Department of Veterans Affairs

Quality Enhancement Research Initiative (QUERI)

Evaluation of Implementation of a National Point-of-Care Ultrasound Training Program

Partnered Evaluation Initiative

(NCT03296280)

September 9, 2016

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1. Specific Aims

Point-of-care ultrasonography (POCUS) is a focused, goal-directed bedside ultrasound examination to guide evaluation and management of patients. POCUS allows clinicians to rapidly detect conditions and reduces the number of diagnostic imaging tests, particularly computed tomography (CT) scans.[1] POCUS can also be used to guide procedures and has been shown to reduce procedural complications and improve procedural success rates.[2] Thus, POCUS improves patient care by expediting diagnosis, especially of life-threatening conditions; reducing radiation exposure from unnecessary diagnostic imaging tests; and minimizing risks of complications from invasive bedside procedures. By reducing the number of imaging tests and time to diagnosis, POCUS reduces healthcare costs.[3]

Despite its potential advantages, increased availability, and supporting evidence, POCUS has not been incorporated into routine clinical practice. For instance, despite both strong evidence from randomized trials and recommendations from national patient safety organizations over the past 20 years, ultrasound guidance for central line insertion has not been universally adopted, and adoption rates may be worse in the VA healthcare system.[4-7] Data from a national survey conducted by our group revealed that only 49% of VA providers use ultrasound guidance to insert central lines compared to 72-88% of non-VA providers, and VA medical coding data revealed only 21% were inserted with ultrasound guidance.[8] Barriers to POCUS use include limited access to ultrasound machines, lack of training, and provider resistance to change.[9, 10]

The VHA Specialty Care Centers of Innovation (SCCOI) and Simulation Learning, Education and Research Network (SimLEARN) are partnering to develop a national POCUS training program to teach VA providers basic POCUS applications. Starting in October 2016, hands-on POCUS training courses will be held at the new SimLEARN National Simulation Center in Orlando. Training of providers has traditionally consisted of a combination of didactics and supervised scanning on live models to learn image acquisition and interpretation skills.

The goal of our partnered evaluation is to assess the effect of the VA's national POCUS training program on local implementation of POCUS use. First, we will evaluate the effectiveness of the 2.5-day POCUS Training Course on provider POCUS skill acquisition and skill retention. Second, we will assess the frequency of POCUS use by providers before and 6 months after participation in the POCUS Training Course. Third, we will survey providers and facilities to identify provider and facility barriers to POCUS use. This evaluation plan will allow us to accomplish the following objectives:

Objective 1. Evaluate provider skill acquisition and retention, and frequency of POCUS use after participation in the POCUS Training Course. Pre- and post-course testing will be used to assess acquisition of knowledge and technical skills to perform POCUS exams. Post-course testing for knowledge and skill retention, and frequency of use, will be performed 6 months after the training course. We postulate that immediate post-course knowledge and skills test scores will improve by ≥25% or to a minimum passing score of >75% for the majority of providers. After returning to their facilities, providers that use POCUS frequently (>3 times/week) will have better skill retention (reduction in 6-month post-course test scores <10%) after 6 months vs. providers that use POCUS infrequently (<3 times/week) who will have worse skill retention (reduction in 6-month post-course test scores >10%).

Objective 2. Determine the effect of the POCUS Training Course and implementation facilitation on facility-level frequency of POCUS use. Facilities with providers that infrequently use POCUS will be eligible to participate in the POCUS Training Course. However, not all facilities will be able to be accommodated in the 1st year of the training program, requiring a facility waiting list. Facilities with providers participating in the POCUS Training Course will be compared to wait-listed facilities with regard to frequency of POCUS use. Using the Brief Provider POCUS Survey, frequency of POCUS use by providers in both participating and wait-listed facilities will be compared. Additionally, coding data will be reviewed to assess frequency of procedures performed with and without imaging guidance and procedural complication rates comparing the two groups of facilities. We postulate that facilities with trained providers will have a higher frequency of POCUS use to guide bedside procedures (>10%) and relatively lower procedural complication rates compared to wait-listed facilities over the same time interval.

Objective 3. Determine provider and facility-level barriers and facilitators to POCUS use. Provider and facility-level barriers will be assessed using 3 tools: Provider POCUS Survey (trained providers), Brief Provider POCUS Survey (wait-listed and participating facilities), and Facility POCUS Survey (all facilities). Differences in barriers reported and their relationship to frequency of POCUS use will be compared. We postulate the frequency of POCUS use by providers will be inversely proportional to the number of provider- and facility-level barriers reported. Further, providers at facilities where barriers to POCUS are relatively low will have greater skill retention after 6 months.

2. Research Plan

Background:

Medical error is estimated to be the third leading cause of death in the United States. Implementation gaps exists for integration of existing technologies to intercept and record medical errors, rescue patients when errors occur, and reduce the frequency of preventable errors.[9] Point-of-care ultrasonography is one such technology that can reduce the frequency of preventable errors but has been slow to integrate into patient care.

Point-of-care ultrasonography improves patient care. The advent of compact, portable ultrasound devices over the past 25 years has given rise to point-of-care ultrasonography (POCUS) – real-time use of ultrasound by clinicians at the bedside to guide the evaluation and management of patients. POCUS can be used to guide invasive bedside procedures, or perform goal-directed diagnostic examinations. Use of POCUS in clinical care has been shown to expedite diagnostic work-ups and reduce the number of required tests, especially computed tomography (CT) scans that are costly and harmful through cumulative radiation exposure; reduce the risk of procedure-related complications, especially for central line placement; and reduce the risk of failed procedures.[1, 2, 10-13]

POCUS is underutilized by providers in current clinical practice. POCUS has changed the standard of care for certain conditions, but gaps in adoption are evident. For example, national safety organizations, including the Agency for Healthcare Research and Quality (AHRQ), National Institute for Health and Care Excellence (NICE), and Centers for Disease Control and Prevention (CDC), have recommended the use of ultrasound guidance to insert central lines since 2001.[5, 14, 15] However, approximately half of providers do not use POCUS to guide insertion of central lines.[4, 8] Data from a recent national survey conducted by our group revealed that only 49% of VA providers use ultrasound guidance to insert central lines compared to 72-88% of non-VA providers, and these numbers likely overestimate the actual frequency of use.[16]

Many veterans would benefit from integration of POCUS in VA healthcare. Based on 2015 inpatient ICD-9 CM coding data for VA hospitals, a substantial number of veterans would benefit from the procedural and diagnostic applications of POCUS. Below are the numbers of Veterans that could potentially be impacted by POCUS, although we anticipate the actual numbers to be greater due to underreporting and under-coding using ICD-9 codes, especially for procedural complications. We believe ICD-10 may differentiate procedures performed with or without imaging guidance, reducing under-coding compared to ICD-9.

Diagnostic Applications			Procedural Applications & Complications			
Heart failure	110,263		Central line placement	35,448	Arterial injury	4
Shock	37,551				Pneumothorax	355
Hypotension	33,208		Thoracentesis	7,423	Pneumothorax	295
Joint effusion	27,026		Paracentesis	7,130	Hemoperitoneum	29
Urinary retention	20,929				Bowel injury	167
Pneumonia	13,794		Lumbar puncture	2,477	Subarachnoid bleeding	8
Pleural effusion	15,603				Subdural bleeding	15
Peritoneal free fluid	10,997		Arthrocentesis	1,904	----	---

Limited provider training is a barrier to POCUS use in clinical care. Slow integration of POCUS in clinical care has been attributed to the limited number of trained providers.[7, 8] Peer institutions, national patient safety organizations, and educational accreditation bodies are increasingly pressuring healthcare systems to incorporate POCUS training into clinical practice. The Accreditation Council for Graduate Medical Education (ACGME) now requires ultrasound training for at least nine different medical specialties.[17] However, most practicing providers, including faculty supervising trainees in ACGME-accredited residencies and fellowships, are unfamiliar with POCUS use because they have not been trained. Despite the ACGME requirements, only 25% of accredited internal medicine residency programs reported having a formal POCUS curriculum in 2013.[18] The provider training gap is likely to persist until large-scale POCUS training programs are developed and deployed in healthcare systems, such as the National POCUS Training Program for the VHA.[19]

The VHA's Simulation Learning, Education and Research Network (SimLEARN) and Specialty Care Centers of Innovation (SCCOI) are collaborating to develop a National POCUS Training Program. Frontline VA providers have voiced the need for the VHA to offer POCUS training, and SimLEARN has been tasked to bridge this gap. SimLEARN's primary goal is to develop an effective training program to teach basic POCUS applications, and SCCOI's primary goal is to support SimLEARN's efforts and facilitate dissemination of POCUS training nationally.

The goals of our proposal are consistent with the goals of SimLEARN and SCCOI. Our evaluation plan will measure the outcomes of the initial implementation of the National POCUS Training Program. First, we will assess the change in provider skill acquisition after participation in the POCUS Training Course, and assess skill retention 6 months post-course. Second, we will compare the difference in frequency of POCUS use and procedural complication rates between facilities that participated in POCUS training and wait-listed control facilities using data reported by providers and system-level coding data. Lastly, by defining the provider and facility-level barriers to POCUS use, our findings will guide our operating partners' efforts to implement POCUS use nationally in the VA healthcare system.

Implementation of a national POCUS training program fulfills several VA national priorities in the VA's Blueprint for Excellence. First, Strategy 2 under Theme 1 in the Blueprint for Excellence is to "deliver high-quality, Veteran-centered care that compares favorably to the best of private sector in measured outcomes, value, access, and patient experience."[20] Successful implementation of POCUS use in the VHA is an opportunity for the VHA to provide high-quality, patient-centered care that is equal to or better than the care provided in the private sector. POCUS use can flourish quickly in the VHA because the patient benefits and healthcare system incentives are well aligned. Second, our project also fulfills Strategy 5 under Theme 2 to "foster an environment of continuous learning, responsible risk-taking, and personal accountability."[20] By encouraging learning of new skills among providers, this project supports the "continuous development of clinical, technical and professional skills to assure the highest levels of competency" among those providing direct patient care. Third, this project meets the requirements of Theme 3 to "advance healthcare innovation for veterans and the country." System-wide implementation of POCUS use in a large integrated healthcare system like VHA has not been previously described. Findings from our project will serve as a national model for system-wide implementation of POCUS. Finally, integration of POCUS use in the VHA meets the Institute for Healthcare Improvement's Triple Aim of "improving the patient experience of care (including quality and satisfaction); improving the health of populations; and reducing the per capita cost of health care," because POCUS improves provider and system efficiency, reduces the number of imaging tests, and reduces patient risk of harm from radiation exposure or invasive bedside procedures.

Our evaluation plan is based on the i-PARIHS framework for implementation of innovations (Figure 1) as modified by Harvey and Kitson.[21] This framework was chosen because it guides us in the assessment of the multiplicity of factors (barriers and facilitators) that can impact the success of POCUS implementation. The PARIHS framework recognizes that successful implementation is the result of the interrelationship of evidence, context, and process. The i-PARIHS framework, in contrast, recognizes the role of facilitation in the implementation process as well as the role of the innovation recipient as they act within the local organizational and system context.[21] The revised framework, acknowledges the role of individual and group agency in not only defining how an innovation is implemented but also how knowledge is diffused given both local and broader organizational contexts. The complexity of these interactions at the local (micro) and system (macro) levels is spanned by the active facilitation of the innovation in each facility which enables innovation spread.[21]

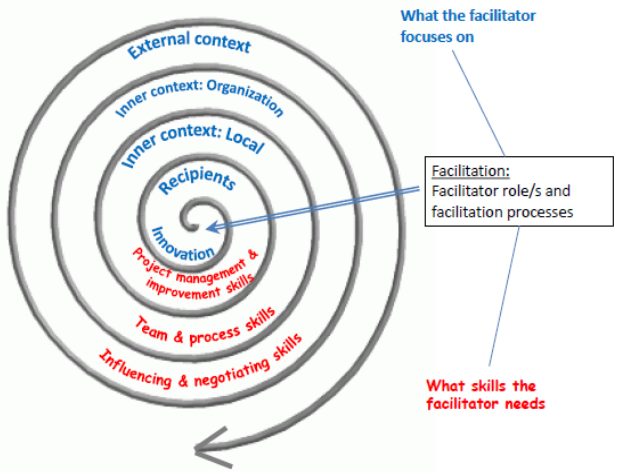

Figure 1. i-PARIHS Framework

The factors for predicting successful implementation of the national POCUS training program are based on the i-PARIHS Framework. The external context to develop the national POCUS training program is driven by patient safety organizations, accreditation organizations, and clinical practice guidelines recommending adoption of POCUS use based on current evidence as well as third party payers denying reimbursement of potentially preventable procedural complications. The inner organizational context of the VHA system includes SimLEARN, SCCOI, and the National Emergency Medicine Field Advisory Group (EM FAG). In addition, providers advocating for the VHA to provide POCUS training are part of this inner context because the initiative to develop a VHA POCUS training program was driven by requests from frontline providers. The inner local facility context includes assessment of the local barriers and facilitators to POCUS implementation that will be performed using the national Facility POCUS Survey completed by Chiefs of Staff

and Provider POCUS Survey completed by VA providers. The recipients are the frontline providers that desire acquisition of POCUS skills, and the facilitation strategy is the 2.5-day POCUS Training Course, monthly conference calls, and SharePoint® website. The assessment tools for the recipients and facilitation strategy include the Pre- and Post-course Knowledge and Skills Tests, Provider POCUS survey, and Course Evaluation. Specific questions will assess the provider's frequency of use and comfort level for POCUS applications.[21]

Factor	Who/What	Assessment Tool
External Context	▪ Patient safety organizations ▪ Accreditation organizations ▪ Clinical practice guidelines ▪ Payers	None
Inner Context: Veterans Health Administration	▪ SimLEARN ▪ Specialty Care Centers of Innovation ▪ National Emergency Medicine Field Advisory Group ▪ Providers interested in POCUS	▪ Monitor VHA policies and requirements for POCUS use by team members that are operating partner leaders or members of the national Emergency Medicine Field Advisory Group
Inner Context: Local VHA facility	▪ Local barriers and facilitators to implementation of POCUS ▪ Providers interested in POCUS	▪ Facility POCUS survey ▪ Provider POCUS survey
Recipients	▪ Providers participating in POCUS Training Course	▪ Pre-/post-course Knowledge & Skills Tests
Facilitation Strategy	▪ POCUS Training Course ▪ Monthly conference calls ▪ SharePoint® website	▪ Provider POCUS Survey ▪ Course evaluation

Methods (Evaluation Plan):

Study Design. A prospective, observational study with wait-listed control facilities will be conducted to: 1) evaluate the effectiveness of the POCUS Training Course on provider skill acquisition and retention, 2) assess the frequency of POCUS use after the POCUS Training Course, and 3) identify provider and facility-level barriers to POCUS use. Providers from facilities that participated in the POCUS Training Course will be compared to wait-listed control facilities with regard to frequency of POCUS use and procedural complications.

Project Preparation. In April of 2016, a national Facility POCUS Survey was sent to all Chiefs of Staff (COS) in the VA healthcare system. Also, the core faculty of the national POCUS training program will gather to pilot test the POCUS Training Course curriculum, Pre-/post-course Knowledge and Skills Tests, and the Provider POCUS Survey during four pilot courses at the SimLEARN National Simulation Center in April, June, July, and August of 2016. Feedback from these pilot courses will be incorporated to fine tune the course and assessment tools. Logistics will be finalized in preparation for full launch of the POCUS Training Course in October of 2016 (FY17) with 2 sessions per month during most months.

Population and Sampling Plan. *Provider Recruitment:* Approximately 200 participants from 15 different VA medical centers will participate in the 2.5-day POCUS Training Course at the National Simulation Center in Orlando. Fifteen VA medical centers will be selected based on data gathered from the VA Facility Survey: 1) COS financial support to pay for travel to Orlando, 2) COS support for release from clinical duties, 3) Facilities with providers that infrequently use POCUS, and 4) Availability of ≥2 portable ultrasound machines at the facility. Facilities (n=22 per preliminary data) reporting no POCUS use will be excluded from this first training cohort due to high likelihood of providers not having access to a portable ultrasound machine, a barrier that has to be surmounted before training ensues. Approximately 10 providers per course will participate in the POCUS Training Course from October 2016 to September 2017. *Provider Sites*: Facilities participating in the POCUS Training Course will constitute the "intervention" sites while the wait-listed "control" facilities will be similar VA facilities based on eligibility criteria above. After closure of the Facility POCUS Survey in June of 2016, intervention and waitlist facilities will be selected. *Provider Specialties:* Novice physician providers without prior ultrasound training or experience primarily from emergency medicine, internal medicine/hospital medicine, and critical care medicine will be invited to participate in the 2.5-day POCUS Training Course. Completion of all surveys and skills assessments will be a course requirement disseminated by SimLEARN in the invitation letter and emphasized at the start of the POCUS Training Courses.

POCUS Training Course. The 2.5-day course will combine focused didactics and supervised hands-on ultrasound scanning practice with live and simulation models. A standard provider to core

faculty ratio of 3-4:1 will be maintained. Each course will have a maximum of 10 providers and minimum of 3 faculty.

Data Sources and Assessment Tools. Here is a summary of the data sources and assessment tools.

Assessment Tools	Source	Data Elements	Timing
VA Facility POCUS Survey	Chiefs of Staff/ Service Chiefs	1. Provider and facility-level barriers	Pre-course and 18 months
POCUS SkillsTest	Course Participants	1. Image acquisition skills 2. Image interpretation skills	Pre-course, immediately and 6 months post-course
POCUS Knowledge Test	Course Participants	1. POCUS knowledge	Pre-course, immediately and 6 months post-course
Provider POCUS Survey	Course Participants	1. Frequency of POCUS use 2. Self-efficacy 3. Procedural complications 4. Provider and facility-level barriers	Pre-course, 6 months and 18 months post-course
Brief Provider POCUS Survey	Providers at both participating & wait-listed facilities	1. Frequency of POCUS use 2. Self-efficacy 3. Procedural complications	Pre-course and 18 months
Coding Data Review	VHA Corporate Data Warehouse	1. Frequency of POCUS use for procedure guidance 2. Procedural complications	Pre-course, 18 months
Course Evaluation	Course Participants	Feedback on training course: 1. Lectures 2. Hands-on training sessions 3. Faculty	Immediately post-course
Monthly Conference Calls	All Course Participants and Faculty	Narrative summary of: 1. Provider and facility-level barriers 2. POCUS training course feedback	Every 1 month
SharePoint® website	All Course Participants and Faculty	Narrative summary of: 1. Provider and facility-level barriers	Open access for all course participants and faculty

Pre-course Assessments. *VA Facility POCUS Survey:* This survey was disseminated in April 2016 to COS's by the HAIG (Healthcare Analysis and Information Group) to gather baseline data on the use of POCUS, assess provider training needs, and identify potential barriers/facilitators to POCUS use at individual facilities. The survey will be repeated at 18 months. *Pre-course Provider POCUS Survey:* Prior to starting the POCUS Training Course, providers will complete the Pre-course Provider POCUS Survey using REDCap™ survey software. The Pre-course Provider POCUS Survey will be available only to registered providers. The survey should be completed before arriving at the National Simulation Center, but staff will ensure completion by all providers before starting the course. This survey will assess the pre-course frequency of POCUS use, known procedural complications, provider self-efficacy (i.e., confidence in POCUS), and provider and facility-level barriers to POCUS use. Provider demographic data will also be gathered (gender, age, primary specialty, practice setting, percentage of time providing direct clinical care). The provider questions were developed by POCUS subject matter experts and education specialists, and self-efficacy scales are based on published scales.[22] *Pre-course Knowledge and Skills Tests (Appendices 8 and 9):* To assess baseline knowledge and skills, providers will take an electronic Pre-course Knowledge Test and hands-on Pre-course Skills Test using standardized checklists. The tests are based on similar tools used by national professional society POCUS training courses and input from our multidisciplinary group of core faculty. Clinical knowledge relevant POCUS applications, image acquisition, and image interpretation skills will be assessed. The Skills Test will be administered by the same core faculty to ensure consistency in grading. *Course Evaluation:* A standard course evaluation survey administered by Employee Education System (EES) will gather feedback on the course structure, facilities, and faculty. *Brief Provider POCUS Survey:* This survey will be administered by the HAIG (Healthcare Analysis and Information Group) to gather facility-level comparison data from physicians specializing in emergency medicine, critical care medicine, and internal medicine/hospital medicine that are not participating in the POCUS Training

Course, but practicing at both participating and wait-listed facilities. This survey will assess providers' frequency of POCUS use, known procedural complications, provider self-efficacy (i.e., confidence in POCUS), and barriers to POCUS use. *Coding Data Review:* Using Coding Data from the VHA Corporate Data Warehouse, we will assess frequency of procedures performed with and without imaging guidance and rates of specific procedural complications. The rationale to focus on procedures is 1) POCUS diagnostic applications are not currently coded, 2) Procedural coding is relatively more specific, and 3) Reduction on procedural complications has the strongest evidence base.

Post-course Follow-up. *Monthly Conference Calls:* After participation in the POCUS training course, providers will be invited to participate in monthly conference calls led by one of the core faculty. The conference calls will be unstructured discussions to address technical questions, gather feedback on provider and facility barriers encountered to POCUS use in clinical practice, and discuss potential short-term and long-term solutions to overcome barriers. Conference calls will be recorded and transcribed. Faculty will also keep notes. These qualitative data will be reviewed and presented in the final report to inform our operating partners and the VHA about provider experiences that will be important for system-wide implementation. *SharePoint® website:* A website will be established on the VA intranet for the POCUS Training Program by SimLEARN to facilitate dialogue between faculty and providers, and amongst providers. Documents from the *SharePoint® website* will be archived and synthesized for inclusion in the final project report.

Post-course Assessments. *VA Facility POCUS Survey :* This survey will be repeated 18-months into the grant period (April 2018) to assess for changes in POCUS use, provider training needs, and barriers/ facilitators to POCUS at individual facilities. *Post-course Provider POCUS Survey:* The Post-course Provider POCUS Survey will contain additional questions about facilitation (monthly conference calls, SharePoint website) compared to the pre-course Provider POCUS survey. The post-course survey will be distributed electronically to providers at the time of the 6-month post-course Skills and Knowledge Test and at 18 months. *Post-course Knowledge and Skills Test (Appendices 8 and 9):* An immediate Post-course Knowledge and Skills Test to assess skill acquisition and a 6-month Post-course Knowledge and Skills Tests to assess skill retention will be conducted. The same Knowledge and Skills Test templates will be used pre- and post-course. However, the 6-month Post-course Skills Test will be administered remotely using REACTs™ simulation services, a program designed specifically for remote ultrasound training. REACTs™ will allow the faculty to see the ultrasound probe position on the body by camera while simultaneously seeing the ultrasound images on the screen. Paid volunteers that may be administrative personnel or non-participating providers will be used for the 6-month Post-course Skills Test. Each patient volunteer will receive a $50 incentive each time they volunteer for a Post-course Skills Test. If REACTs™ is not available, an alternative strategy will be to use Microsoft Lync® to videoconference. *Brief Provider POCUS Survey:* The HAIG (Healthcare Analysis and Information Group) will be repeat administration of the Brief Provider POCUS Survey to providers at both participating and wait-listed facilities after 18 months to asses change in frequency of POCUS use, known procedural complications, provider self-efficacy (i.e., confidence in POCUS), and barriers to POCUS. *Coding Data Review:* Coding data from facilities of providers that participated in the POCUS Training Course and wait-listed facilities will be reviewed at 18 months post-course.

Data Collection Procedures: The Facility POCUS Survey and Brief Provider POCUS Survey have been developed by the HAIG (Healthcare Analysis and Information Group) who will administer the survey and collect survey responses. The Pre-course and Post-course Provider POCUS Surveys and POCUS Knowledge and Skills Tests will be administered and collected using REDCap™ survey software available through VA servers. The Course Evaluation will be administered by the Employee Education System using the Talent Management System (TMS) at the conclusion of the POCUS Training Course before providers depart the National Simulation Center. Coding data from the VHA Corporate Data Warehouse will be collected and analyzed with SAS. Field notes collected during the monthly conference calls led by core faculty and from the SharePoint® website will be analyzed qualitatively.

Data Analysis:

Objective 1. Evaluate provider skill acquisition and retention, and frequency of POCUS use after participation in the POCUS Training Course. The statistical approach used for this specific aim is hierarchical repeated measures (mixed effects) analysis. The repeated learner assessments collected for this aim have a natural hierarchical structure with level 1 being the repeated assessment, level 2 being the individual learner, and level 3 being the facility/organization with which the individual learner is associated.

Level 1 will capture within subject variation while level 2 captures the between subjects variability, and level 3 captures the between organizations variability. Our analyses will enable us to identify key determinants associated with our outcomes and our estimated mixed effects models will have the following general form:

$$E(Y(i,j,k))=f^{-1}(\alpha+X(i,j)\,\beta + Z(j)\,\gamma + \mu(j) + W(k)\eta + \varepsilon(i,j,k))$$

Regression models will be estimated using the PROC MIXED procedure in SAS 9.4. We will conduct diagnostic tests to ensure appropriate model specifications and we will also estimate intraclass correlation coefficients relating the percent of variation in the assessment score explained by individual learner characteristics (demographics) and by organizational-level factors.

Variable	Definition	Project Data Elements
Y(i,j,k)	learner assessment score for learner i within organization j, at time k	Post-course and 6-month Knowledge and Skills Test scores, Self-efficacy, Self-reported frequency of POCUS use
X(i,j)	vector of learner characteristics	Provider demographics (age, post-graduate year, specialty), Pre-course knowledge/skills/self-efficacy
Z(j)	vector of organization-level variables	Barriers/facilitators identified from Facility POCUS Survey, Provider POCUS Survey
μ(j)	organization-level random intercept	N/A
W(k)	time element	W = 0 post-course, W=1 at 6-month assessment
ε(i,j,k)	error term	N/A
f(·)	functional form for f(·) will be determined by the data generating process of the learner assessment score	N/A

Objective 2. Determine the effect of the POCUS Training Course and implementation facilitation on facility-level frequency of POCUS use. The frequency of POCUS use by each provider and by each facility would ideally be measured quantitatively using encounter or coding data. Capture of POCUS usage is an active area working groups are addressing. In the regression model for this objective, the outcome variable will be the difference in self-reported frequency of use by providers from the Brief POCUS survey administered by the HAIG at 0 and 18 months. Predictor variables will include the vector of organization-level barriers and facilitators, whether the facility participated in POCUS training or was wait-listed, and a variable that categorizes the facility's frequency of POCUS use at the start of the study (e.g., 0-25%, 26-50%, etc.).

Objective 3. Determine provider and facility-level barriers and facilitators to POCUS use. *Descriptive Analysis:* The Facility POCUS Survey will be analyzed for the following: number of responding VHA facilities that use POCUS; reasons why facilities are not using POCUS; for those facilities using POCUS the following: how POCUS is specifically being used (both diagnostic and procedural applications), what new POCUS applications facilities would like to incorporate in the future, the clinical areas that are using POCUS, the specialties of the providers performing POCUS including whether trainees use it and who trains them; do local policies or practice guidelines exist for POCUS, is there a formal credentialing process for POCUS and/or a competency evaluation; is a quality assurance process for POCUS in place; how is workflow documented and captured; and how are providers trained in POCUS. These data will be used to guide the implementation strategies to be used in the monthly conference calls and on the SharePoint website. The barriers to POCUS use in the participating and wait-listed facilities will be captured in the Brief Provider POCUS Survey and VHA Facility POCUS Survey that will both be repeated at 18 months. Categorical variables will be compared using chi-squared test and continuous variables using t-test or Mann-Whitney if data are not normally distributed. Relevant variables will be used in the models described in Objectives 1 and 2 for the facility level. *Qualitative Analysis:* In addition to the descriptive analysis of the Brief Provider POCUS Survey and the VHA Facility POCUS Survey, the core faculty will interface with providers during monthly conference calls to create field notes to record the barriers/facilitators to POCUS implementation. These activities will also be recorded to facilitate verification of field notes. Dr. Soni will maintain a database of the barriers and facilitators. He will group them first by known themes and add to the list of themes as new barriers and facilitators are revealed. The investigative team will group these barriers that should be addressed at a national policy level vs. those that should be addressed at a local level using active facilitation. This qualitative description of barriers and facilitators will be part of the final report to SimLEARN and SCCOI,

but will also be relayed in real-time as new barriers are identified. Solutions to overcoming barriers described by facilities will be coded as well.