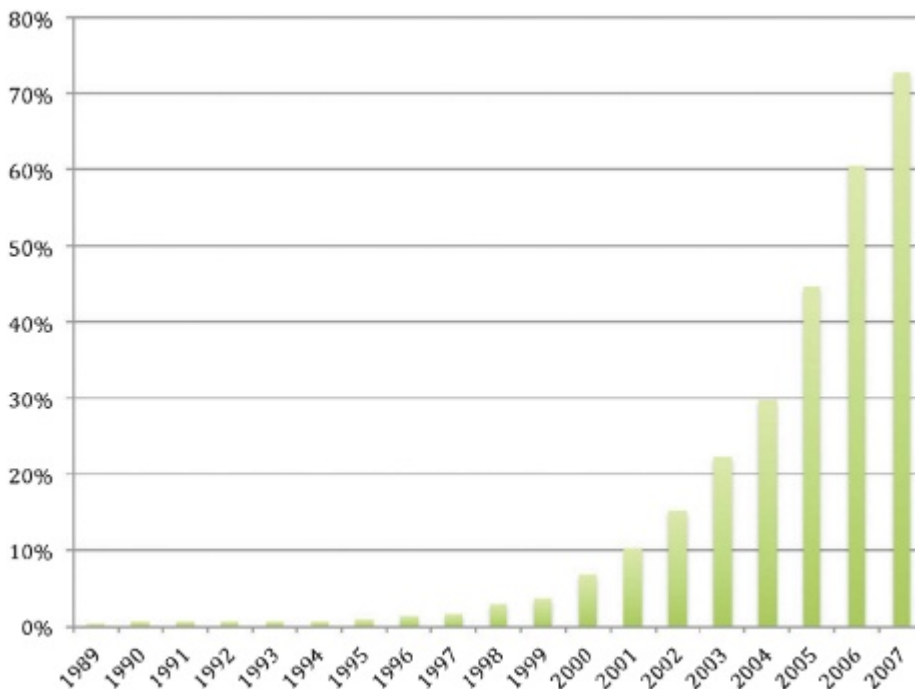


Figure 5. Demonstration of point-of-care ultrasonography (PoCUS) availability with time.

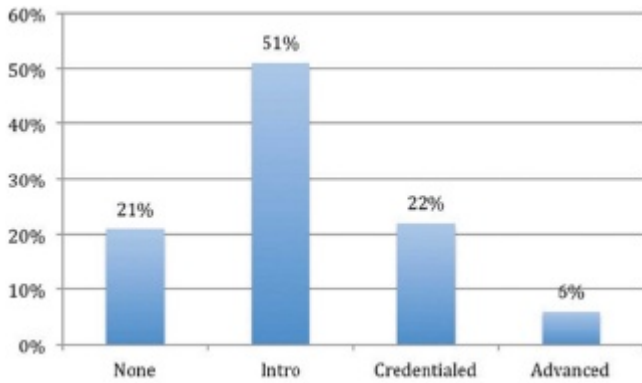


Figure 6. Differences in level of point-of-care ultrasonography (PoCUS) training.

determine whether there are changes in adoption. In addition, ETUDE could be used to compare the state of PoCUS adoption in different countries.

Rogers’ theory is also useful when considering barriers to PoCUS adoption by emergency physicians. In particular, clinical workload in high-volume, urban EDs was a barrier to adoption. This is an example where adoption is influenced by the level of compatibility of PoCUS with assimilation into the daily emergency physician practice in a busy urban ED.⁹ Other factors that can affect adoption include the relative advantage of the adoption (e.g., improves patient care, CVC insertion); the complexity of the adoption (e.g., requires technical training); the trialability, or ability for the user to test the innovation (e.g., sufficient indications to use in the ED); and the observability, the extent to which the innovation is visible to others (e.g., seeing others use it in the ED).⁹ Although emergency physician time with the patient may be increased when performing PoCUS,

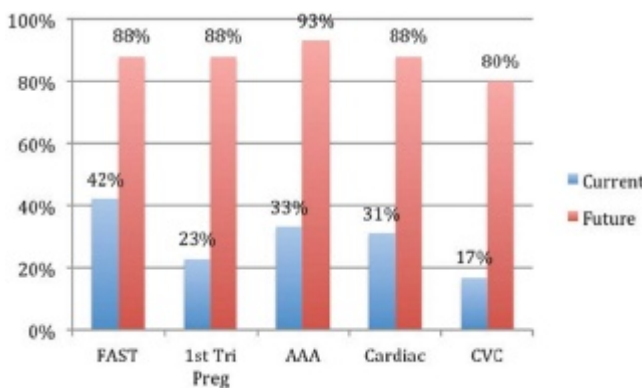


Figure 7. Current and future use of primary indications of point-of-care ultrasonography (PoCUS). AAA = abdominal aortic aneurysm; CVC = central venous catheterization; FAST = focused assessment with sonography in trauma; 1st Tri Preg = first trimester pregnancy.

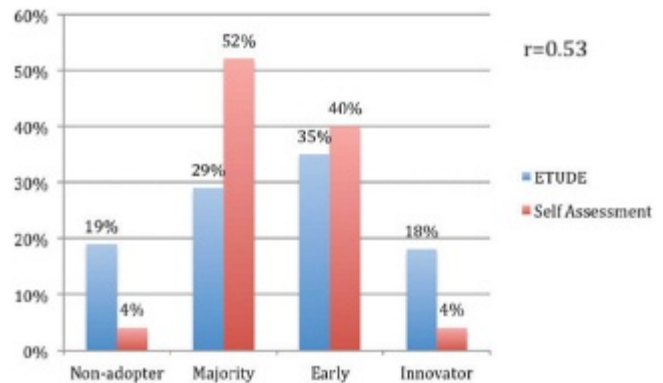


Figure 8. Comparison of the Evaluation Tool for Ultrasound skills Development and Education (ETUDE) category with self-assessment.

the time to diagnosis is improved, the length of stay in the ED is shortened, and, ultimately, patient care is improved.¹⁹⁻²¹ Interestingly, women did not feel that they had adequate training, compared with men, and considered this a barrier to PoCUS adoption ($p < 0.05$). Similarly, emergency physicians working part time compared to full time felt that clinical workload, difficulty recording scans, inadequate access to formal training, supervision and review of findings, and inability to complete 200 scans in a timely manner were all barriers to adoption ($p < 0.05$). Adequacy of opportunities to apply a skill is required not only to obtain competence but also to maintain it over time.²² This affects small/rural EDs, where PoCUS can perhaps have the greatest impact. Emergency physicians more than 42 years old felt that the ease of access to CT scanning was also a barrier to adoption compared to those emergency physicians who were younger ($p < 0.05$). Reasons for this may include the fact that younger physicians are more willing to acquire the new skills required to perform PoCUS compared to older physicians despite the accessibility of CT scanning. Older physicians with increased clinical experience may feel that CT scanning provides a better assessment of patients than PoCUS. Notably, the ease of obtaining a radiology-performed sonogram was not a barrier to PoCUS use. From this study, barriers to PoCUS adoption have been identified within particular groups. Understanding and addressing these barriers are required to improve PoCUS adoption in the future.

LIMITATIONS

The objectives of the study were clearly defined and instruments pilot tested prior to distribution to minimize

errors associated with surveys. The response rate (36.3%), although high for a national survey of Canadian physicians, may reflect responder bias and therefore limit interpretation of the results. However, with 296 responses, this is still the largest survey to determine the state of PoCUS adoption in Canada to date. The CAEP database is based on membership and may not reflect emergency physicians who are practicing but not members of CAEP. The lack of a French survey may also have resulted in the low participation rate from emergency physicians in Quebec. This study was conducted in 2007 and, given the rapid changes in this area, may not reflect the current state of adoption today.

CONCLUSION

We developed a novel, validated tool (ETUDE) that can be used to evaluate uptake of PoCUS over time and to compare its adoption in different countries. Applied to Canadian emergency physicians, we have characterized the state of adoption of PoCUS nationally and identified barriers to adoption. The findings from this study can be used by leaders in PoCUS to guide interventions to enhance adoption in the future. Further studies to determine changes in adoption since 2007 are warranted.

Acknowledgements: We would like to acknowledge the Department of Emergency Medicine, University of Ottawa for support of this research. In addition we would like to thank Dr. Amanda Hanson, Dr. Guy Hebert, and Dr. Louise Rang.

Competing interests: Dr. Michael Woo receives compensation as the Fellowship Director from the Department of Emergency Medicine and has received speaking fees as an EDE2 and CAEP EDTU instructor.

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