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An Analysis of Gaps in Resident Performance Data and Competence Determination in Surgical
Training

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ABSTRACT

Medical training is evolving with technological advancements, but non-interoperable hospital systems and unstandardized resident performance documentation create challenges for medical educators and researchers in evaluating whether skills developed during resident training translate to clinical performance. Specifically, these challenges arise from training and assessment measures that differ by specialty and institution, reporting across multiple systems, and inconsistent and unstandardized documentation. This study aimed to identify resident procedural performance documentation systems and barriers to accurate, consistent data tracking for Central Venous Catheterization (CVC) at a large academic medical center. Thirty-minute semi-structured interviews were conducted with 5 medical residents, 1 fellow, 1 attending physician, and 2 program coordinators at a large academic medical center. Interviews were audio-recorded and transcribed, then analyzed using thematic analysis. Thematic analysis identified key themes of (1) procedural training is front-loaded, unstandardized, and non-evaluative, (2) formal procedural skill reassessment is absent, (3) clinical performance is not defined or documented in a systematic way, and (4) complication tracking is fragmented and informally connected to resident training. Residents' CVC experience was inconsistently documented across the currently used systems, and clinical performance was rarely documented in a systematic way. Additionally, explorations of CVC training revealed infrequent training reinforcement and very minimal evaluations beyond informal observation of the resident performing on a mannequin. These findings highlight how disconnected and unstandardized documentation practices limit the usability of procedural performance data in resident competency assessments. Together, the disconnect between training, clinical performance, and

documentation complicates resident CVC competence determinations and identifications of skill decay. Although this study is specific to a single institution, it highlights general challenges faced in medical education, specifically in accurately evaluating resident clinical performance using existing systems.

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Chapter 1

Introduction

There is growing concern around medical resident training and preparedness to perform procedures in the United States (Cadish et al., 2016; Collins et al., 2020). Medical errors, defined as preventable adverse effects of medical care, are a leading cause of death in the United States, contributable to the cause of about 98,000 deaths per year (Soori, 2024). Improper training is a factor leading to medical errors that cause patient harm, so ensuring adequate, on-going training is critical to maximizing patient safety (Soori, 2024).

Specifically, there is a need to look at resident training for Central Venous Catheterization (CVC), also referred to as central line placement, because of the high complication rate. Over 5 million central lines are placed annually in the US, and up to 39% of patients experience adverse effects (Yovanoff et al., 2018). Importantly, the experience of the doctor performing the CVC procedure has been linked to complication rates (Kehagias et al., 2023; Pepley et al., 2017; Smith et al., 2010). A challenge related to CVC training is that there is no standardized training curriculum, training evaluation, or competency assessment (Cameron et al., 2021; Segall & Bennett-Guerrero, 2016; Soffler et al., 2018), leading to institution-specific training, performance assessments, and program requirements. While the medical field is shifting to a competency-based model of surgical education (Bhatti & Ahmed, 2015), clear and standard competency definitions, assessments, and maintenance methods across the nation are lacking for CVC education.

Traditional training methods of central line placement are outdated, utilizing static manikins and unstandardized checklists, global rating scales, knowledge assessments, or other training assessment methods (Soffler et al., 2018). This creates variable and unstandardized reports of performance related to CVC placement. Recently, there have been strides forward in CVC training with simulation-based learning. Simulators allow for hands-on, practical training without an actual patient. Research shows that simulation-based training leads to improved patient, resident performance, and clinical outcomes, and this has been demonstrated for CVC training (Elendu et al., 2024; Ma et al., 2011). Simulation-based training (SBT) allows repeated practice with specific feedback, called deliberate practice (Soffler et al., 2018), which has been shown to be more effective for procedural skill acquisition than traditional training methods (Ericsson, 2015; McGaghie et al., 2011).

Importantly, training and procedural skill acquisition in the medical field aligns with broader theories that demonstrate skill acquisition follows a learning curve (Pusic et al., 2015). Additionally, skill decay has been shown to occur for surgical skills, suggesting that when training stops, performance declines and may drop below competency levels (Laack et al., 2014; Pusic et al., 2015). Therefore, training reinforcement is critical to maintain high levels of competency for surgical skills, and advancements in training are only as effective as how often training occurs.

Simulation-based training and competency-based frameworks emphasize deliberate practice, performance feedback, and continued assessment to be effective, which assumes there is a method to measure and evaluate performance in both training and clinical procedures. In practice, because of a lack of a standard training assessment metric or competency determination, how residency programs assess performance is variable (Goyal et al., 2018; Jones

et al., 2017). It is unclear how training, supervised clinical experience, and procedural performance are utilized to determine when residents are deemed competent or how skill decay is identified and addressed.

There are a few systems hospitals currently use to track resident experience and document clinical data. The Accreditation Council for Graduate Medical Education (ACGME) requires resident experience to be documented through case logs, which are key components of resident competency assessments (Cadish et al., 2016; Collins et al., 2020; Wolf et al., 2017). Multiple studies, however, have identified errors and high levels of inaccuracy within ACGME case logs, presenting concern regarding the reliability of using these logs to evaluate resident procedural experience (Cadish et al., 2016; Gill et al., 2007; Nygaard et al., 2015; Wolf et al., 2017). Medical institutions also use an Electronic Health/Medical Record System (EHR/EMR) to record patient data, as well as other program-specific tools, such as complication tracking systems or third-party residency management software (RMS) (Kwan et al., 2024; Nygaard et al., 2015). Usually, these systems are fragmented and do not communicate, making it challenging to review and manage clinical data.

This system disconnect makes mapping holistic clinical data across the EHR, ACGME case log system, and other hospital systems difficult. While integration of the ACGME and EHR systems has been done as a quality control mechanism to improve case log data accuracy, limited application of integration to link resident training to procedural outcomes has been done. Even if quality control is implemented, the question of if ACGME case logs or the EHR provide relevant data needed to assess resident clinical performance remains, especially related to assessing the effectiveness of novel training methods.

While prior work has examined simulation-based training and hospital documentation systems independently, there remains a critical gap in understanding how training data, clinical performance, and patient outcomes can be systematically integrated and utilized to enable objective, long-term assessments of procedural competency. Simulation technologies can continue to advance and improve initial training but assessing how skills acquired in training translate to clinical procedures is a critical step to ensure patient safety. The goal of this study is to identify the current CVC training and assessment practices, what data is documented within the currently used systems, where and how resident clinical performance is recorded, if patient outcomes are used to assess or improve resident performance, and the barriers to tracking and monitoring this data within hospital systems to ultimately investigate how skill acquisition, retention, and transfer occurs for CVC at a single institution.

Research Objectives

The objective of this thesis was to explore how resident CVC competency is developed, assessed, and systematically determined at a large academic hospital. Specifically, the investigation surrounded the following research questions (RQ):

RQ1: How do residents and faculty describe current training and assessment practices for CVC, what criteria are used to determine competency, and to what extent are these practices standardized across the institution?

This question aims to characterize the structure and consistency of training and evaluation processes. It is hypothesized that while simulation-based training and formal assessment mechanisms exist, competency determination remains largely subjective and varies

across departments and evaluators. Additionally, it was hypothesized that competency determinations revolve around ACGME case logs and faculty comments from procedural evaluations (Meliagros et al., 2023; Moureau et al., 2013), but specific institution determinations of competency were desired to be discovered.

RQ2: How is resident performance currently documented across clinical and accreditation systems, what are the reporting requirements exist, and what gaps limit comprehensive tracking of performance data?

This question investigates how data related to resident performance is captured and managed across systems such as ACGME case logs and electronic health records. It is hypothesized that performance data is distributed across multiple systems with limited integration, resulting in incomplete and inconsistent representations of resident competency.

RQ3: How are procedural outcomes and complications tracked, and to what extent are these data used to assess or inform resident performance and training?

This question examines whether patient outcomes are systematically linked to resident performance and whether such data are used to guide competency assessment or remediation. It is hypothesized that while complications are tracked at the institutional level, they are not consistently attributed to individual residents or integrated into training feedback processes.

Chapter 2

Literature Review

Current Resident Training

Considerable attention exists around resident preparedness and competence to perform clinical procedures in the United States (Cadish et al., 2016; Collins et al., 2020). Medical errors-- preventable complications of medical care-- remain a significant problem in the United States, contributing to about 98,000 deaths per year (Soori, 2024). Improper training is a key factor leading to these medical errors that cause patient harm (Soori, 2024). In academic medical centers, residents navigate heavy workloads within 80-hour time capped weeks, having to balance delivering patient care, attending educational lectures, and completing administrative tasks. This workload means that getting as much hand-on procedural training in a variety of complex settings, especially for procedures with high complication rates, is challenging for residents, but critical to resident success in procedure performance.

One common procedure with significantly high mechanical complication rates is Central Venous Catheter (CVC) placement, also called central line placement. Of the over 5 million central lines placed annually in the US, around 39% of patients experience adverse effects, like arterial puncture, pneumothorax, or infection (Yovanoff et al., 2018). CVC is a common procedure in which a central line is placed in one of three access sites to monitor or provide medication and nutrients to patients (Yovanoff et al., 2018). This procedure is performed by residents across various specialties, commonly anesthesiology, general surgery, internal medicine (IM), and emergency medicine (EM) (Yee et al., 2024). Surveys have identified that resident confidence with performing central venous catheterization is lower than other

procedures, and confidence has been linked with competence (Hayat et al., 2021; Hicks et al., 2000). These high complication rates have highlighted a need in recent medical research for improved CVC training.

The experience level of the doctor performing the central line placement has been linked to complication rates (Kehagias et al., 2023; Pepley et al., 2017; Smith et al., 2010). The risk of complications is decreased with the experience of the person performing the procedure (Aminizadeh et al., n.d.; Kehagias et al., 2023). One study found that mechanical complications during central venous catheterization procedures are twice as likely when performed by a surgeon who has inserted central lines less than 50 times, indicating the importance of hands on experience in CVC training (Yovanoff et al., 2018). Additionally, another study found that 86% of general surgery residents reported that they did not feel comfortable performing a specific procedure alone if they had performed that procedure 20 times or less (Suwanabol et al., 2009). The variability in complication rates and comfortability across operator experience levels highlights how interactions between procedural volume, hands-on training methods, and number of procedures performed affect patient outcomes.

Therefore, there exists a need to investigate resident preparedness to perform CVC procedures. Traditional surgical training follows the apprenticeship model of “see one, do one,” but the medical community is moving away from this model to a competency-based model of surgical training (Bhatti & Ahmed, 2015). The traditional apprenticeship model involves subjective competency assessments, which credentialing agencies and the public have extended concern over (Bhatti & Ahmed, 2015). In response, the main residency accreditation program in the United States, the Accreditation Council for Graduate Medical Education (ACGME), established six core competencies that all residents should be evaluated for: patient care, medical

knowledge, practice-based learning and improvement, systems-based practice, interpersonal and communication skills, and professionalism (Bhatti & Ahmed, 2015). These form milestones that residents are evaluated against throughout their training.

In response to the high complication rate of CVC procedures and transition to a competency-based model of surgical training, there exists a need to improve the current outdated training methods for CVC placement. It is important to note that a standardized training curriculum for central line insertions does not exist (Cameron et al., 2021). The current CVC training methods typically utilize a static manikin that lacks in accounting for anatomical patient differences (Yovanoff et al., 2018). These differences in patient anatomy are important to account for in training because specific patient anatomy is found to be a contributing factor to complications in CVC procedures (Yovanoff et al., 2018). Training on manikins also often does not allow for central line placement to be performed all the way through without damaging the manikin (Knaf et al., 2026), meaning that training on all steps of the procedure cannot occur because it is unrealistic to continuously damage and purchase new mannikins.

Additionally, traditional CVC training assessment methods need to be investigated. A standardized performance grading method to assess CVC placement skills does not exist. Traditional methods require significant faculty time for evaluations because an instructor is required to be present to give qualitative feedback (Pepley et al., 2017). These instructors may experience “examiner burnout” and thus fail to give fully comprehensive feedback, highlighting a need for both better training and feedback systems (Pepley et al., 2017).

Instructors use methods like non-standardized checklists to grade performance in training, leading to institution-specific competency requirements and assessments (Segall & Bennett-Guerrero, 2016). One study found that nine different checklists were used for nine

recent studies, ranging from 7 to 30 checklist elements (Segall & Bennett-Guerrero, 2016).

Checklists may be more general or specific, but tend to include things like consent obtained, setup, hand hygiene, applied anesthesia, proper ultrasound use, needle insertion angle, and confirm entry with aspiration (Ma et al., 2012; H. M. Tzamaras et al., 2024). The variability in checklist steps reveals an underlying uncertainty of what the essential key components of a CVC procedure are and indicates that these steps are not widely agreed upon, further complicating evaluations for CVC competence (Segall & Bennett-Guerrero, 2016). Other assessment modalities for CVC training include global rating scales, knowledge assessments, number of needle passes, or a mix of them (Soffler et al., 2018). Each assessment method measures competency slightly differently, and certain assessment measures may overestimate or underestimate resident competence. Research shows that checklists tend to overestimate competency compared to entrustment measures like global skills assessments and entrustment scores (Longino et al., 2026).

Simulation Based Training Related to Skill Acquisition and Retention

The shortcomings in CVC manikin training and the associated faculty-evaluation method are being addressed by advancements in CVC simulation training (Soffler et al., 2018).

Simulating the procedure is enticing because it does not require or risk an actual patient (Soffler et al., 2018). One advancement is in Virtual Reality (VR) training to teach and assess motor skills related to CVC placement outside actual clinical procedures (Mohamadipanah et al., 2016). These methods are easily accessible and can provide precise feedback to trainees (Soffler et al., 2018). Virtual reality has been shown to improve needle insertion time, idle time, and hand

smoothness during CVC procedures (Mohamadipanah et al., 2016). Related to local patient anatomies, it has been found that the incorporation of haptic feedback in simulators (feedback that simulates touch and forces) has been found to improve learner performance (Ström et al., 2006). Traditional manikins cannot incorporate this, but virtual reality and other simulation advancements can.

Another simulation advancement that incorporates haptic feedback is the Dynamic Haptic Robotic Trainer (DHRT+). The DHRT+ device allows for a more tailored training by utilizing an actual CVC tool kit, a patient vitals simulation, a mock ultrasound probe, sensors to track tool precision, and a haptic robotic arm that simulates the effect of changing patient anatomies on the force required for needle insertion (Tzamaras et al., 2024). The DHRT+ tracks key metrics like aspiration rate, number of needle insertions, needle centering in the vein, angle of insertion, and puncture (Tzamaras et al., 2024). Trainees are provided with an overall performance score and a performance summary screen that explains performance on key metrics (Tzamaras et al., 2024). The DHRT+ system eliminates faculty time for training assessments because the system itself provides immediate, personalized feedback (Yovanoff et al., 2018). It has been demonstrated that the DHRT is as effective as manikin training, even significantly improving learning over time (Tzamaras et al., 2024). A key limitation to simulation advancements is that most studies assess improvements in resident performance on simulators rather than actual clinical settings, limiting the understanding of transferability of the skills gained in simulation to actual procedures (Soffler et al., 2018).

Research shows that simulation-based training (SBT) leads to improved patient, resident performance, and clinical outcomes, and this has been demonstrated for CVC training (Elendu et al., 2024; Ma et al., 2011). Simulation based training allows for practice that can occur over and

over again with specific feedback, called deliberate practice (Soffler et al., 2018). Deliberate practice is a learning method with nine elements that include highly motivated learners, a well-defined task(s), focused repetitive practice, feedback, monitoring and error correction, and evaluation and mastery performance (McGaghie et al., 2011). Compared with traditional learning approaches, simulation-based deliberate practice has been demonstrated to be more effective for procedural skill acquisition (Ericsson, 2015; McGaghie et al., 2011). Research shows deliberate practice through simulation training advances skill acquisition and retention compared to traditional training methods (Laack et al., 2014; Soffler et al., 2018).

It is important to note that feedback is key in simulation learning to enforce correct behaviors through correcting errors (Elendu et al., 2024). Research shows that simulation training without feedback is not sufficient in increasing procedural skills (Oestergaard et al., 2012; Tejos et al., 2021). In fact, simulation without error correction can actually lead to the enforcement of bad habits (Oestergaard et al., 2012), which is actually doing more harm than good.

Furthermore, procedural skill acquisition in medical training aligns with broader frameworks of motor learning and mastery development, which emphasize performance improvement through repeated exposure, deliberate practice, and feedback over time (Bhatti & Ahmed, 2015). These frameworks explain that skill acquisition follows a learning curve (Pusic et al., 2015). Performance rapidly increases during early practice with simulation training, deliberate practice, and repeated exposure (Pusic et al., 2015). Trainees vary in the rate at which they acquire and retain these skills due to individual differences in learning (Ericsson, 2015). Performance is shown to reach a “competence” threshold, and residency programs typically stop training after competence is reached. However, skill decay is known to occur for surgical skill

(Pusic et al., 2015). When training stops, performance declines and may drop below competency levels, representing by a “forgetting” or “skill degradation” curve (Pusic et al., 2015). Therefore, maintaining competency in surgical skills requires training reinforcement and simulation training is only as effective as how often it is being done.

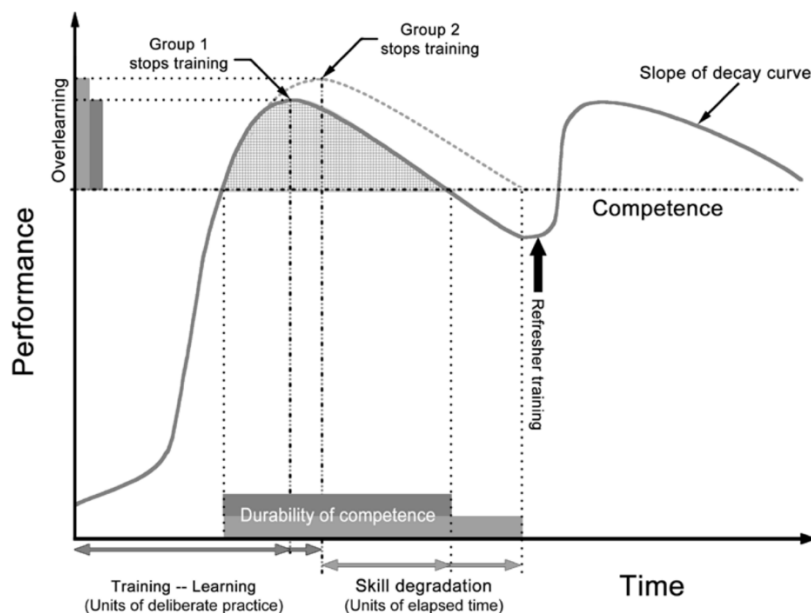


Figure 1. Performance Versus Time Experience Curve (Pusic et al., 2015)

The learning curve and related skill decay reveal the importance of evaluating procedural performance and outcomes in both early training and throughout physician careers. Research has found that attending physician clinical skills are also affected by this skill decay (Barsuk et al., 2016; Hafford et al., 2013; Kogan et al., 2010). When tested on simulators using a 29-component checklist for CVC insertion, only 18-24% of experienced attending physicians met or exceeded the predefined passing score (Barsuk et al., 2016). This research demonstrates how even experienced physicians can miss key steps of CVC procedures, and skill re-evaluation or refreshers is important to maintaining competency levels of attending physicians as well as

residents. The uneven and poor performance by attending physicians in this study is concerning because these attending physicians are the ones supervising residents and fellows during clinical procedures and often train residents in these procedures. If these attendings are missing key procedural steps, their training and assessments of resident performance in key steps is likely also lacking.

Skill acquisition and deliberate practice rely on performance feedback, which assumes that there is a method to measure and evaluate performance in both training and clinical procedures. However, “performance” is defined in different ways throughout literature. Research comparing traditional CVC training methods and novel CVC training methods often compares relative performance using checklists of CVC placement steps, the time for the procedure to be completed, and asking residents key quality indicators (Barsuk et al., 2009; Britt et al., 2009; Laack et al., 2014). Researchers also track quality indicators like the average sticks to cannulation, inability to place the line, if a senior resident had to take over the procedure, as well as identification of complications like arterial puncture or blood stream infection (Britt et al., 2009). Actual simulation training devices, like the DHRT, provide assessments of resident performance through computer vision and sensors to provide performance metric indicators, but assessing these metrics in actual clinical practice is challenging.

Competency Assessments

The variability in metrics used to evaluate clinical performance stems from the lack of a standardized CVC competency assessment (Soffler et al., 2018). The typical competence assessment in resident training is based on the number of procedures performed (Moureau et al.,

2013; Soffler et al., 2018). The number of procedures a resident performs is tracked through ACGME case logs, which are the primary method to assess surgical training experience and are used as a representation of surgical “competence” to graduate from residency (Cadish et al., 2016). In the absence of a standard competency or maintenance of competency assessment tool, the number of procedures performed is an even greater factor in competency determinations than actual performance level (Meliagros et al., 2023). Therefore, there are arguments over whether case volume is an adequate determination of clinical competency (Moureau et al., 2013). Research suggests that clinical competency may be better determined by clinical observations during actual procedures using evaluations like a global rating scale (Moureau et al., 2013).

In practice, institutions have determined clinical competency progression through Clinical Competency Committee (CCC) meetings (Goyal et al., 2018; Hauer et al., 2015). All ACGME-accredited residency programs are required to have a Clinical Competency Committee that meets twice a year to assess resident performance on ACGME milestones (Goyal et al., 2018; Hauer et al., 2015). How these committees determine competence progression may vary. One institution looked at the number of procedures logged, general comments in procedure evaluations, and resident self-assessment of procedure milestones (Meliagros et al., 2023). A study of 34 residency programs found that these meetings are either oriented around problem identification to identify the residents that are struggling, which most predominantly are, or development (Hauer et al., 2015). Objective assessments that theoretically could be used in these committee meetings to assess resident performance are end of shift evaluations, monthly rotation evaluations, procedure logs, direct observation checklist, monthly staff meeting resident review summary comments, in-training examination, simulation center sessions, unsolicited feedback,

or other institution measures (Goyal et al., 2018). One of the issues with assessments in these meetings is the timeliness and ease of access to data (Goyal et al., 2018; Hauer et al., 2015).

Another challenge with CCC evaluations of competency progression is that ACGME milestone ratings—used to track resident readiness or becoming independently operating physicians—have not been associated with patient outcomes for procedures performed by early career physicians (Kendrick et al., 2023). In fact, one study showed no association between a residents' milestone rating and the occurrences of any complication or death within a 30 day post-procedure period (Kendrick et al., 2023). This research raises questions around the completeness of using ACGME milestones to assess resident readiness for unsupervised practice.

Related to the ACGME milestones, the 6 ACGME core competencies have been noted to be challenging to meaningfully assess, so leaders in general surgery have been investigating the incorporation of Entrustable Professional Activities (EPAs) into competency-based assessments for general surgery residents (Brasel et al., 2019; Montgomery et al., 2024). Current graduation requirements for general surgery residents are based on case volume and time in residency, though residents may actually achieve procedural competence at a different number of cases or time intervals (Montgomery et al., 2024). EPAs are observable and measurable in practice, capturing the essential activities of a physician that consider all of ACGME's competencies (Brasel et al., 2019). Incorporation of these EPAs has the potential to create a standard definition of competency, decrease faculty assessment burdens, make resident assessments more centered around clinical performance, and allow for easier assessment of resident skill transfer from training to clinical settings (Brasel et al., 2019).

Currently, however, evaluating the effectiveness of training compared to performance in actual clinical environments is done through simply observing residents during procedures which

creates a high burden on faculty. This typically involves researchers or faculty experts performing manual checklist evaluations during procedures or asking residents to self-assess quality outcomes like the number of attempts to access the vein (Jones et al., 2017). This is unsustainable for tracking large amounts of clinical data as it requires significant time and additional workload for hospital faculty and residents who just want to work on patients.

Therefore, this work seeks to identify if performance metrics are reported somewhere in hospital systems and the associated challenges with tracking this data. This study seeks to investigate current hospital documentation systems, their entry requirements, and if performance data can be attained systematically without adding to resident, attending physician, or any other hospital faculty workload.

Hospital Documentation Systems

Many hospital systems are used to document procedures and system selection varies by institution, resulting in hospital-dependent resident workflows. This variability complicates not only resident administrative tasks, but also research in medical resident education, as relevant resident performance data may be spread across multiple hospital-specific systems. Consequently, researchers must learn an institution's unique systems and workflows to be able to successfully conduct training-related research.

One key type of system used across the United States is an Electronic Health Record (EHR) system. Electronic health records (EHRs) are digital systems that maintain patient information like demographics, medications, diagnoses, etc., over time (Ehrenstein et al., 2019).

Many hospitals also use a separate residency management software (RMS) to track resident progress and manage resident administrative tasks (Kwan et al., 2024). This is sometimes integrated with the ACGME case log system where residents record their participation in medical procedures (“cases”) to fulfill ACGME graduation requirements and prove procedural competency. In the ACGME system, residents document their involvement in procedures and medical education coordinators can monitor resident procedural volume, experience variety, and ensure educational expectations are met (Xiao et al., 2022). As well as serving as a proxy for competency, ACGME case logs are critical for medical residency program accreditation, as case log information is used to determine if programs are providing residents with sufficient procedural experience to meet requirements of program accreditation (Cadish et al., 2016).

Often, a complication tracking system is used to track any complications associated with procedures. Sometimes, this tracking system can be linked to the EHR (Blackburn et al., 2024). Related to this are Morbidity and Mortality (M&M) conferences where adverse patient outcomes, complications, or deaths are reviewed by surgical departments. Cases reviewed in these conferences are logged or stored, containing complication data (Sajankila et al., 2024). These records ultimately show complication rate trends for the institution.

While each of the hospital systems are generally isolated and have different uses, studies show that much of the manual information being inputted in each system is the same (Kwan et al., 2024). A study focusing on case logging habits and attitudes of residents at a large academic medical center found that the case log entry and electronic medical record contain almost the same data, with the resident’s surgical role being the only additional piece of data provided in the

case log that is not already in the patient's electronic medical record (Cadish et al., 2016).

Therefore, duplicate data must be entered by residents, unnecessarily increasing workload.

Since resident case logs are used as a proxy for surgical competency, it is hypothesized that they may be useful in attaining resident performance data. However, it has been found that cases are not consistently documented in the ACGME system for a variety of reasons (Cadish et al., 2016; Gill et al., 2007; Nygaard et al., 2015). Institution-specific case logging habits, documentation practices, and reporting exceptions are often unknown outside of residents and program directors, presenting a key challenge of medical education research in tracking resident procedural data.

ACGME Reporting Guidelines

To help understand documentation exceptions, it is important to first understand the current procedural tracking documentation guidelines given by the ACGME. According to ACGME documentation, residents are responsible for accurately and timely inputting data, and program directors are responsible for maintaining case log accuracy (*Pccaseloginstructions.Pdf*, n.d.). It is important to note that specific ACGME case logging guidelines are not standardized across residency specialty.

One of the general logging rules given by the ACGME is that for each procedure, resident role must be determined and noted in the case. However, these roles differ by specialty. Only certain roles can log cases that count towards defined category minimums. For example, in general surgery, residents can classify their role as "Surgeon," "Teaching Assistant," or "First Assistant," but only receive credit towards defined category minimum case counts if their role

was Surgeon or Teaching Assistant. According to the “Defined Category Minimums and Credit Role for general surgery” document published on the ACGME website, general surgery residents must perform a minimum of 250 operations prior to starting their third year of residency (PGY-3), all of which must be as the Operating Surgeon or First Assistant and only 50 can be in “non-defined cases.” To be considered the “Surgeon” role, the resident must have “significant” participation in diagnosis, preoperative care, selection and performance of the procedure, and direction of postoperative care as outlined in the “Defined Category Minimums and Credit Role for General Surgery” document published on the ACGME website. These participation categories are somewhat subjective, so residents may inappropriately categorize their role or fail to log a case entirely because of their involvement perception (Nygaard et al., 2015).

Another general logging rule is that after a procedure, a current procedure terminology (CPT) code must be selected based on the type of procedure performed (Collins et al., 2020). Residents can only choose one CPT code to log the case with, and this code is standard across specialties for the procedure type. These codes can get very specific and newer residents often have trouble choosing the correct CPT code (Collins et al., 2020). For example, central line placement has many CPT codes depending on patient age, method of insertion, and catheter type. Proper CPT code selection is important to ensure the case counts towards the correct procedure and minimum required number of cases.

The ACGME also gives a minimum required number of cases that must be performed for some specialties to graduate from residency. Specifically, the ACGME outlines minimum required numbers on their website for all surgical specialties (Robinson et al., 2022). Anesthesiology, general surgery, and emergency medicine have minimum case numbers for procedure categories. Internal medicine, however, no longer requires a universal set of

procedures or minimum required cases that all residents must perform to allow for specialization in chosen subspecialties (Meliagros et al., 2023). These minimum case numbers determine if a resident is competent and ready to be an independently operating physician. The variability in minimum case numbers means that the same procedure performed by all these specialties—like CVC—may have different minimum required numbers or logging rules for the different specialties. This can also create discrepancies in resident documentation habits, resulting in a need to analyze resident workflows connecting training, clinical procedure, and performance documentation.

Although the ACGME may provide minimum case numbers, there is no single agreed upon number of central venous lines required to be placed by residents under direct supervision before being able to perform the procedure independently (Moureau et al., 2013). Moreover, no national standards exist for determining how many central lines should be placed before deemed competent in the procedure (Moureau et al., 2013; Ray et al., 2024). CVC training and competency assessments are thus determined by the residency program directors based loosely on the ACGME's provided core competencies (Meliagros et al., 2023; Yee et al., 2024). Program directors often use case log volume as a critical determination of competency, but these case logs contain inconsistencies for various reasons.

Reporting Inconsistencies and System Challenges

Research shows inaccuracies in case logs and logging habits, causing concern in the appropriateness of using case logs to determine resident operative experience and preparedness. This is cause for concern in the medical community not only regarding the preparedness of

residents to competently perform procedures, but also for medical training research. Many studies show that resident experience is not accurately captured by case logs and documentation quality control measures are limited in hospitals (Bhattacharya et al., 2010; Cadish et al., 2016; Gill et al., 2007; Nygaard et al., 2015). One study compared ACGME case logs from 3 surgical disciplines (general surgery, neurosurgery, and orthopedic surgery) to the matched operating room electronic records to estimate the accuracy of the case log system at capturing a resident's operative experience. It was found that the ACGME case logs captured less of a resident's actual operative experience with an overall accuracy of only 72% (Collins et al., 2020). These documentation gaps can occur for various reasons.

One contribution to logging inaccuracies is that residents may not always know the specific ACGME rules. One study of 7 3rd year and 5th year general surgery residents reported that while 57% of 3rd year and 43% of 5th year general surgery residents were aware there were specific ACGME requirements for case logging, none could accurately define them (Wolf et al., 2017).

Another reason inaccuracies can arise in case logs is related to resident involvement in the case. Residents are often brought into cases at different times, like during an operation or only for postoperative/preoperative care for example, so they may not meet the ACGME comprehensive care (involvement in all four aspects of care) requirements (Morgan et al., 2017). One study found that residents perceived themselves meeting all the requirements in more cases than they actually did, logging significant participation in 71.9% of cases, but only 44% of cases actually met the ACGME requirements (Wolf et al., 2017). Some residents may also never log some cases, causing under-reporting (Gill et al., 2007; Kwan et al., 2024). For example, general surgery residents often fail to log cases in which they were the "First Assistant" role, or cases

which they perceive as minor (Nygaard et al., 2015). Quality checks of resident involvement data are important to ensure residents are gaining sufficient hands-on experience.

Inaccuracies may also arise due to the perceived effort required to use the logging system. Logging in the ACGME case log system takes time, requires manual effort, and is often redundant, so residents sometimes wait until the end of a rotation or academic year to log cases (Kwan et al., 2024; Nygaard et al., 2015). One study found that 51.4% of general surgery residents were at least three months behind in logging their cases, with some reporting delays of over a year (Cadish et al., 2016). These reporting can increase errors in recall (Cadish et al., 2016). In regards to training, this delayed data entry or under-reporting can inhibit medical education coordinators from identifying gaps in clinical experience and timely intervention, hindering resident development (Kwan et al., 2024).

Despite these errors, most residents still say that accurate case logs are important in surgical training. In one study, it was found that 83.5% of residents believed that it is important to accurately log cases during training, but over a third of residents believe the case log system is inaccurate (Cadish et al., 2016). Despite their inaccuracies, case logs remain a central assessment tool for residents and residency programs because there is an absence of other objective educational measures (Cadish et al., 2016). To attain more accurate data, researchers have attempted to extract resident case information from the EHR, but the EHR often does not clearly indicate resident involvement, making the system an unreliable source for procedural performance attribution (Xiao et al., 2022). The variability in case logs and discrepancies across residency programs highlights a need for some quality control measure related to case logs or identification or creation of another educational competence measure.

Research has been done on potential quality control solutions to improve records of resident operative experience. One study implemented weekly comparisons of resident ACGME case logs and EMR operative logs to identify gaps (Nygaard et al., 2015). A weekly education conference was held with residents, and graphs of each individual's case logs and potential missing cases were displayed. This continued monthly and resulted in residents significantly logging more of their cases (95.5%, $p < 0.001$) (Nygaard et al., 2015).

To improve case log data quality while reducing resident manual data entry, opportunities to streamline the hospital systems have been identified and successfully implemented (Cadish et al., 2016; Xiao et al., 2022). A study conducted in 2022 and 2023 at the University of California, San Diego Health describes an automation strategy to create and implement an automated system for extracting procedural data from the Epic Hyperspace EHR system (used in 60% of U.S. teaching hospitals) to automatically create resident ACGME case logs (Kwan et al., 2024). Creating the automation was not complex, and it increased the number of procedures logged in ACGME over a 1-year period by 78% with an overall accuracy of 99.5% (Kwan et al., 2024). This study focused on residents in a single residency program, so scalability was not determined.

Another study attempted to improve case log representation of resident experience with some success. This study was initiated in 2018 to investigate the feasibility of linking a hospital's ACGME and EHR systems (Xiao et al., 2022). A single developer was able to implement the integration over a few months using just the existing institutional IT resources. The resulting system allowed residents to log cases directly through a link in the EHR, automatically populating patient data into a new case log entry. Two years-post implementation, 100% of case logs were logged through the integrated system and cases more accurately represented resident operative volume (Xiao et al., 2022). Additionally, resident satisfaction with the logging process

increased significantly from 55% pre-implementation to 100% two years post implementation (Xiao et al., 2022). Challenges emerged when attempting to expand the solution to other specialties with different logging criteria or to institutions using different EHR platforms. However, the study is encouraging and demonstrates the feasibility of integrating systems within a few months.

As artificial intelligence models and technology evolve, system integration should continue to be studied so the medical field can benefit from advancements in technology. While these system integrations may increase the number of cases logged and reduce resident workload, the question of if these systems provide the key data needed to assess resident clinical performance remains, especially related to assessing the effectiveness of novel training methods.

This study looks at one institution to specifically identify systems that track training and actual clinical performance data. The study also seeks to identify current quality control practices at the institution and their limitations. Ultimately, this work will inform understanding of documentation of procedural performance data to evaluate resident clinical progression and the effectiveness of current training methods without adding to resident or attending workload.

Chapter 3

Methodology

Research Design

This study was an explorative, qualitative study with the purpose of identifying the systems that record medical resident performance and the challenges with tracking and evaluating that data within a single institution. The research began with four months of literature review to analyze systems used in hospitals, reporting requirements, medical professionals' perceptions of hospital systems, hospital system integration successes, and the gaps in hospital system workflows. After the IRB approved this study, key data was collected through semi-structured interviews with medical residents, fellows, attending physicians, and program coordinators. Qualitative data was analyzed using reflexive thematic analysis.

Participants

Participants for this study were required to be medical residents, fellows, attending physicians, or program coordinators from specialties that perform CVC placement. All participants from these roles had to be at least 18 years old. A written email script was sent to a resident program coordinator with the contacts of relevant perspective participants. Snowball sampling was used to recruit more participants. After recruitment, participants were asked to fill out a background survey through Qualtrics to collect demographic data and initial information about their experience. In the background survey, participants were asked to generate a unique 6-digit code to ensure confidentiality and anonymity. The background survey also contained 5

questions: (1) gender, (2) ethnicity, (3) hospital role, (4) time in role, (5) specialty area if applicable. In total, 5 residents, 1 fellow, 2 resident program coordinators, and 1 attending physician were interviewed for this study.

Data Collection

Data for this study was collected through one-on-one semi-structured interviews with the stakeholders via a secure Zoom browser. Interviews varied in length, with the minimum time being 22 minutes and the maximum time being 1 hour and 11 minutes. The average interview time was 35.5 minutes with a standard deviation of 13.8. Interviews were conducted in March 2026. An initial list of interview questions was developed by discussing the goals amongst the research team. The key goal of the interviews was to identify the data tracked by current hospital systems, where and how resident clinical performance is recorded, and barriers to tracking and monitoring this data within hospital systems. The interview questions were updated as interviews progressed based on newly identified concepts, allowing for flexibility of conversations and exploring new ideas. The interviews were audio recorded and transcribed via Zoom for analysis. The transcripts were de-identified and stored in an encrypted, anonymous platform. Interview questions were related to the topics provided in Table 1. A full list of interview questions can be found in Appendix A.

Table 1. Interview Topics and Types of Questions for Respective Participant Roles

Participant Role	Resident	Resident Program Coordinators, Attending Physicians, Fellows
Question Topics	• Central line training • Training assessment methods • Formal competency evaluation • Clinical reporting requirements • Certain number of supervised procedures before unsupervised • ACGME requirements • Procedure logging • Tracking performance in procedure vs. training • Main systems interacted with during training and actual operations • Pre, during, and post procedure documentation and reporting steps • Reporting criteria • Exclusion criteria • Approval chain • Needs (confidentiality, workload, etc.) • Challenges	• Central line training components • Standardized checklists or policies • Ensuring sufficient supervised CVC cases • ACGME criteria • Competency criteria • Resident performance data • Approvals for competency • Main system interactions • Current systems access • Involvement in approvals • Evaluation criteria • Data quality checks • Needs (data, confidentiality, workload, etc.) • Challenges

Data Analysis

Data from the semi-structured interviews was analyzed following Braun & Clarke's proposed reflexive thematic analysis framework: (1) data familiarization, (2) initial code generation, (3) search for themes, (4) review of themes, (5) definition of themes, (6) writing the report (Braun & Clarke, 2006). Audio transcripts were first read through many times to understand the data. Key content was highlighted, and annotations were made to the transcripts. Then, transcripts were coded in NVivo to categorize the content into key themes and categories (Brunner et al., 2025). These themes were then analyzed to determine patterns and codes were grouped together to discover important relationships. The goal of this data analysis was to

identify current training methods, hospital systems, documentation requirements, and gaps in capturing data.

The analysis of the qualitative data gathered from interviews informed flowchart mapping of the flow from initial CVC training to the first supervised central line on a patient to when a resident is deemed competent in CVC. Institution documentation was reviewed to supplement interviewee perspectives. These flowcharts were used to analyze how the current hospital systems interact, where data is lost, and where gaps occur.

The flow of the procedure method is shown in Figure 2.



Figure 2. Study Flow

Chapter 4

Results

Nine interviews were conducted with medical residents, fellows, attending physicians, or resident education/program coordinators that are involved in central line training or placement at a single institution. The sample data is contained in Table 2.

Table 2. List of Participant Data

Participant ID	Gender	Role	Specialty	Time in Role/PGY
Participant 1	Male	Resident	General Surgery	PGY-2
Participant 2	Male	Resident	General Surgery	PGY-2
Participant 3	Female	Resident	General Surgery	PGY-2
Participant 4	Male	Resident	Emergency Medicine	PGY-3
Participant 5	Female	Resident	Emergency Medicine	PGY-3
Participant 6	Male	Chief Fellow	Pulmonary and Critical Care	PGY-6
Participant 7	Male	Attending Physician	Emergency Medicine	4 years
Participant 8	Female	Program Coordinator	General Surgery	1 year
Participant 9	Female	Program Coordinator	General Surgery, Thoracic, Surgery Critical Care	23 years

Interview data were analyzed using reflexive thematic analysis to identify methods and patterns in surgical training, procedural documentation, and performance tracking across the institution. Four major themes were identified: (1) procedural training is front-loaded, unstandardized, and non-evaluative, (2) formal procedural skill reassessment is absent, (3) clinical performance is not defined or documented in a systematic way, and (4) complication tracking is fragmented and informally connected to resident training. The key themes and subthemes are represented in Figure 3 below.

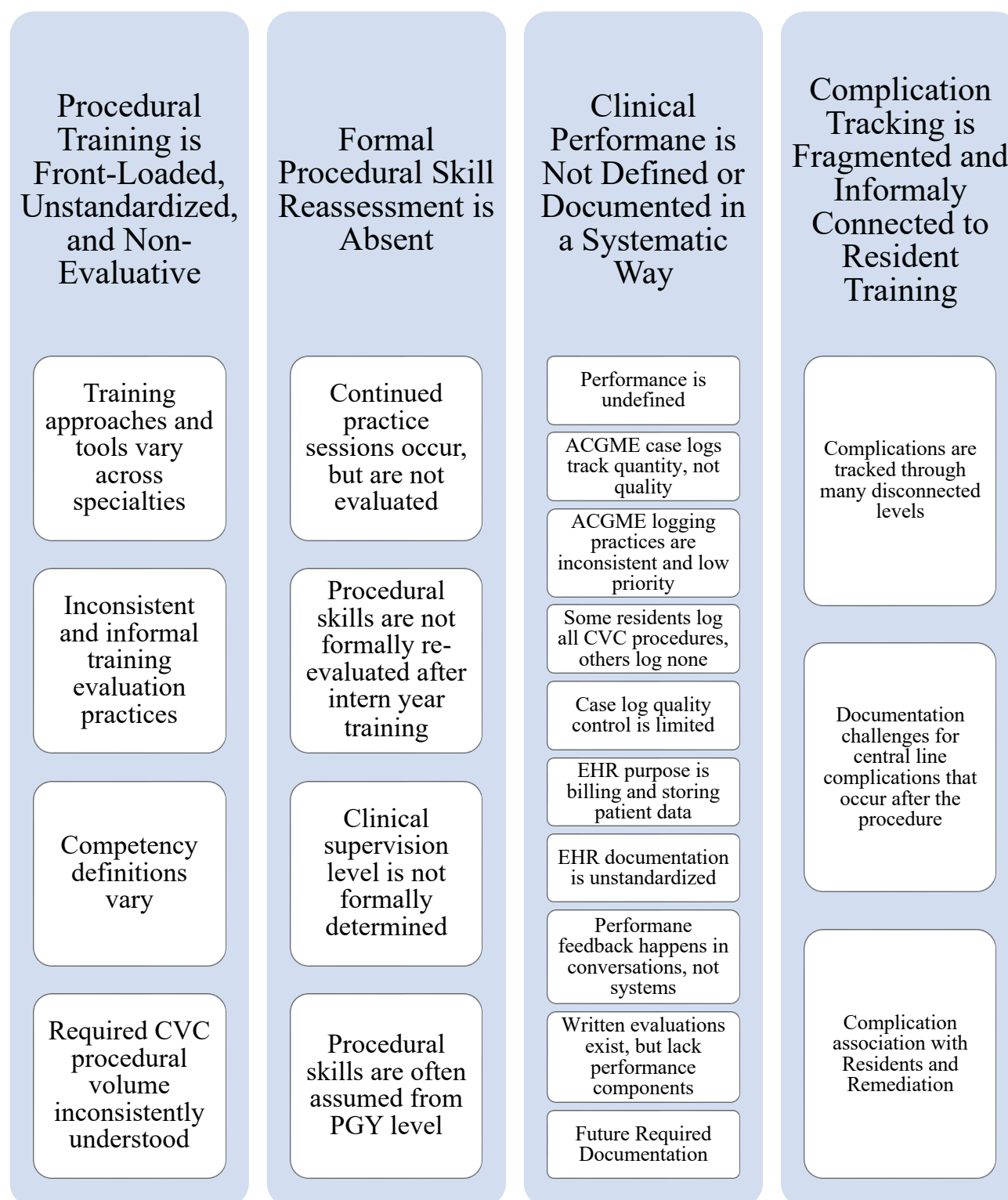


Figure 3. Key Themes and Subthemes

The key themes and broad subthemes are represented in Table 3. This table encompasses key topics that will be explored in Result section. The full codebook is supplied in Appendix B.

Table 3. Key Themes, Broad Subthemes, Descriptions, Frequencies, and Example Quotes

Theme	Category of Subtheme	Brief Description	Participants Mentioned (n=9)	Illustrative Quote
Procedural Training is Front-loaded, unstandardized, and formative rather than evaluative	Training approaches and tools vary across specialties	Participants described two different training programs depending on their specialty. The simulators available at the time may vary, which leads to different tools used in baseline training.	88.9% (n=8)	“There was a VR thing, live mannequin session, and then some, like, low-fidelity simulation models” (Participant 2) “There's a short little course, that, you know, you just kind of had to memorize the indications, the relative contraindications, and all that for central line placement, and then we used... it was kind of like a game, where you had a little block that represented the ultrasound, and then you were holding a needle.” (Participant 4)
	Inconsistent and informal training evaluation practices	Participants explain that there is not a formal grade associated with training. A consistent evaluation method was not described.	66.7% (n=6)	“It's very informal, to be completely honest. It's usually me just, watching them go through the steps and kind of helping them give instructions of, like, things that are easy.” (Participant 6)
	Competency definitions vary	Competency was described in the context of completing the initial training, completing the number of required central lines, or after graduating from residency.	66.7% (n=6)	“There's a lot of debate, internally within our own system and externally within the national, community about what competency is and what number is needed to reach competency.” (Participant 6)
	Unknown Number of Central Lines Required	Some participants mentioned being unsure of the number of central lines required to be placed to graduate from their specialty.	33.3% (n=3)	“I believe 10... the number might have gone up recently, but... It's, like, 10 or 15 to get to, like, independent practice.” (Participant 5)
	Known Required Number of Central Lines	Some participants mentioned specific numbers of central lines required to be placed to graduate from their specialty. Although, these numbers varied.	33.3% (n=3)	“For emergency medicine, it's 15. And that's to be... that's to be, you know, to finish your requirements for a residency.” (Participant 4)
	No Required Number of Central Lines	Some participants mentioned that a specific number of central lines is not required to be placed to graduate from their specialty. These residents were from internal medicine and general surgery.	33.3% (n=3)	“I think you technically don't get credit for central lines, because they're, like, minor procedures. Right. So I think that's why I haven't logged them,” (Participant 1)

Theme	Category of Subtheme	Brief Description	Participants Mentioned (n=9)	Illustrative Quote
Formal Reassessment is Absent	Procedural skills are not formally re-evaluated after initial intern year training	Participants mentioned that there is continued practice through periodic simulation practice sessions, but these are not formally evaluated. After completing the initial central lines training course, there is not another objective test of skills.	77.8% (n=7)	"It's just, we do the one as an intern, and then it's just sort of much more informal feedback throughout the years." (Participant 4)
	Clinical Supervision Level is not formally determined	Supervision level during clinical procedures is not based on objective skills assessments. Rather, attendings decide how much supervision to give residents during a procedure based on familiarity, comfortability, the complexity of the procedure, or resident post grad year.	77.8% (n=7)	"The various specialties, most of them... nobody has a formal process for supervised or unsupervised, with hard stops on either end. It's either, I trust you, you can be unsupervised, and if Bill doesn't trust you as much, then you can't." (Participant 7)
Clinical Performance is Not Defined or Documented in a Systematic Way	Performance is Undefined	When discussing performance, some participants questioned how performance is defined. Various descriptions of performance were mentioned, including number of attempts to access the vessel, procedure time, whether the procedure is going well, or if an attending had to take over.	44.4% (n=4)	"But no, there is no set sort of way to tell us, say, if this is good or bad performance." (Participant 3)
	ACGME case logs capture quantity, not quality	Participants describe that ACGME case logs are used to track procedural quantity. They do not include resident performance information.	66.7% (n=6)	"It's solely quantitative, no qualifying factors." (Participant 1)
	ACGME logging practices are inconsistent and low priority	Whether logging occurs or does not occur depends on the resident. Logging may occur the day of or months later—there is no timeliness requirement.	66.7% (n=6)	"If it's a good day, I'm doing it, like, same day... Sometimes we're doing it days or months after the fact." (Participant 5)
	Case log quality control is limited	Entries into the ACGME system are not consistently monitored and cannot be cross-checked with procedure data from the EHR.	55.6% (n=5)	"So, I mean, it's trusted that when the residents enter them, they're valid, and that they're accurate." (Participant 9)
	EHR purpose is billing and storing patient data	The EHR was described as a system to store patient clinical data and billing information.	44.4% (n=4)	"From my standpoint, as a clinician, it is a tool for... All of the information on a patient. That other providers can read, and then a billing tool for insurance companies." (Participant 2)
	EHR documentation is unstandardized	What is entered into the EHR is unstandardized. There is a procedure not that documents information about the procedure, and this is filled out via a prepopulated template. There is no standardized template	55.6% (n=5)	"So, we do, like, record the procedure in the patient's chart. There are templates that we use that are kind of handed down from faculty to residents, or among residents." (Participant 5)

Theme	Category of Subtheme	Brief Description	Participants Mentioned (n=9)	Illustrative Quote
		required by the institution, so what is entered into the EHR may vary slightly by the template.		
	Performance feedback happens in conversations, not systems	Specific performance-related information is not documented. Performance feedback is attained through conversations, like biannual Clinical Competence Committee Meetings or verbal feedback after procedures.	66.7% (n=6)	"We track number of procedures performed or supervised. We don't... Assess or track, like, performance of the procedure." (Participant 5)
Complication Tracking is Fragmented and Informally Connected to Resident Training	Complications are tracked through many disconnected levels	Participants described various complication tracking mechanisms. However, these mechanisms produce data that is not connected, and not all complications are affirmatively reported.	55.6% (n=5)	"Residents affirmatively report a complication. If... If that doesn't happen, if a complication is identified administratively, they go through the quality and RCA process." (Participant 7)
	Documentation challenges for central line complications that occur after the procedure	Complications are typically noted in the EHR. However, that documentation occurs soon after the procedure. If a complication occurs after the procedure, it will not be noted in the EHR.	22.2% (n=2)	"So if you, if you, like, know about it as it's happening, you would put that in the EHR... I don't know what happens if there's something, like, later down the line?" (Participant 5)
	Complication Association with Residents and Remediation	Connecting complications to residents is very challenging systematically. Therefore, if remediation occurs, it is through verbal suggestion or escalation up the leadership chain.	44.4% (n=4)	"If I was, you know, dramatically failing a bunch of lines, they would say, alright, you need to do something, like, what are we gonna do?... But it wouldn't necessarily be, you know, based on this formal feedback, you now need to do this. It's more just... Kind of through the grapevine, so to speak" (Participant 4)

RQ1: How do residents and faculty describe the training and assessment practices used for central line placement, what determines competency, and to what extent are these practices standardized?

Theme 1: Procedural Training is Front-loaded, Unstandardized, and Non-Evaluative

Participants described central line training occurs in the intern year of residency, but training courses varied across specialties and lacked standardization. In general, participants described a single session at the beginning of their intern year where the steps of the procedures were learned through some type of course (“online VR” – Participant 2, “didactic” – Participant 9) and practiced on a simulator and mannequins. An attending physician described that the institution’s central line training course covers emergency medicine, internal medicine, neurosurgery, and anesthesia residents, but general surgery residents go through their own boot camp training course for CVC. No participant described one formal assessment measure—some mentioned they thought a checklist was used, others mentioned assessment was very informal watching of the procedure being done on a mannequin. Procedural training is designed to be formative and establish initial exposure to basic skills, rather than evaluate for competency.

Training Approaches and Tools Vary Across Specialties

General surgery residents and program coordinators described a central line training course, called a boot camp, that occurs during their intern orientation. The general surgery central line training includes an initial didactic session to learn the procedure steps and then practice on models and a simulator. There is also a separate central line training course for other specialties (like emergency medicine and internal medicine). This training is very similar to the general surgery training course where procedure indications and contraindications are taught, along with basic skills and practice on models and simulators. Eight of nine participants discussed training session components, and descriptions varied. Four participants mentioned that training sessions were conducted and assessed by either attending physicians or senior residents.

“So, when the residents start during orientation, we have a boot camp with them, and, we also have a specialized intern curriculum, so really, they get all their training in their first year when they're an intern. And, they get basic skills during boot camp.... So it definitely starts out with a didactic session explaining the procedure and showing them a video. And then, we do simulation, where they actually, perform on a blue phantom mannequin.” (Participant 9)

Training practices varied across specialties and lacked standardization.

“And then we used... it was kind of like a game, where you had a little block that represented the ultrasound, and then you were holding a needle and you would have to... you would enter into the vessel, and then afterwards it would give you, like, your accuracy.” (Participant 4)

“We had a mandatory, like, online VR simulation type thing, that went through, like, the... mainly just, like, the steps, of the procedure.” (Participant 2)

Inconsistent and Informal Training Evaluation Practices

Participants involved in the training “evaluations” explained that training evaluations during the central line session are informal and no standard checklist or metric was described. Six total participants mentioned informal training evaluations. Senior residents or attendings typically “evaluate” these training sessions.

“It's very informal, to be completely honest. It's usually me just, watching them go through the steps and kind of helping them give instructions of, like, things that are easy.” (Participant 6)

“The standard of care is still very much sort of this sort of qualitative very, very hazy. Yeah. Like, yeah, we'll just make sure they're good at this.” (Participant 7)

Five residents mentioned that for the initial central lines course, they think there was a basic checklist that graders were using to confirm that residents knew the steps of the procedure, but they were not provided their score related to the checklist. In practice, after participating in the central lines course, attendings would let residents start to learn the procedure on real patients.

“They had one, like, the graders did, we never got to see it. And then as long as we said, you know, enough of these steps in the correct order... Once we proved that we could do it, then we had passed the central line course, and then that, to the attendings, was viewed as, okay, you can now learn to do these on real people.” (Participant 4)

Three participants (out of the 3 emergency medicine participants) also mentioned that the emergency medicine board exams are changing to include an actual procedural simulation component rather than just verbalizing the steps of the procedure. Residents discussed it would be helpful to have more formal evaluations of simulation training to prepare.

“I think next year, our curriculum will change to include more formal sim evaluation.as it pertains to our boards, because I think that would be pretty helpful.” (Participant 4)

With this, a participant described a challenge with the current assessment measures of CVC training. They mentioned there is a lack of formal documentation of the actual key steps of the procedure that would determine “competence” in these new emergency medicine board exams.

“But I don't think there's, like... I don't think anyone's, like, written down or published what are the key steps of the procedure that, you know, so we're all, like, working off the same information. Like, I could guess what it would be, right? But, like, we often in the

ER don't transduce, so if that was on the board exam, I'd be like, oh, I haven't done that in a very long time, right?" (Participant 5).

Competency Definitions Vary

Discussions of when residents are deemed “competent” revealed different understandings of what determines when a resident is “competent” in procedures. Competency was used in the context of completing training, completing the required number of central lines, and after graduating from residency. Most participants described competency as completing the required minimum number of cases from the accreditation standpoint. One participant clarified that competency technically is gained after a resident graduates.

“I say, the sum total of my case logs, proving that I have met all of the ACGME requirements, means that I'm competent in all of these procedures. But that happens after graduation. There is no... there's no intermediate step in which we say this first-year, second year, third year resident is now competent.” (Participant 7)

Required CVC Procedural Volume Inconsistently Understood

In terms of an actual required number of central lines logged to graduate from residency, participants had different answers. One general surgery resident mentioned an institution requirement of 10 central line placements, but all general surgery residents stated that ACGME does not require central lines to be logged for graduation. Two of these residents mentioned they have never logged central lines in ACGME.

“I don't think I've ever had anyone be like, I had to produce my list of 10 patients, you know? It's kind of, yeah, it's kind of just been like, yeah, I've done 10 ish” (Participant 2)

Emergency medicine residents discussed there is a required number of central lines that must be logged in ACGME to graduate and 30% of those procedures can be simulated.

Consensus around this required number was not reached. One EM resident was unsure if it was 10 or had recently increased, one EM resident mentioned 15, and the EM attending mentioned they did not know the specific number off the top of their head, but that it was between 15 and 25. It was also mentioned that Internal Medicine removed their number of required central lines to be performed for graduation requirements to allow for residents to specialize in their interests.

Internal and national debate over the specific number of procedures needed to be competent in central line placement was mentioned. With this, criteria that determines competency was also mentioned.

“There's a lot of debate, internally within our own system and externally within the national community, about what competency is and what number is needed to reach competency... Because competency is not only placing the line, or placing a procedure, but troubleshooting as well. Like, I can put a central line in, but if there's an issue, and I need to call someone at the first hiccup, am I competent to put a line in then?”

(Participant 6)

Theme 2: Formal Procedural Skill Reassessment is Absent

Participants explained that after the initial central lines training course, continued practice opportunities exist in the form of simulation sessions, but there is no official re-evaluation of procedural skills to prove competency over the course of their residency. Attending comfortability with a resident or PGY (post grad year) level assumptions informally determine when residents can begin to perform central lines with less attending supervision, rather than

using standard criteria for reduced supervision. In practice, there is no “check off” to determine when residents can begin to perform procedures “unsupervised.”

Continued Practice Sessions Occur, But Are Not Evaluated

Participants consistently mentioned that after the original central line course, there is continued periodic simulation practice. Some participants also mentioned a cadaver lab day where procedures are practiced on cadavers. However, a participant described that in their general surgery training experience, as residents progress in year, simulation practice specifically for central lines occurs less. Participants explained these sessions are for practice rather than opportunities to formally grade resident competence as they progress through their residency.

“Throughout every year, we have separate SIM sessions with central lines, and those are not formally graded. Those are just really for our practice.” (Participant 4)

Procedural Skills Are Not Formally Re-evaluated After Initial Intern Year Training

Training was described to occur once through a formal dedicated course early in the resident intern year. Once interns complete the course, participants explained there is no re-evaluation of skills.

“But there's no, like... it's not like every year I have to go and do another Central Line course to prove that... You know, with another faculty member that, you know to prove that I have to do it. It's just, we do the one as an intern, and then it's just sort of much more informal feedback throughout the years.” (Participant 4)

One participant described their perspective on a key challenge they see related to central line training—opportunities to practice the procedure vary. It was described that residents may not actually place a line until months after their training course depending on the specialty. There is no training refresher before they are expected to be able to perform the procedure.

“So, we train residents to do this once, and then they may not have another chance to practice the skill prior to the 10 months before they're put in front of a patient to perform the skill. So there's no remediation, there's no refresher, there's no kind of continuing education associated with this. It's all one and done, essentially.” (Participant 6)

Clinical Supervision Level is Not Formally Determined

Seven participants (out of nine) mentioned supervision levels in CVC procedures are not based on any objective skill assessment. When discussing competency and supervision, many participants clarified that residents technically are never performing procedures “unsupervised.” An attending should be present for the “key portions of the procedure” for both billing and patient safety reasons, but that is subjective and may vary based on the attending physician. However, in practice, residents can perform procedures with very little supervision. Participants consistently mentioned that there is no formal “check off” for determining when residents can start to perform procedures with less supervision.

“The... the various specialties, most of them... nobody has a formal process for supervised or unsupervised, with hard stops on either end. It's either, I trust you, you can be unsupervised and if Bill doesn't trust you as much, then you can't.” (Participant 7)

Residents mentioned that attendings typically do not ask about how many central line procedures the resident has performed previously when determining if a resident can operate with less or no supervision. Rather, the level of supervision depends on the attending.

“But I've, in practice, like, never been asked, are you...checked off on this. It's kind of attending-dependent for how much.” (Participant 5)

Procedural Skills Are Often Assumed from PGY Level

Three residents also mentioned that as they get more senior, attendings assume competence in certain procedures, therefore assuming residents need less supervision.

“And then from a competency standpoint some attendings, you know, by the time you're a second year and you're considered a senior resident, they'll let you do any procedure. They don't need to always be in the room and stuff. A lot of times, third years, they expect that you should be able to do this on your own.” (Participant 4)

A mix of the resident's own comfortability, exuded confidence, and the type of procedure were also mentioned as contributing to supervision levels in the operating room.

“So, as you become more senior, you can kind of start to do procedures unsupervised. Typically, those procedures are, like, central line placement, technically, chest tube placement. Those are procedures that, once you're comfortable with them, you can, you know, hopefully an attending will know that you're comfortable with them at that point... I think it also is about, like, how you, you know, exude your confidence, and, you know, if you're confident, like, yeah, no, I can do this without any supervision, then, like, alright, go for it, call me if you have any problems.” (Participant 1)

RQ2: How is resident performance currently documented across clinical and accreditation systems, what are the reporting requirements, and what gaps exist in tracking/capturing performance data?

Theme 3: Clinical Performance is Not Defined or Documented in a Systematic Way

A key finding of this study is that specific resident performance data is not consistently documented in any systems currently used across the institution. Participants describe the hospital EHR system as being used for billing purposes and to store patient data. Most participants described that the institution uses New Innovations to log cases that get submitted to ACGME, but one specialty logs their cases through the specific ACGME case log browser. Case logs were explained to track procedural quantity rather than quality. It was identified that neither the EHR nor the case logs include a resident performance component. It was discovered that residents receive faculty evaluations through New Innovations at the end of rotational blocks (monthly), but these comments may be delayed, vary in quality, and typically do not contain specific procedural performance feedback. The documentation requirements and reporting workflows and habits were also identified, which will be discussed as a part of this theme.

It was identified that performance is monitored through official performance review meetings that occur twice a year, through verbal feedback, or not at all. General surgery participants described a performance documentation system that will be required for general surgery graduation in the next few years but is not currently widely used. As discussions of performance occurred, residents expressed a challenge with tracking performance: what defines “good” performance?

Performance is Undefined

It was described that there is no standard measure of performance at the institution. There are various metrics associated with central line placement, so participants questioned what does performance even mean?

“I'm just wondering... how we're grading performance. For example, like there is probably one school of thought that's, like, was there a complication, right? Like, is that what we mean by, you did a good job? Or maybe you took two attempts at entering the vessel for a central line, right? Like, is that not, as good?” (Participant 5)

ACGME Case Logs Capture Quantity, Not Quality

The key data elements required to be included in ACGME case logs were described by six participants. Participants consistently mentioned that the required elements were the procedure date, date procedure entered, resident PGY year, patient ID (typically Medical Record Number), attending worked with, hospital, learner's role, rotation, patient type (pediatric vs adult), CPT code, and a free text section. Case logs were also described to be HIPAA compliant and should be anonymous with respect to the patient. One participant described a case log is:

“Solely quantitative, no qualifying factors.” (Participant 1)

Regarding case log documentation related to performance, participants mentioned that the case log does not contain information on resident performance in the procedure.

“When we log the cases, there's no, like, performance component to that.” (Participant 2)

ACGME Logging Practices are Inconsistent and Low Priority

One participant mentioned that technically for a case to be eligible to log, the resident had to be involved in a certain amount of care, but that threshold is subjective. There is inconsistent determination of when a case can be considered eligible to log in ACGME.

“I think everybody is different on their philosophy on this. Like I said, I think the technical definition is that if you were involved in 50% of the care, including peri and post-op, which we're all involved in periop, post-op stuff on the floor, then you can log

it... I don't do it unless I've done 50% of the case itself, so it just... everyone draws that line in the sand a little differently.” (Participant 3)

For what information is entered into case logs, residents explained that they typically include only the required ACGME elements, but additional information may be written in the free text portion of the case log. For example, complications or if the attending took over the procedure are not required to be in the ACGME case log but may be in the free text portion. However, there is unstandardized practice for filling out the free text box. One participant mentioned they copy the text section from the EHR and paste it in the ACGME log’s free-text comment section, but many participants mentioned that residents often do not fill out the free text box because it is added work with no benefit for the resident.

“There are free text options that people can put in, but I will tell you right now that no one will do any of that. This is just excess work that we’re doing for logging and ACGME requirements, so people are doing it to say that they’ve done it, but not actually putting thought into it.” (Participant 6)

Participants explained there is no timeliness requirement for when logs must be documented. Residents expressed logging takes up more time than they would like, so sometimes it gets put off. Some residents log at the end of the day or shift, while other residents log every three months.

“If it's a good day, I'm doing it, like, same day... Sometimes we're doing it days or months after the fact.” (Participant 5)

“I mean, we tell them, you must do this. But...it's nobody's priority.” (Participant 7)

Some Residents Log All CVC Procedures, Others Log None

Most participants stated that in general, all procedures should be logged in ACGME, whether it was their very first procedure or if there was a complication. Participants explained that some residents want to log as many procedures as possible, while others may be less thorough. An emergency medicine resident said:

“Any procedure that I do, whether it... whether there was complications, whether it passed or it failed... the outcome doesn't matter for the logging purposes, as long as attempted it, you can log it... I want to log as many as humanly possible just for my own comfort level in, you know, doing these.” (Participant 4)

Additionally, once the required number of cases for graduation is logged, participants mention there is less incentive to log in ACGME.

“The problem with the reporting mechanism is that if I am a third-year resident and I have hit 27, 35, you know, I'm well above and beyond my reporting requirements. The incentive to continue to diligently and accurately and exhaustively report all procedures above and beyond the count that's required is minimal.” (Participant 7)

All general surgery residents mentioned they do not actively log central line procedures in ACGME because it is not required. However, many residents described that even if not required, having record of their case volume is important for post-graduation job applications.

“For the purpose of central lines, I would say that let's say I graduate general surgery training, and I want to go do an ICU fellowship, or get a job as a surgical critical care doctor. I don't need central lines, documented to be a board-certified general surgeon, but if I have them all logged into ACGME, I can show my fellowship, and I can show my future job that I'm applying to, hey, look, I have 55 central lines in residency.”

(Participant 2)

Case Log Quality Control is Limited

It was discovered that there is no real quality control mechanism for case log data. Participants explained that residents are taught how to log cases and when to select the different roles in a case. Most participants described a trust system for case log quality control.

“So, I mean, it's trusted that when the residents enter them, they're valid, and that they're accurate” (Participant 9)

Some residents mentioned that the case log is being sent to the attending that performed the procedure with the resident to confirm that the attending supervised the resident on that case, while other participants mentioned nobody is really overseeing the case logs. One resident described that sometimes the attending may be too busy to approve all these cases, so the program director can approve it. The program director may not approve it if indications or a description is not included for certain procedures.

“Like, I've heard that if people don't put enough... if they're trying to say, I led a medical resuscitation, but they don't actually say what happened or why it was a medical resuscitation, like, I've heard they'll decline the log.” (Participant 5)

A key challenge identified with case log quality control is that the EHR and ACGME systems cannot be cross-checked, so billing numbers and procedure numbers cannot be reconciled.

“We don't cross-check anything, but we do review to say, like, okay, this is what you should log as, like, a chief case, you should... you shouldn't log that. Like, we do review it, but it's not cross-checked.” (Participant 8)

EHR Purpose is Billing and Storing Patient Data

It was found that information in the patient chart and ACGME case log is similar, but the systems have different purposes. Four participants (out of nine) mentioned billing when talking about the EHR. Some of the same data is logged in ACGME and the EHR, but it must be entered separately because the “EHR doesn’t talk to ACGME” (Participant 9).

“EHR has all these requirements and buzzwords and all these key things that they have to say in order to get max billing.” (Participant 9)

“The EHR is, from my standpoint, as a clinician, it is a tool for all of the information on a patient that other providers can read, and then a billing tool for insurance companies”
(Participant 2)

EHR Documentation is Unstandardized

Participants consistently described the key items required to be in the EHR are resident name, attending name, patient’s name, and the procedure note. The procedure note includes information about the procedure, but there is no required procedure note template. In the procedure note, participants often mentioned the central line site, local anesthesia, key parts of the procedure, complications, post-procedure chest x-ray confirmation, and blood loss as being included. Two ways to fill out the procedure note we identified: dynamic documentation (pre-populated from the EHR system) or “dot phrases.” Six participants described dot phrases that are templates often passed down from other residents or faculty.

“There are templates that we use that are kind of handed down from faculty to residents, or among residents. there’s not, to my knowledge, like, an official one that we have to use.” (Participant 5)

“There is not an agreed-upon standardized document from the system that you can use.”
(Participant 6)

Thus, it was found that some procedural data might not make it into the EHR, depending on the procedure note used. Things like the number of skin penetrations with a needle, changing sides because of access issues, or other steps may not be included.

“What is missing in the note, and what I've tried to correct myself, depending on, the situation, is important steps. How many times the skin was penetrated with a needle? Was arterial access accidentally obtained and then pressure was held? A lot of that is missing. Did we change sides from left to right because of access issues? Did we change from, IJ to growing because of access issues. That is not well documented.” (Participant 6)

Five participants (out of nine) mentioned that the EHR must include both the resident and attending name. While the resident name is in the EHR, residents explained there is no way to determine how much of the procedure was performed by the resident or if the attending or another senior resident took over the procedure.

“I won't say what parts of the case we did. It'll just say, like assistant so-and-so, and it won't say what we did or how much of the case we were in.” (Participant 3)

Performance Feedback Happens in Conversations, Not Systems

Participants did not mention a single system that is currently widely and consistently used to specifically track resident performance. Six participants (out of nine) mentioned that resident clinical performance is not tracked through systems. Rather, feedback is given verbally during or after a procedure or not at all, and that feedback is not documented anywhere. Some residents mentioned that when a shift is particularly busy, feedback may not even happen after the shift.

“So, I think the short answer is we probably really don't [log performance], other than, like, real-time, like, verbal feedback.” (Participant 2)

“We track number of procedures performed or supervised. We don't... Assess or track like, performance of the procedure.” (Participant 5)

Participants did mention a Clinical Competency Committee that formally meets twice a year to assess resident competency progression through evaluating faculty reviews, case logs, and comparing resident progression to ACGME milestones. These meetings also are for identifying the outliers that might be less procedurally competent, and ensuring they stay on track.

“CCC looks through a lot of, a lot of things. Evaluations from a medical knowledge, performance, citizenship, but they also review ACGME standards. Have we placed... has this person done enough procedures? What are their procedural counts?” (Participant 6)

“So those people will then... will then review all of the comments made about the resident as part of that clinical competency committee. And if one of those comments is, needs-heavy supervision, had to take over for a procedure. Then we address that as part of their competency progression.” (Participant 7)

It was explained that ACGME milestones are discussed during the Clinical Competency Committee meetings, and residents are graded one to five on what level they are compared to the ACGME milestones. However, the ACGME milestones are general, not specific procedural performance milestones.

“You're supposed to show progression through the CCC throughout your three years. So, like, by the end of year one, you should be level 2. By the end of year three, you should be level three. By the end of year... by end of year two, you should be level 3. By the end of year three, you should be between a 4, which is, I trust them to get this with a little help, and a 5, which independent attending-level practice.” (Participant 6)

Written Evaluations Exist, but Lack Performance Components

One method of documented feedback was identified in the form of post-rotation attending and fellow evaluations of residents. Participants said that evaluations are inconsistent in both quality and completion. Multiple evaluators mentioned they are often behind with a backlog of hundreds of evaluations to do. These evaluations occur through New Innovations, but there is no procedural component to them.

“And it's very non-specific. It's very much, what did they do well, what didn't they do well? There's no, you know, procedural component to it or anything like that.”

(Participant 4)

“So after every rotation and every time you work with a, individual, you are given an evaluation. These are, like, personal evaluations... more personal, more knowledge, more medicine-based, and not procedural-based.” (Participant 6)

Future Required Documentation

The one true procedural feedback documentation system identified was SIMPL (System for Improving and Measuring Procedural Learning). Within this system, resident progress on required Entrustable Professional Activities (EPAs) set by the American Board of Surgery will be tracked. After a procedure, residents can send feedback to a faculty member who rates them on their competency, complexity, and entrustability, and there is a free-text spot for the attending to provide written feedback. Residents outside of general surgery had not heard of SIMPL.

“They are trying to transition to an EPA system, so the goal with that would be that those are tracked and looked at to see how competent somebody actually is, not just based upon a number...It, like, tells you what kind of supervision they got, the feedback, the complexity score, and, like, what they were doing. So like procedures.” (Participant 8)

Currently, using SIMPL is not a requirement, so its use is inconsistent and evaluations are often not completed depending on the attending.

“But I can tell you I probably have 8 evals on Simpl, and I’ve done way more than 8 cases. So it’s, like, it depends on the residents, on us to initiate, and it depends on the attending. Sometimes, you know, I think they get, like, 48 hours, and it disappears, or something like that.” (Participant 3)

“I’ve used it a little bit, and a couple of our attendings will, you know, pretty regularly use it, but it’s... Honestly, like, mostly an afterthought for a lot of attendings, and they often don’t get to it.” (Participant 1)

RQ3: How are procedure outcomes and complications tracked, and is this data used to assess or improve resident performance?

Theme 4: Complication Tracking is Fragmented and Informally Connected to Resident Training

The final key theme identified through interviews is that complication tracking occurs through many reporting layers and systems. Many different complication metrics were mentioned by participants, along with different reporting workflows that are based somewhat on subjective determination of what is a reportable event. Complications that are identified during the procedure will be entered in the EHR, but many participants mentioned challenges with tracking complications if complications occur hours after the procedure. Additionally, participants noted there is no formal process for remediation when skill gaps are identified or complications occur.

Complications Are Tracked Through Many Disconnected Levels

Descriptions of complication tracking varied. One participant mentioned a weekly Morbidity and Mortality (M&M) conference that occurs where a list of cases where complications occurred are discussed. Two participants described the official reporting process for significant adverse events that affect patient care, which includes filling out a Midas form that gets sent to leadership to determine if a Root Cause Analysis (RCA) is needed. If the RCA is determined necessary, it will make binding recommendations for the department that force a change in behavior. One participant described a list of nationally tracked government complication reporting metrics called Patient Safety Indicators (PSI) that affect hospital funding. Two main complications associated with central lines—central line associated pneumothorax and central line associated bloodstream infection are included in the PSI metrics. Only extremely serious cases will be reported as part of this metric. It was explained that each of these complication tracking layers are meant to check each other and catch dangerous complications.

“So that, first off, its residency reporting is the first layer. Residents affirmatively report a complication. If... If that doesn't happen, if a complication is identified administratively, they go through the quality and RCA process. And if that process doesn't catch anything, on the final backend, you have the government reporting metrics that will force an evaluation, even if nobody thinks the problem is occurring.”

(Participant 7)

Documentation Challenges for Central Line Complications that Occur After the Procedure

Six participants (out of nine) explained that any complication that was immediately identified during or right after the procedure will be noted in the EHR. However, many

participants expressed that if complications like sepsis or pneumothorax are discovered later down the line after clinical documentation occurs, the EHR will not capture it.

“So if you, if you, like, know about it as it's happening, you would put that in the EHR...I don't know what happens if there's something, like, later down the line?” (Participant 5)

Complication Association with Residents and Remediation

Many participants mentioned that there is not a formal way that resident complications or procedural outcomes are tracked.

“There's not a formal way that we track for complications, or...like, other outcomes from the procedure.” (Participant 5)

Four participants (out of nine) mentioned that if a resident performs poorly in a clinical procedure, there is no formal system to ensure remediation occurs.

“If a resident who tries to do a procedure... tries a procedure, is not... competent, or let's say they have a poor performance, what remediation is available for them? And the answer is there's none. There are individuals who would take it upon themselves to be like, man, I really wish I could, like, get better at XYZ component, and depending, the fellow, the attending on might take them to the Simulation Center in their free time, might bring stuff up for remediation, but there's not a formal process that if we identify a resident who is procedurally behind where we think they would be for them to remediate.” (Participant 6)

If remediation does occur, it is suggested verbally or through escalations to leadership. This does not create any formal documentation to track remediation efforts.

“And I do know in the past that there's been, like, repeated problems with a particular resident, or with a particular procedure, then that will get escalated up the chain of

command, and, you know, our PD... if I was, you know, dramatically failing a bunch of lines, they would say, alright, you need to do something, like, what are we gonna do? ... But it wouldn't necessarily be, you know, based on this formal feedback, you now need to do this. It's more just... Kind of through the grapevine, so to speak.” (Participant 4)

Connecting the Themes

Across all interviews, the four themes collectively highlight a fragmented system of training, performance assessment, and outcome tracking for central venous catheterization. Training is front-loaded and inconsistently evaluated, with no formal mechanisms for reassessment or remediation over time. Performance is not systematically defined or documented within existing systems, and available data sources lack resident performance components. ACGME case logs capture procedural quantity but not quality, and EHR documentation may include procedure metrics that could be related to performance, but resident attribution is challenging, and unstandardized templates lead to inconsistent data reporting. Finally, complication tracking occurs across multiple disconnected systems, limiting the ability to link procedural outcomes to individual resident performance or prior training experiences.

Together, these findings demonstrate that training practices, performance documentation, and outcome tracking operate as largely independent processes rather than as an integrated system for competency assessment. Figure 4 illustrates the relationships between these themes and the key breakdowns in the current system.

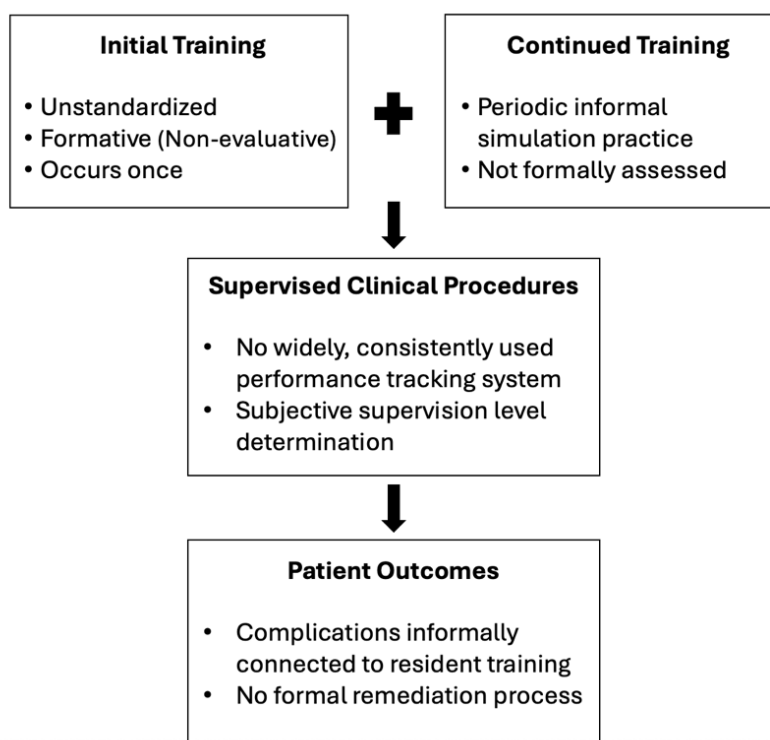


Figure 4. Resident Progression and Breakdowns Through Stages

The flow from training to the first supervised central line to when deemed “competent” is represented in Figures 5 and 6. Boxes highlighted with orange exclamation points indicate where processes are unstandardized or inconsistently implemented.

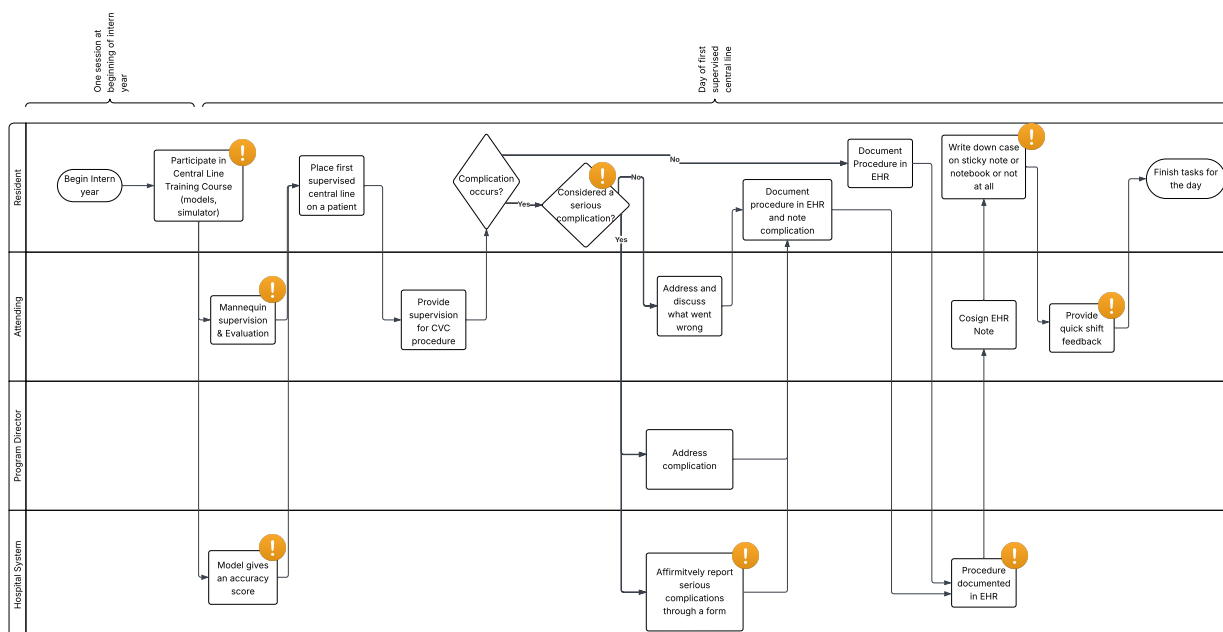


Figure 5. Map of Training to First Supervised Central Line with Inconsistencies Highlighted

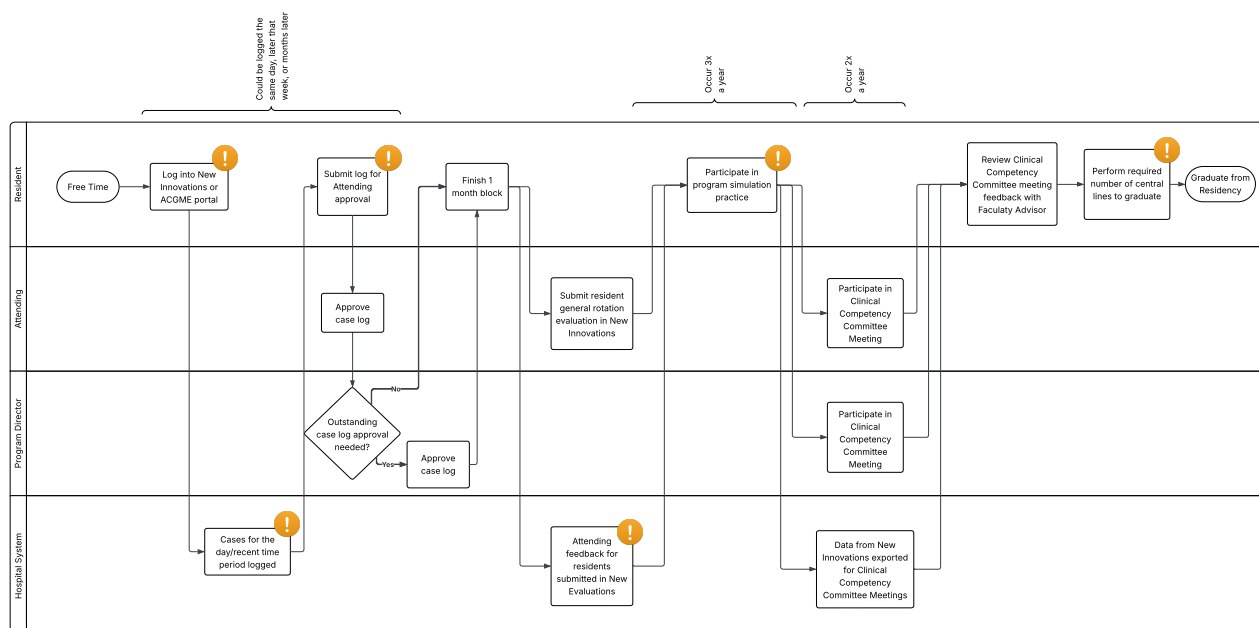


Figure 6. Map of After First Supervised Central Line to "Competency" with Inconsistencies Highlighted

Figures 5 and 6 provide a high-level representation of the CVC training and residency progression workflow, highlighting points where processes are inconsistent and oversight is limited. The swim lane structure shows where stakeholders interact with the process and how documentation systematically operates in parallel.

Figure 5 represents the flow from training to the first supervised central line on a patient. Areas of inconsistency include the central line course structure, method of evaluation (if at all), use of simulators that may or may not provide performance scores, and subjective determination to affirmatively report a complication. The EHR clinical documentation is highlighted as procedure note templates are unstandardized and not connected to resident performance. The various methods used by residents to remember cases to log along with variable depth and completion of verbal post-shift debriefs shows the gaps in capturing early resident clinical performance.

Figure 6 represents the flow following the first supervised central line to when residents are deemed competent in CVC. Points of inconsistent oversight include variable submission timing and approval processes of case logs, the lack of logging by some residents, and New Innovations post-rotation evaluations that differ in quality, content, and time of completion. Program simulation practice occurs periodically but is inconsistent as it may become less focused on central lines as residency progresses, depending on specialty. Performance data from these periodic practice sessions are not recorded in any systems or monitored by program directors or attending physicians. Finally, differences in CVC procedure volume required by specialty further adds to inconsistent data collection.

Chapter 5

Discussion

The goal of this study was to identify how training and assessment occur across the institution, where and how resident performance data is recorded, how complications and resident outcomes are monitored, and the challenges in tracking this data to ultimately examine how resident central line placement competency is assessed at a singular institution. Ultimately, this study suggests that at this institution, CVC training is unstandardized, infrequent, and minimally evaluated, and procedural performance in clinical settings is not tracked. This study provides a systems-level view showing that training, performance assessment, and outcome tracking are disconnected, obscuring objective performance metrics from competency determinations. The workflow diagrams in Figures 5 and 6 serve to visually demonstrate the system-level disconnect of performance data that contains unsystematic skill acquisition evaluations and skill retention monitoring.

Regarding the first research question related to training, this study explores how central line training is unstandardized. Three participants in one specialty described basic CVC training happened during a boot camp in intern orientation supplemented by practice on mannequins and simulators. Three participants described another central line course that occurs for other specialties consisting of a single course where basic skills are taught, and practice on mannequins and simulators. Use of simulators depends on what is available. Unstandardized training courses leads to uneven skill acquisition and baseline knowledge, making it difficult to determine standard resident readiness criteria.

Six of the nine participants described how the institution does not utilize a standard, formal assessment during training. The “check-off” at the end of the initial training course is for

completion, not competence. Therefore, training is designed to be formative in providing a skill baseline at the beginning of resident education, rather than evaluative related to competency. Five participants mentioned they thought there could have been checklist graders were using to evaluate them, but they never got to see the checklist or their score, which defeats the whole point of evaluation. However, the attending physician and fellow who are involved in the “check off” of this training both mentioned the evaluation is informal observations of residents as they perform and verbally describe the CVC procedure steps on a mannequin. Thus, while checklists may exist, they are inconsistently used. Importantly, the lack of a formal assessment hinders deliberate practice. Deliberate practice requires evaluation to be effective, and this institution seems to lack this component in their current training method.

Four participants mentioned that attending physicians and senior residents often perform training “evaluations.” While this informal evaluation poses challenges to the training itself, the skill decay of the graders is also an inherent problem with this training evaluation method. Research shows that attending physicians frequently could not meet minimum passing scores on a 29-component checklist for CVC insertion (Barsuk et al., 2016), raising concern around the validity of physicians who have not received CVC training recently evaluating resident performance on the steps of the CVC procedure, especially when this evaluation is informal and revolving around the grader’s judgement. Simulators with built-in feedback components can reduce the need for informal, subjective evaluations.

Two residents expressed concern over the informal evaluations related to simulator training, especially with changes to the emergency medicine board exam which will soon include a simulation component. One participant expressed uncertainty around if an official documented list of CVC procedural steps that all surgeons in the United States work with exists. This

uncertainty likely stems from the fact that evaluations during training at this institution are informal, so residents may never see a checklist or scoring of their performance in training. While residents can confidently guess what the key steps to the procedure are after performing it many times in practice, residents expressed formal evaluations using a checklist like what will be used on the board exam would be helpful. These board exam changes call for a change in how programs are training and evaluating their residents, specifically to include more formal simulation training evaluations.

It is important to note that in medicine, there are many ways to successfully complete a procedure. Procedures may also vary depending on patient anatomy. This makes it hard to evaluate performance in actual procedures based on a checklist.

Assuming that advancements in simulator training can standardize the initial CVC training and evaluations, skill decay still occurs with simulation training. While simulation training has shown improved patient, resident performance, and clinical outcomes (Elendu et al., 2024), the simulation training is only as good as the frequency at which it occurs. Skill decay should be addressed in residency programs, like through continued education sessions.

At this institution, five participants mentioned that the initial course is supplemented by simulation practice that occurs a few times a year, but these practice sessions do not involve a formal evaluation component and may become less centric around central lines as residents progress through their training. Simulation training without formal instruction and evaluation does not allow for learners to correct mistakes, which can reinforce bad habits (Oestergaard et al., 2012). Thus, simulators that provide real-time feedback within the simulator itself are extremely useful in these informal continued practice environments to help effectively mitigate the skill decay curve.

Some residents may go months without placing a central line, and this study found that formal re-training does not occur frequently, so skill decay may not be addressed before performing the procedure. If a central line is needed immediately, and a resident has not placed a line for a while, there is no skill refresher or simulation available they can use to immediately practice before the procedure. There is a conscious effort at this institution to remove this barrier by placing a plastic model or simulator in the ICU so residents do not have to figure out time to do extra practice, the practice is readily available at any time in real time. This could help mitigate attending skill decay as well, making it very easy for any surgeon to practice the skill before performing it on a patient.

The lack of a formal reassessment of procedural skills contributes to procedural competence and clinical supervision level determinations that lack objective assessment measures. As residents move on to supervised clinical practice, eight participants mentioned there is no official method for determining the supervision level a resident needs. In practice, attendings often do not check the number of central lines a resident has placed when determining how much supervision a resident needs. Rather, supervision levels vary based on attending trust of the resident and PGY level. Attendings who have worked with a resident before may feel more comfortable to let the resident operate more independently. It was also described that there is inherent trust and expectation that senior residents should be able to perform certain procedures on their own, meaning that procedural competency is sometimes assumed from PGY level rather than objective skill.

When discussing competency, residents in this study were not able to provide a consistent ACGME or institution required number of central lines to be placed before being deemed “competent” within a specialty. Three participants supplied a required number of lines for their

specialty, three mentioned they did not know how many are required, and three mentioned a specific number of central lines are not required for their specialty. This uncertainty may be due to the specific role the participant is in. General surgery may not actively track the number of central lines they place because ACGME does not require this specific procedure to be logged. This numeric threshold of competency may exist in some specialties as an ACGME requirement, but it is not actively applied in resident training. Furthermore, the unstandardized number of central lines required to be placed before graduation (or the lack of this requirement) contributes to an unshared definition of competency or varying degrees of resident competence across the institution.

One participant brought up a critical component of competency that is not considered in resident competency assessments using procedural volume: troubleshooting ability. A resident may have exceeded the minimum number of central line placements required to graduate from surgical residency, and therefore be deemed “competent” in the procedure, but if there is an issue in the procedure and the resident needs help troubleshooting, are they truly competent? This raises a broader question of what the definition of competency is in surgical settings.

Additionally, if competency is defined as being attained after a certain number of procedures, questions are raised around individuals slower to acquire procedural skills. The current training is designed for the average resident to acquire skills to be procedurally competent. However, there will likely be a few outliers who need more practice, and they may not get the practice they need to be as procedurally competent unless it is identified or if the individual makes the conscious effort to seek out simulation opportunities.

To mitigate this, the institution’s Clinical Competency Committee (CCC) conducts performance reviews two times a year to ensure no resident falls behind in their procedural skill

level. Since training is not designed to assess competency, CCC meetings monitor competency progression by reviewing ACGME case log volume, faculty feedback, and progression towards ACGME milestones. Faculty feedback likely does not include specific procedural outcomes and milestone ratings have not been associated with the patient outcomes of procedures performed by residents (Kendrick et al., 2023), so using these evaluations and milestones as determinations of readiness for unsupervised practice is disconnected with actual procedural outcome measures.

In some ways, CCC meetings serve as a backstop to the institution's relatively informal training evaluations because poor progression can be identified through these performance reviews. However, assessments in these meetings may be less objective because accessing relevant data and the timeliness of attaining data can be challenging (Goyal et al., 2018; Hauer et al., 2015). Furthermore, these performance reviews are verbal and tracking discussions in these reviews is systematically difficult.

Related to Research Question 2 on performance documentation systems, this study explores how "performance" is not clearly defined or systematically documented for CVC procedures at this institution. None of the current widely used systems were found to explicitly record resident CVC clinical performance.

Six of the nine participants explained that case logs do not contain performance data. Any qualitative component of a case likely is not entered in the ACGME log unless the resident decides to put it in the comments. This is added work on the resident's part, so it is unlikely the comment section is filled out. Thus, complications, if an attending had to take over, or any outcomes from the procedure are not included in the case log, and competency determinations based on case logs do not include any qualitative procedural data.

Additionally, ACGME reporting habits were found to be inconsistent. One resident described that to log a case, they had to have significant participation in it. That determination is subjective, so some residents may log cases where they were involved in the pre-operative or post-operative care but had minimal involvement in the actual procedure. Besides having required numbers to graduate residency, residents mentioned that these case logs are provided to future employers to demonstrate procedural experience and breadth during residency. Thus, some residents desire to record as many procedures as possible. This logging is motivated by future employment and graduation rather than educational feedback.

Another inconsistent ACGME workflow habit explored is the time of case entry in ACGME. There is no timeliness requirement for these logs to be submitted, so nothing is stopping residents from putting off logging cases. Cases may not be logged in the ACGME system until months after the procedure occurs, although best practice is to do it within a week to reduce errors from lack of recall. Research shows that in regards to training, delayed case log entry or a complete lack of logging can inhibit residency progression reviews from identifying gaps in clinical experience and interventions that support development (Kwan et al., 2024), like during Clinical Competency Committee meetings.

Findings identified some reasons for why a resident would not log a case. If the resident has exceeded the minimum number required to be logged, they often do not log cases for that procedure anymore. Central lines are not even required to be logged by general surgery residents, so some general surgery residents mentioned they have never logged a case in ACGME at all. Thus, not only is performance information not included in the case log, but case logs are also not consistently filled out.

While relevant performance metrics may be in the EHR, findings from this study suggest that the EHR procedural note where key components of the procedure are entered is unstandardized. There are auto-populated templates for central lines that residents use and edit based on the procedure, but there is no required template. Depending on the template, certain information like the number of attempts to access the vein or if the site of the central line was changed, may or may not be included. Resident attribution was described to be unattainable from the EHR because while the resident name is included in the EHR, the resident role or if an attending took over will not be documented. Thus, although “performance” metrics that may be relevant can be included in the EHR, it is difficult to attribute the case to the resident from the EHR.

A combination of the respective EHR and ACGME reports could be useful in attributing resident role to procedure outcomes, but these systems are disconnected, so cross-referencing does not currently occur. By themselves, the subjective role selection, inconsistent time of data entry, and absence of central line logging by general surgery in ACGME suggests that case logs are unreliable and incomparable representations of procedural experience. As a result, residency programs and researchers assessing skill transfer from training to clinical settings lack the ability to accurately monitor resident procedural experience, skill gaps, or competency progressions. While accuracy of case logs could be increased by comparing EHR records to ACGME case logs (Kwan et al., 2024; Xiao et al., 2022), these systems fragmentation at this institution hinders the pairing of corresponding ACGME case logs and EHR notes.

When discussing tracking performance, some residents questioned what defines good performance. Does “good” performance mean an attending or senior resident did not have to take over? If so, that is not documented in the EHR or the case log. Is “good” performance based on

time, so the resident who can place a central line in 15 minutes has better performance than one who can place it in 45 minutes? Is “good” performance based on the number of needle pokes? That would not be in a case log, and it may not be in the EHR. Thus, some of the relevant performance assessment measures may be included in the EHR, but because that documentation is not standardized, that information may not be included.

Therefore, this study suggests that the currently widely used systems at this institution, the ACGME case logs and EHR, cannot be relied on to attain consistent resident performance data. Findings from this study indicate that procedural performance feedback occurs through conversations rather than through structured documentation. Participants explained performance feedback is attained through verbal feedback from attendings during or after a procedure and biannual discussions of resident progress through Clinical Competency Committee meetings. These conversations are critical for specific, real-time feedback and a broader, holistic review of residents, but they do not produce systematic records or documentation that can be used to review specific resident performance on a single CVC procedure.

Similarly, it was discovered that attendings and fellows are supposed to write evaluations of residents after they conclude a rotation with them. However, attendings get so many of these, so they are often behind in completing them, and therefore the depth and quality of the evaluations vary. Participants also explained that specific procedure performance is not included in these evaluations.

While none of the current systems consistently tracks specific resident procedural performance data, a new system, SIMPL, may be used to do so in the future. The American Board of Surgery will require the use of SIMPL to track graduation requirements for general surgery residency in a few years. Residents will be able to send the attending they performed a

procedure with an evaluation, and the faculty can rate them on the complexity, supervision, and their performance. This system rates residents in general surgery EPAs which are aimed to focus resident competency assessments more on clinical performance (Brasel et al., 2019). This institution is just starting to implement the system now, but it is a promising system that can be used to systematically attain general resident performance data in the future. Whether performance metrics like number of attempts or if an attending had to take over will be in that system remains unknown.

In relation to the final research question regarding tracking complications and procedural outcomes at this institution, it was identified that complication tracking is extensive and thorough, but it is fragmented and not formally connected to remediation efforts or resident performance assessments. Complications are not included in ACGME case logs, and even if complications are in the EHR, resident attribution is difficult to determine. Thus, there is no way to track, for example, the number of complications in the institution that are attributed to procedures performed by residents or the number of central lines taken over by attendings. Importantly, some complications with CVC can occur hours after the procedure, and if that occurs, the complication will not be documented in the EHR. This further complicates tracking procedural outcomes.

Participants described it is difficult to associate residents with complications other than through watching procedures or verbal discussions. This stems partly from the disconnect between the multiple layers of methods used to track complications. The affirmative reporting forms, root cause analysis, M&M conferences, PSI metrics, and the EMR all produce separate, disconnected data sets. These are all monitored by different stakeholders, so if a problem is identified through a root cause analysis, it would be challenging to go back through multiple

layers of the tracking to determine how well the resident performed in training sessions. Thus, complication tracking is often not connected to resident performance data.

Findings suggest that complication remediations at this institution do not occur systematically. When issues occur during a procedure and a resident needs assistance troubleshooting, it would make sense for them to go back to simulation after the procedure to work on that skill. Deliberate practice would call for this. However, in this institution, the lack of formal system that monitors or enforces remediation behavior in combination with residents being so busy, residents may not find time to deliberately practice in order to reach a high level of competency.

If remediations are suggested, it is typically through verbal escalation to the program director and the program director talking with the resident to suggest simulation or more controlled practice. Attendings may also suggest more simulation training. However, these interventions are not documented, so these interventions would be difficult to monitor or track.

Ultimately, these findings reveal a systems-level problem: surgical training, clinical documentation, and accreditation system reporting are disconnected and fail to operate as integrated monitoring tools for resident competency progression. Findings suggest that resident performance in actual CVC procedures is not systematically tracked or linked to patient outcomes at this institution, making skill decay detection challenging and hindering objective measures from being included in resident competency progression determinations. This means that residents can operate with varying levels of competency, putting patient safety at risk and likely contributing to the complication rate associated with CVC placement. Thus, there is a need to investigate not only resident CVC training, but also resident skill decay, procedural performance tracking, and competency progression metrics related to CVC.

Chapter 6

Recommendations & Limitations

This study revealed unstandardized and inconsistently evaluated CVC procedure training within a single hospital. Training can be enhanced through simulators that have built in real-time feedback mechanisms and therefore do not require faculty for subjective evaluations. These simulators can provide a standardized training experience, but skill decay will still occur. Residency programs may benefit from incorporating more opportunities for formal skill refresher training and reassessments of procedural skills throughout residency and physician careers. Currently, there are no clear criteria for determining supervision levels, so establishing metrics that objectively demonstrate competency progression may further support resident readiness for independent practice and better define competency within the institution. This directly relates to establishing clear, consistently used CVC training evaluation assessments. The findings in this study suggest that this institution lacks formal assessment metrics that can help residents progress in their training, so a recommendation is to research the most effective training assessment method (checklist, global rating scale, etc.) and investigate implementation.

Additionally, this study found an absence of an explicit, consistently used system to track resident performance data. This removes critical performance metrics from resident procedural competency determinations. SIMPL seems to be a promising system to attain performance data and support a more standardized, progression-based determination of competency, but only one specialty in this study had used this system before. It is recommended to define performance and further investigate performance tracking systems.

There are limitations to this thesis. First, this study investigates a single academic medical center, which may limit the generalizability of results to other institutions. Additionally, the sample size of this

research was nine, and participants came from different specialties in the institution, so the sample sizes within specialties is smaller and therefore less generalizable.

However, the systems described in this study are used across the United States, so challenges with collecting performance data through the EHR or ACGME case logs apply widely to residency programs across the United States.

Recommendations for future work include investigating how competency is assessed at other academic institutions across the United States, exploring how performance is tracked through other residency programs, expanding the study sample size, and applying this analysis to other procedures with high complication rates.

Chapter 7

Conclusion

CVC is a procedure currently under high investigation to reduce the associated complication rate. This research explores a singular institution's resident training, assessment, and performance tracking methods for central venous catheterization to explore how performance is assessed systematically and discover gaps in the systems. The study findings highlight a disconnected system of training, performance assessment, and outcome tracking for CVC, suggesting there is an unstandardized systematic determination of competency in this procedure. Training can be enhanced through advanced simulators that contain performance tracking metrics, but skill decay still occurs, so repeated refresher trainings are key to maintaining competency levels. Evaluating those periodic practice sessions so that errors can be corrected and bad habits are not enforced is also important to monitor skill decay and performance progression. Simulation technologies and assessment metrics can continue to evolve, but it is critical to assess how skills transfer from training to clinical procedures because patient safety is of the utmost importance. Current systems, like ACGME case logs and EHR documentation, capture procedural volume and billing requirements, but do not systematically record procedural performance. As a result, specific resident procedural performance on patients is not consistently defined or tracked in a systematic way. Complications may indicate procedural performance, but complication tracking occurs through disconnected processes, and there is currently no formal link between complications made by residents and remediation training. Therefore, complication tracking is not formally tied to resident competency progression. These findings highlight a disconnect between surgical training, clinical

documentation, and performance evaluations that ultimately makes it challenging to assess resident competence and evaluate the skill transfer from training to actual procedures. Residents are ultimately responsible for performing central venous catheter placements on patients, so accurate tracking of procedural performance and competency assessment is critical for patient safety.

Appendix A

Interview Questions

Interview Questions for Residents:

Role & program context

- Tell me a little bit about your background – How long have you been at this institution? Where were you at before this institution for your training?

Training, assessments & supervision

- Have you completed any central line training here where you were formally evaluated for competency?
 - How was the training assigned?
 - What are the formal components of the training?
 - How are you assessed during training (Checklists? Procedure steps? A grader?)
 - Who did the training and assessment (your department, simulation center, etc.)
 - How were you evaluated for completing the “course”?
- Were there any requirements to track your clinical performance after the completion? If so what were they?
- When were/are you allowed to perform your first procedure without supervision?
 - How are you deemed “competent” to operate on a patient?
 - If they had already done it; did you feel prepared for this first attempt; why or why not.
 - Is there an assessment you must pass to establish competency and perform on a patient?
 - Are there formal escalation rules that determine when a supervisor might take over a procedure? If so, please describe.
- Is there ongoing training sessions?

Clinical documentation

- Can you walk me through how you log how a procedure went in the patient’s chart or other reporting system after a procedure.
 - What system(s) do you use?
 - What minimum data elements are required in those records (operator name/level, supervising clinician, indication, approach, ultrasound use, complications)? Are these always included?
 - Do you include any additional information other than what is required?
 - When do you complete it?
 - Is there a form (standard way) you complete or is it free-hand?
 - Where do you note complications that happened during operation (if any)
 - Does anyone monitor this?
 - When do you connect these reports to the official case log/system?
 - Are resident names included in the documentation of procedures? IF so, where and how? If not, why not?
 - What goes into the EMR procedure note? Who is included in the EMR note? Can you tell what components of the procedure a resident performed from this?
 - What is the most challenging or frustrating part about these reporting requirement? part about this?

ACGME reporting requirements and practices

- What are your clinical reporting requirements for the Accreditation Council for Graduate Medical Education (ACGME)?
 - When do you work on these reporting requirements?
 - If it is much after a procedure, how do you keep track of your procedures?

- How do you track progress?
- What all do you log? How strict is the criteria for what goes in the report?
 - Are complications required to be in the case log?
- Is this linked in any way to other systems within the hospital or do you have to duplicate your efforts?
- Who within the hospital has access to this system or your reports?
- Do you submit the case logs to anyone? Who do you submit it to?
- Is there any reason you would not log a case?
- Would you log the first procedures you perform on a patient in ACGME?
- What is the most frustrating part of these requirements?
- Are there certain procedures where you have to document completing them supervised successfully on a certain number of patients before you are able to do them without supervision?
 - If so, what procedures
 - If so, how is this documented and verified

Performance documentation

- How do you monitor, track, and document your performance?
 - How do the people assessing your performance monitor and assess it?
 - Is there actual logging or records of your performance in procedures?
- What other institution reporting requirements do you have for tracking your clinical outcomes or procedures completed?
 - Who do you report to?
 - What do you report?
 - How often do you report?
 - Is this a duplicate effort with ACGME or not? Who has access to them?
- Our goal is to identify ways in which we can monitor resident progress on clinical procedures on their first set(s) of real patients without requiring additional documentation and/ or work.
 - What systems do you currently use that could potentially be leveraged to help monitor new resident clinical performance
 - What challenges do you see in adoption/ uptake within the hospital
 - What concerns would you have?

Interview Questions for Administrators or Attendings

Role & program context

- Briefly describe your role and oversight responsibilities related to procedural training (title, departments supervised, time at this hospital).
- Do you know which departments and provider types are covered by the hospital's current central line training program (attendings, APPs, residents, fellows, vascular access team, nurses)?
- How does your unit ensure all trainees receive sufficient supervised CVC cases?

Program curriculum

- What are the formal components of the hospital's CVC training program (didactic, simulation, supervised clinical cases, maintenance/dressing training)?
- Who is responsible for designing and delivering training (medical education, department faculty, simulation center, vascular access team)?
- Are there standardized curricula/checklists or policy documents?

Competency & supervised practice

- What are the formal criteria for granting unsupervised privileges to perform CVC insertion (concrete number of supervised insertions, checklist items, simulation pass)?

- Who signs off on competency (program director, service chief, privileging committee)? Is there a timeframe or re-evaluation schedule?
- What defines “ready for independence / competency” (counts vs. checklists vs. simulation criteria)
- What about new physicians to the hospital – are they also required to show competency?
- What about if someone hasn’t performed the procedure in a long time – how is this tracked and are they also required to re-certify?

Assessment, documentation & clinical logging

- What about if someone hasn’t performed the procedure in a long time – how is this tracked and are they also required to re-certify?
- What systems are used to document completed procedures (EHR procedure note, separate app such as ACGME case log)?
- What minimum data elements are required in those records (operator name/level, supervising clinician, indication, approach, ultrasound use, complications)? Are these always included?
- Is there a standardized form/template or free-text note?
- How and when are complications recorded and escalated? Who reviews/monitors complication reports?
- Have there been any recent documentation changes in the last few years on how central line complications are recorded?

Ongoing monitoring, quality and outcomes

- Are first-in-practice or early independent procedures actively monitored? If so, how (automatic review, proctoring, chart review)?
- How are remediation and re-training handled when deficiencies or complications are identified?
- Do you require an immediate post-procedure review or debrief for trainees’ first procedures? If so, describe the process.

Integration with GME/ACGME requirements

- How do hospital documentation, program records, and the official ACGME case log system get coordinated so they are consistent, accurate, and compliant?
- Do trainees duplicate entries across systems (EHR, ACGME portal, departmental logs)? If so, why?
- Who in the hospital/program reviews and approves reported cases and competency sign-offs?
- Are the ACGME requirements integrated with other hospital systems, or do trainees/programs need to duplicate entries?

Burdens, gaps & improvement opportunities

- What are the most significant frustrations with current training, documentation, and monitoring (duplication, workflow, lack of integration, staffing)?
- Where do you see the biggest gaps in ensuring early trainee competence and patient safety?

Appendix B

Codebook

Subtheme	Brief Description	Code	Illustrative Quote
Training approaches and tools vary across specialties	Talking about components of the training session, when training occurs, and what tools were used in training (didactic, VR, simulation, etc.)	Intern year training	"So they're all trained during their intern year, and then, Move on from there." (Participant 9)
		Training session components	"There is a VR thing that we used, I don't know what it was called, or who ran it, but there was a VR thing, live mannequin session, and then some, like, low-fidelity simulation models." (Participant 2)
Inconsistent and informal training evaluation practices	Talking about how they were evaluated during training, if there was a checklist or other grading metric, and who was performing the training and assessments	Training evaluation	"The answer for most of them is it's done qualitatively or not at all." (Participant 7)
		Checklist Evaluation	"They had one, like, the graders did, we never got to see it. And then as long as we said, you know, enough of these steps in the correct order." (Participant 4)
		Informal Evaluation	"It's very informal, to be completely honest. It's usually me just, watching them go through the steps and kind of helping them give instructions of, like, things that are easy." (Participant 6)
		Training oversight	"The attendings and mid-level and senior residents teach the juniors." (Participant 2)
Competency definitions vary	Talking about when competency is gained throughout residency and what determines competency	Proving Competency	"There is no... there's no intermediate step in which we say this... this first-year, second year, third year resident is now competent." (Participant 7)
Required CVC procedural volume inconsistently understood	Talking about how many central lines are required to be placed or logged by either the institution or ACGME	Unknown required number of central lines	"I don't know the specific number off the top of my head, it's between 15 and 25." (Participant 7)
		Known required number of central lines	"So, we... technically, you have to be able to do 10, once you do 10 central lines." (Participant 2)
		No required number of central lines	"They don't... necessarily...count for, like, towards our numbers that graduate. They still, like, get tallied onto, like, a bigger number, but they're not part of our graduation requirements." (Participant 2)
Continued practice sessions occur, but are not evaluated	Talking about if/how continued training after the initial training course occurs. If it does occur, how is it assessed? Additionally, can these practice simulations count towards ACGME requirements?	Continued training	"We do other... Trainings periodically, through our residency program. But there's no... Formal evaluation or standardized evaluation process as part of that." (Participant 5)
		Log Simulated Procedures	"Throughout every year, we have separate SIM sessions with central lines, and those are not formally graded. Those are just really for our practice, and we can log those as our procedures." (Participant 4)
Procedural skills are not formally re-evaluated after initial intern year training	Talking about how there is really only one true central lines training course and procedural skills are never re-assessed after that	No re-evaluation of skills	"It's just, we do the one as an intern, and then it's just sort of much more informal feedback throughout the years." (Participant 4)

Subtheme	Brief Description	Code	Illustrative Quote
Clinical supervision level is not formally determined	Talking about what determines how much supervision a resident needs during clinical procedures and when residents can start to perform unsupervised procedures	Transition to Unsupervised Procedures	"So, as you become more senior, you can kind of start to do procedures unsupervised. Typically, those procedures are, like, central line placement, technically, just tube placement." (Participant 1)
		Supervision for every line	"Their simulation training happens, and then they're supervised in the clinical setting. By the faculty members. Really, every time they place the central line." (Participant 9)
		Attending-based supervision	"I think every attending has a different level of trust." (Participant 3)
		Procedure-based supervision	"I guess it depends the procedure. You know, I've never intubated somebody without an attending next to me. I've never... I've done lines, I've done central lines without, an attending." (Participant 4)
Procedural skills are often assumed from PGY level	Talking about how attendings typically assume senior residents have the skills to operate with less supervision	PGY-based supervision	"And then from a competency standpoint some attendings, you know, by the time you're a second year and you're considered a senior resident, they'll let you do any procedure. They don't need to always be in the room and stuff" (Participant 4)
Performance is undefined	Asking what defines performance, talking about different performance metrics, or describing their opinion of what good or bad performance is	Defining performance	"It's a very vague term for, like, performance. I think from, like, a documentation standpoint of how many needles, needle pokes, time it took through the entire procedure, estimated blood loss, etc, etc, could be relevant, but it's... that's also kind of hard to assess... But yeah, there's no, like, excellent job versus okay job versus need improvement job. There's no scale like that." (Participant 6)
ACGME case logs capture quantity, not quality	Talking about the required components of ACGME case logs, whether or not complications are required to be in ACGME case logs,	ACGME documentation components	"The fields that you have to have are day of the procedure, the attending on record for the procedure, and then you have to put in the code, associated code for the procedure. Yeah. And then the location as well. Like, what hospital? Adult slash pediatric is another thing that you have to check off. And then there's also a checkbox for trauma, if it was a trauma scenario." (Participant 2)
		Complications not in ACGME	"No, it's solely quantitative, no qualifying factors." (Participant 1)
ACGME logging practices are inconsistent and low priority	Talking about when logging occurs in ACGME, the workflow after a procedure, what is required to be included and what may be included in a case log, or what is not allowed to be in the case log (patient identifiers)	ACGME logging habits	"I normally do it at the end of the week, so I, like, make a list on my power chart of all the patients that I, like, operated, and it's like, it's like an own list called, like, cases that I have to log, and then I just sit down at the end of the week and log them all." (Participant 3)
		ACGME case log free text section	"There are free text options that people can put in, but I will tell you right now that no one op... no one will do any of that. This is just excess

Subtheme	Brief Description	Code	Illustrative Quote
			work that we're doing for logging and ACG requirements.” (Participant 6)
Some residents log all CVC procedures, others log none	Talking about when or why they would not log in ACGME, why they want to log in ACGME, and which procedures they are supposed to log	Personal future incentive to log in ACGME	“Let's say I graduate general surgery training, and I want to go do an ICU fellowship, or get a job as a surgical critical care doctor. I don't need central lines, documented to be a board-certified general surgeon, but if I have them all logged into ACGME, I can show my fellowship, and I can show my future job that I'm applying to, hey, look, I have 55 central lines in residency.” (Participant 2)
		Which procedures to log in ACGME	“I think the technical rule is if you're involved in 50% or more, you can log it.” (Participant 3)
		Reasons for not logging	“It's not really required for us, so yeah, I have never logged a central line” (Participant 3)
Case log quality control is limited	Talking about if and how case logs are monitored for accuracy or talking about how it is just trusted that the case log data is being entered accurately	Case log quality control	“I believe that you send the attending the... a procedure that you did, and they either say that, yes, you supervised them, or no, you didn't.” (Participant 6)
		Trust system	“So, I mean, it's trusted that when the residents enter them, they're valid, and that they're accurate” (Participant 9)
EHR purpose is billing and storing patient data	Talking about the purpose of the EHR system	EHR purpose	“EHR has all these requirements and buzzwords and all these key things that they have to say in order to get max billing” (Participant 9)
EHR documentation is unstandardized	Talking about required elements in the EHR and procedure note, if complications are entered into the EHR, if resident name is required to be in the EHR, if resident role is in the EHR, or how the procedure note is filled out	EHR documentation	“there's a template that's resident name, attending name, patient's name, indication, site. Preparation, like, it'll talk about, like, any local anesthesia... There's a very specific note template that's just drop all of these things down.” (Participant 7)
		Complication noted in EHR	“Complications, blood loss. Technically, all of that is supposed to be in there.” (Participant 1)
		Unstandardized EHR procedure note	“There's not, to my knowledge, like, an official one that we have to use. There are things that the coders and billers ask for when we document.” (Participant 5)
		Resident attribution in EHR	“So if the nurse put my name in there, and all I was in there was helping move the patient, and I wasn't even scrubbed in, but for some reason she, like, put my name in there because she thought I was in there, that's gonna auto-populate as part of the op note, even if I actually didn't do anything.” (Participant 3)
Performance feedback happens in conversations, not systems	Talking about if and how performance is evaluated, the clinical competency committee, or how performance feedback occurs through verbal feedback	Evaluation of performance	“But I don't formally grade. the interns on their performance or anything, and we don't necessarily have, to specifically answer your question, I guess, there's no, like, true procedural feedback... It's really just built into the general shift feedback that we get from the attendees.” (Participant 4)

Subtheme	Brief Description	Code	Illustrative Quote
		No formal performance evaluation	"How do we get evaluated for, like, how we perform? So, I think the short answer is we probably really don't, other than, like, real-time, like, verbal feedback." (Participant 2)
		Performance reviews	"So twice a year, our... The program director, the assistant program directors, and then some of the faculty, including our faculty advisors for each resident, will go and they'll talk about the resident, and they review the, like, written feedback, they review, like, on-shift. feedback that's been submitted by faculty, they review procedure numbers, they talk about if you've gotten any, like, other good feedback or negative feedback, and there's milestones from ACGME that we're all scored against, so they want to make sure that you're literally, like, meeting your milestones." (Participant 5)
		Clinical competency committee	"It's like, I don't know, some type of meeting, basically, that happens every 6 months, like clinical competency... And we meet with our program director, who basically got a compiled you know, feedback form from all of the people we rotate with, all the attendings... he performed at, you know, his level, below his level, or above his level... But they don't necessarily say, like, you know, his central line technique is phenomenal, or terrible, or average, you know?" (Participant 1)
		Verbal feedback	"so it's tricky to evaluate procedural stuff in a formal setting like that. They do it, it's much more, you know, based on live feedback and stuff like that." (Participant 4)
Written evaluations exist, but lack performance components	Talking about end of block faculty evaluations, the components of these evaluations, and how timely or in depth they are	New innovations evaluations	"Yes, so after every rotation and every time you work with a, individual, you are given an evaluation. These are, like, personal evaluations." (Participant 6)
		Delayed, none, or lacking evaluations	"The amount of effort and time that each attending puts into the... to set evaluations varies drastically, between persons." (Participant 6)
		No performance component of faculty evaluations	"It's very non-specific. It's very much, what did they do well, what didn't they do well? There's no, you know, procedural component to it or anything like that." (Participant 4)
Future required documentation	Talking about the SIMPL system that will be required in the future, how often it is currently used, and what goes into these evaluations	SIMPL	"Trying to transition to an EPA system, so the goal with that would be that those are tracked and looked at to see how comp... like, how competent somebody actually is, not just based upon a number" (Participant 8)
Complications are tracked through many disconnected levels	Talking about how complications are tracked or the different complication tracking layers	Complication tracking	"If there's a complication, there's a... we have a separate... there's a separate quality assurance process. So,

Subtheme	Brief Description	Code	Illustrative Quote
			if something bad happens there's multiple layers, so the individual departments will do a quality review process." (Participant 7)
		Root Cause Analysis	"And if this was a serious enough lesson, it will get escalated then to something called an RCA, a root cause analysis that something bad happened, and a mistake was made. Why was the mistake made?" (Participant 7)
		PSI 100	"The second piece is that there are, a number of centrally tracked complications through an entirely different metric for entirely different reasons. They're called the PSI 100." (Participant 7)
Documentation challenges for central line complications that occur after the procedure	Talking about how complications that occur hours after a procedure are not included in the EHR procedure note	Complications after procedure not in EHR	"So if you, if you, like, know about it as it's happening, like. So I don't know what happens if there's something, like, later down the line?" (Participant 5)
Complication association with residents and remediation	Talking about the process (or lack thereof) for remediation if a complication occurs or if a resident performs poorly in a CVC procedure	Complication remediation	"If a resident who tries to do a procedure, tries a procedure, is not... competent, or let's say they have a poor performance, what remediation is available for them? And the answer is there's none." (Participant 6)

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