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Creating a Competency-Based Medical Education Curriculum for Canadian Diagnostic Radiology Residency (Queen's Fundamental Innovations in Residency Education)—Part 1: Transition to Discipline and Foundation of Discipline Stages

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Abstract

Purpose: The Royal College of Physicians and Surgeons of Canada (RCPSC) has mandated the transition of postgraduate medical training in Canada to a competency-based medical education (CBME) model divided into 4 stages of training. As part of the Queen's University Fundamental Innovations in Residency Education proposal, Queen's University in Canada is the first institution to transition all of its residency programs simultaneously to this model, including Diagnostic Radiology. The objective of this report is to describe the Queen's Diagnostic Radiology Residency Program's implementation of a CBME curriculum. **Methods:** At Queen's University, the novel curriculum was developed using the RCPSC's competency continuum and the CanMEDS framework to create radiology-specific entrustable professional activities (EPAs) and milestones. In addition, new committees and assessment strategies were established. As of July 2015, 3 cohorts of residents (n = 9) have been enrolled in this new curriculum. **Results:** EPAs, milestones, and methods of evaluation for the Transition to Discipline and Foundations of Discipline stages, as well as the opportunities and challenges associated with the implementation of a competency-based curriculum in a Diagnostic Radiology Residency Program, are described. Challenges include the increased frequency of resident assessments, establishing stage-specific learner expectations, and the creation of volumetric guidelines for case reporting and procedures. **Conclusions:** Development of a novel CBME curriculum requires significant resources and dedicated administrative time within an academic Radiology department. This article highlights challenges and provides guidance for this process.

Résumé

Objectif : Le Collège royal des médecins et chirurgiens du Canada (CMRCC) a exigé la transition des programmes canadiens de formation médicale de cycle supérieur vers un modèle de formation médicale par compétences (FMC) divisé en 4 stages de formation. Dans le cadre du projet Fundamental Innovations in Residency Education (Innovations fondamentales du programme de résidence) de Queen's University, cette université canadienne est le premier établissement à effectuer la transition simultanée de l'ensemble de ses programmes de résidence vers ce modèle, y compris la radiologie diagnostique. L'objectif de ce rapport est de décrire le déploiement du programme de résidence en radiologie diagnostique de Queen's University selon un modèle de FMC. **Méthodes :** À Queen's University, le nouveau cursus a été mis au point en utilisant le continuum des compétences du CMRCC et le référentiel CanMEDS afin de créer des activités professionnelles confiables (APC) et des jalons spécifiques à la radiologie. De plus, des comités et des stratégies d'évaluation d'un nouveau type ont été établis. En date de juillet 2015, 3 cohortes

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de résidents (n = 9) ont été intégrées dans ce nouveau cursus. **Résultats :** Ce rapport décrit les APC, les jalons et les méthodes d'évaluation des étapes de la transition vers la discipline et des piliers de la discipline, ainsi que les opportunités et les enjeux associés au déploiement du cursus par compétences dans un programme de résidence en radiologie diagnostique. Les enjeux sont les suivants : la hausse de la fréquence des évaluations des résidents, la détermination des attentes des étudiants pour chaque étape et la création de directives volumétriques axées sur les rapports de cas et les procédures. **Conclusions :** La mise en œuvre d'un nouveau cursus de FMC exige des ressources considérables et du temps consacré aux tâches administratives au sein d'un département universitaire en radiologie. Cet article souligne les enjeux impliqués et sert de guide à ce processus.

Keywords
competency-based medical education, diagnostic radiology residency, entrustable professional activities, milestones, competence by design, postgraduate medical education

Introduction

Competency-based medical education (CBME) is being implemented across Canada as a system of curriculum design centered on a framework of competence in which outcomes are explicitly defined and assessed.[1,2] This approach represents a paradigm shift which diverges from a traditional time-based assessment system to one of competency-based outcomes.[3] It challenges the current model for postgraduate year (PGY) training, which presumes that residents improve with time and can achieve competency within a fixed training period.[4] With CBME, the emphasis for assessment is on the observable abilities of the resident. It focuses their training on specified competencies that are relevant for the resident at a particular stage of training.[5] In this manner, current gaps in training are more easily identified and addressed.[6] The CBME multimodal assessment structure provides transparency and increases accountability for both faculty and residents in training future physicians. This model of training is focused on developing the knowledge, skills, and behaviors that the practicing physicians require to meet evolving patient and societal needs.[7,8]

In 2014, The Royal College of Physicians and Surgeons of Canada (RCPSC) launched CBME with the development of a national curriculum framework using competence by design (CBD) for postgraduate medical education (PGME) across Canada.[9] As part of the Queen's University Fundamental Innovations in Residency Education proposal, Queen's University was granted permission by the RCPSC to adopt an institution-wide accelerated path to CBME. The process of CBME implementation began in 2015, and as of July 2017, all new trainees entering the 29 specialty programs at Queen's University have begun residency within the CBME model. Queen's CBME curriculum models are organized around the 4 stages of training defined by the RCPSC's competency continuum: (1) Transition to Discipline, (2) Foundations of Discipline, (3) Core of Discipline, and (4) Transition to Practice. Each stage consists of discipline-specific entrustable professional activities (EPAs) and milestones.[10-12] EPAs represent the major tasks that a physician performs in their discipline and are entrusted to competent learners as they progress through stages. Milestones are observable skills and abilities used to assess an individual's achievement of an EPA. EPAs and milestones integrate multiple CanMEDS roles and are used as the basis of assessment for residents who started the program in July 2017. They were developed within the Queen's Radiology Residency Program in consultation with the local faculty and correspond with the program's existing goals and objectives. A national consensus meeting is forthcoming and Diagnostic Radiology CBME curriculums will not be implemented at other Canadian institutions until 2022.

There are many stakeholders involved in this undertaking, and a system of support was implemented for the transition to CBME with the establishment of a central CBME leadership team within the PGME office. Multiple working groups were created to develop communication, assessment, program evaluation, faculty development, curriculum, scholarship, and funding processes. Feedback mechanisms and technology implementation were developed, and these components are continually improved in an iterative manner as CBME implementation progresses. Competency-based medical education implementation at Queen's University continues over a multi-year period in tandem with RCPSC CBD development with the national specialty committees.

As the implementation of CBME is still largely in its infancy, there exist many gaps in our knowledge of how best to design and revise effective competency-based curricula and assessment tools, and ultimately, of the short- and long-term outcomes for graduating physicians and the patients they care for. This article describes the Queen's Radiology Residency Program's development of a CBME curriculum, the committees involved, the assessment process, and the challenges encountered thus far. Transition to Discipline and Foundations of Discipline stages are discussed, as the initial cohort of CBME residents have just recently entered the Core of Discipline stage and as of yet, there are no residents in the Transition to Practice stage. The aim is to inform and facilitate the development of other CBME Radiology Residency Programs.

Methods

Components of a CBME Curriculum

Creation of a protected position. In order to facilitate CBME implementation at Queen's University, a CBME Program Lead

position was created for all programs, including Diagnostic Radiology. This position is filled by a faculty member in the Radiology department and is chosen by the department chair. The CBME Program Lead receives 20% protected academic time as well as administrative support. In partnership with the Program Director, the CBME Program Lead is primarily responsible for developing and implementing the new CBME curriculum for Radiology residency, coordinating faculty development needs, and training faculty members on CBME implementation. Administrative support is provided in part by an educational consultant, whose roles include facilitating staff and resident training, as well as compiling evaluations and coordinating meetings. The CBME Lead and educational consultant positions are funded by the department.

Competence Committee. The Competence Committee is a subcommittee of the Residency Program Committee (RPC). The RPC consists of the Residency Program Director, Department Head, CBME Program Lead/Assistant Program Director, 4 department faculty members, and 3 resident representatives. Competence Committee members are selected by the RPC in consultation with the Department/Division Head and serve 2- to 3-year appointments, with the option of further renewable terms. The recommended minimum size of the committee is 3 faculty members, including the Program Director. Depending on the size of the program, other members such as external faculty members and residents may be included. This committee is responsible for monitoring the progress of each resident to determine achievement of EPAs. Committee members make consensus decisions regarding promotion to the next stage of training, readiness for the RCPSC certification exam, and readiness to enter independent practice. They also closely monitor and determine when a trainee is failing to progress within the program and make decisions on enhanced learning, remediation, and probation plans.

Academic advisors. Academic advisors (AAs) are faculty members who are assigned to a CBME resident for the entire duration of their residency. Academic advisors should receive academic protected time, and depending on the size of the program, each AA is assigned between 1 and 5 residents. The AAs regularly meet one-on-one with their residents to review assessments and determine appropriate progression through the program. Meetings should occur every 2 to 6 months, with a mandatory minimum of once per stage, and last for approximately 1 hour. Learning plans documenting a resident's strengths and weaknesses, as well as skills that need to be developed in the immediate future, are created. The learning plans are expected to be shared by residents with their supervisors in subsequent rotations. Academic advisors are the first line for identifying areas of concern and discuss such issues with the resident. They are also responsible for summarizing the resident's assessments and progress on EPAs prior to a Competence Committee meeting. Mentorship is an important role of AAs, who may provide advice to residents regarding career planning.

Competence Committee and Academic Advisor implementation at Queen's University. In the Queen's Radiology Residency Program, the Competence Committee consists of the CBME Program Lead, who chairs the committee, the Program Director, and 2 senior faculty members. There is 1 AA assigned to each CBME resident. The Competence Committee meets for approximately 30 to 60 minutes to discuss each resident at the end of each stage, or as needed, regarding resident progress and promotion. AAs for each of the residents attend these meetings as available. During the Competence Committee meeting, each resident is discussed in turn, relying on the individual's electronic assessment portfolio and the summary presented by the AAs (e.g., aggregated assessments/EPAs, narrative feedback, and entrustment scales). If there are no concerns raised by the AA or committee members and there is successful completion of the EPAs of the stage, a motion to promote the resident will be made by majority vote. If there are concerns raised by the AA and/or committee members, these concerns will be discussed immediately and mapped to the appropriate EPA. In these cases, each EPA will be discussed individually and a plan for completion will be developed. Outstanding EPAs will then be broken down into individual milestones to determine the progress of the resident in each outstanding EPA. From this information, enhanced learning plans, remediation, or probation will be proposed by the committee. Incomplete EPAs can be carried over to the next stage for completion at the discretion of the committee—a resident can be promoted to the next stage even when they have outstanding EPAs from the current stage.

Methods of evaluation. Assessments pertaining to EPAs are performed on an online web-based platform created by the local Elentra™ group (Elentra Consortium). Elentra is an integrated teaching and learning platform that allows trainees, instructors, and curriculum administrators to access academic and clinical scheduling, learning materials, assessments and evaluations, and learner e-portfolios on 1 unified platform.[13] This CBME assessment system allows EPA- and milestone-specific assessments to be completed both in real-time and subsequent to the clinical encounter, once residents or faculty "trigger" online assessments.

Creation of volumetric guidelines for case reporting and procedures. One of the novel areas associated with the EPAs is providing volumetric guidelines for case reporting and procedures. At Queen's University, the volumetric guidelines were developed locally through consultation with each subspecialty group in the Department of Radiology. There is currently no readily available guideline for volume expectations in the radiology literature. The ongoing CBD Royal College workshops will likely lead to a consensus guideline on volumes. Case reporting and procedure volumes are currently tracked with the EPA forms using the Elentra™ platform.

Table 1. Transition to Discipline and Foundations of Discipline EPAs and Required Evaluations.

Stage	EPAs	Assessment Requirements
Transition to Discipline	D1: Manage the acutely ill or unstable patient	Two or more assessments/week
	D2: Assess and manage care of uncomplicated patients	Two or more assessments/week
	D3: Initiate a quality assurance or research project	Resident Research Advisory Board meeting, workshop attendance, supervisor assessment forms
Foundations of Discipline	F1: Code requisitions for various modalities, body systems, and procedures	One or more assessments/month
	F2: Generate radiology reports and present findings to staff radiologist	Weekly assessments, 1 or more assessments of weekend call every 2 months
	F3: Perform basic invasive procedures	Weekly assessments
	F4: Perform basic noninvasive procedures	Weekly assessments
	F5: Conduct a quality assurance or research project	Narrative account of resident progress

Abbreviation: EPA, entrustable professional activity.

Table 2. Sample Stage, EPA, and Corresponding Milestones.

Stage	EPA	Milestones
Foundations of discipline	F2: Generate radiology reports and present findings to staff radiologists	1. Recognize basic normal anatomic and physiologic findings typically depicted on fluoroscopy, radiography (including mammography), ultrasound, CT, MRI, and NM 2. Recognize common artifacts and the limitations they impose on imaging tests 3. Identify and interpret most major/acute imaging findings 4. Provide a differential diagnosis, recognizing common pathologies, and relevant anatomy 5. Suggest management/additional imaging 6. Communicate with other health professionals clearly and respectfully 7. Generate an accurate radiology report

Abbreviations: CT, computed tomography; EPA, entrustable professional activity; MRI, magnetic resonance imaging; NM, nuclear medicine.

Results

Stages of Progression

In this report, we summarize the first 2 stages, Transition to Discipline and Foundations of Discipline, and the EPAs within each stage (Table 1). Each stage consists of 3 to 5 EPAs, which represent the overarching competencies a resident is required to achieve. Each EPA is composed of multiple milestones, which provide detailed objectives to be achieved within the larger EPA (Table 2). Milestones are mapped to corresponding roles within the CanMEDS framework. The creation of EPAs and milestones was based on input from radiology faculty members, central support from the Queen's CBME program team with the dedicated CBME program leader workshops, RCPSC guidelines, and existing goals and objectives from the Radiology Residency Program. EPAs and milestones are assessed using evaluation forms on the Elentra™ platform (Figure 1).

Stage 1: Transition to Discipline. The Transition to Discipline stage in the Queen's CBME Radiology Residency Program is composed of nonradiology off-service rotations. This is analogous to the basic clinical year in the current system or internship/transition year in the United States. Although there is some debate as to the optimal purpose or content of this stage, at Queen's University, it was decided that this stage would feature only the most essential clinical rotations and include a research block. This stage contains 3 EPAs. In *D1: Manage the acutely ill or unstable patient*, the resident must show competence in providing initial management and resuscitation of acutely ill or unstable patients, mainly on emergency department and medical/surgical ward rotations. In *D2: Assess and manage care of uncomplicated patients*, residents must demonstrate the ability to provide care for stable inpatients and outpatients, including proposing appropriate oral and written management plans based on the synthesis of history and physical examination, investigations, differential diagnoses, and evidence-based medicine. Both D1 and D2 require a minimum of 2 assessments per week. Off-service clinical faculty participates in the assessment process for stage 1, including staff physicians, fellows, and residents, using EPA evaluation forms on the Elentra™ platform.

D3: Initiate a quality assurance or research project represents a unique aspect of our CBME Radiology Program. For this EPA, the resident first liaises with the department Resident Research Coordinator (an appointed faculty position in our department). Direct supervision of the resident may be either

F2: Generate radiology reports and present findings to staff radiologist.

Procedure: <**select**>, e.g. Mammogram
Scope of Assessment: <**select**>, e.g. 21 to 30 cases
Basis of Assessment: <**select**>, e.g. Case review
Clinical Setting: <**select**>, e.g. On-service rotation
Case complexity: <**select**>, e.g. Moderate (Complex and Frequently Seen)
Assessor's Role: <**select**>, e.g. Staff physician

Milestones

Recognize basic normal anatomic and physiologic findings typically depicted on fluoroscopy, radiography (including mammography), ultrasound, CT, MRI, and NM.
- <**select**> Not observed, Needs attention, Developing, Achieved
- **Comment**: <**insert**>

Recognize some common artifacts and the limitations they impose on imaging tests
- <**select**> Not observed, Needs attention, Developing, Achieved
- **Comment**: <**insert**>

Identify and interpret most major/acute imaging findings
- <**select**> Not observed, Needs attention, Developing, Achieved
- **Comment**: <**insert**>

Would you trust this resident to perform this activity independently next time?
- <**select**> Not yet, Almost, Yes
- **Comments (mandatory)**: <**insert**>
- **Next steps**: <**insert**>
- **Global feedback**: <**insert**>

Concerns

Do you have patient safety concerns related to this resident's performance?
- <**select**> No, Yes
- **Comment**: <**insert**>

Do you have professionalism concerns about this resident's performance?
- <**select**> No, Yes
- **Comment**: <**insert**>

Are there other reasons to flag this assessment?
- <**select**> No, Yes
- **Comment**: <**insert**>

Have feedback about this form?
- <**select**> No, Yes
- **Comment**: <**insert**>

Figure 1. Sample EPA assessment form used by faculty and learners. For illustrative purposes, this assessment form has been modified from the online version available on the Elentra™ platform, and the additional 4 milestones pertaining to this EPA have been omitted. CT indicates computed tomography; EPA, entrustable professional activity; MRI, magnetic resonance imaging; NM, nuclear medicine.

from the Resident Research Coordinator or another staff radiologist depending on the nature of the project and the level of interest. The resident will then propose a hypothesis-driven question or quality assurance issue amenable to scholarly inquiry, followed by completion of a relevant literature review to determine the viability of the proposition. Finally, they will present the proposal to their project supervisor and Resident Research Advisory Board. Requirements include meeting with the Resident Research Advisory Board, attending the "Introduction to Research" workshop provided by PGME, having the project supervised by a staff radiologist, and completing the supervisor evaluation forms.

Stage 2: Foundations of Discipline. The second stage, Foundations of Discipline, consists of 5 EPAs. In *F1: Code requisitions for various modalities and body systems and procedures*, residents

Table 3. Sample Volumetric Guidelines for Case Reporting During Various Blocks.

Case Categories	Required Minimum Number of Cases/Day
Abdominal X-ray	5-10
Body CT	5-8
Breast	20
Chest CT	5
Chest X-ray	20
MRI	No specific volume expectation
MSK CT	1-2
MSK X-ray	15-20
Neuroradiology	10-15
Ultrasound	5-10

Abbreviations: CT, computed tomography; MRI, magnetic resonance imaging; MSK, musculoskeletal.

Table 4. Sample Invasive and Noninvasive Radiological Procedures Evaluated.

Invasive Procedures	Noninvasive Procedures
Arthogram	Cine esophagram
Drain exchange	Defecogram
Joint injection	Gastrografin enema
Lumbar puncture	Retrograde cystogram
Myelogram	Sinogram/fistulogram
Needle wire localization	Timed esophagram
Nontargeted kidney biopsy	Ultrasound of various organs
Nontargeted liver biopsy	Upper GI series
Paracentesis	Urethrogram
PICC insertion	
Stereotactic breast biopsy	
Temporary dialysis line insertion	
Thoracentesis	
Thyroid fine needle aspiration (lesions >20 mm)	
Ultrasound-guided breast biopsy	

Abbreviations: GI, gastrointestinal; PICC, peripherally inserted central catheter.

demonstrate the ability to appropriately triage patients based on the urgency of their clinical scenario and select the appropriate protocol, including the use and route of delivery of various contrast agents. Staff radiologists will review protocoled requisitions with a minimum of 1 supervisor evaluation form per month on required rotations.

F2: Generate radiology reports and present findings to staff radiologist, focuses on reporting radiology studies of various modalities, both during the day and after-hours on-call. The resident is expected to recognize basic normal anatomic and physiologic findings, as well as common artifacts and the limitations they impose. The resident will detect, describe, and interpret most major and acute imaging findings at the expected competence level of a resident in this stage. A differential diagnosis will be generated, taking into consideration anatomy, commonly encountered pathologies, and clinical context. Management steps and additional imaging tests can be suggested, if appropriate. The resident will document these findings, interpretations, and recommendations in a well-written radiology report at the expected level of a Foundations resident. While on-call, a succinct preliminary report detailing the most relevant findings is sufficient. Staff radiologists will provide weekly evaluations for on-service rotations and a minimum of 1 assessment of weekend call every 2 months. EPA evaluation forms are completed by supervisors based on direct observation during case review sessions. Approximate case volumes are also provided to guide the resident during each block (Table 3).

F3: Perform basic invasive procedures and *F4: Perform basic noninvasive procedures* focus on the resident's ability to perform various radiologic procedures, including obtaining informed consent prior to the procedure and implementing postprocedure management plans. Suggested cases for participation are provided to guide the resident (Table 4). Weekly staff evaluations are required to assess these EPAs.

Similar to D3, in *F5: Conduct a quality assurance or research project*, residents continue to demonstrate the ability to conduct research projects, advancing to applying for possible research ethics board approval and grant funding, data collection and analysis, and conference presentations. A narrative account of resident progress is required for documentation.

Discussion

To date, 3 cohorts of residents (n = 9) have been accepted to the Queen's CBME stream of the Diagnostic Radiology Residency Program. As a result, several challenges have been brought to the forefront. Firstly, the frequency of assessments has been raised as an issue by resident and faculty feedback. Competency-based medical education differs from previous curriculums in that it requires more frequent and formative, but individually low-stakes workplace-based assessments, which translate to multiple assessment forms per resident per week to assess the multiple EPAs required. This contrasts with the previous curriculum where a single, summative, and high-stakes end-of-block rotation assessment (1 assessment per 4 weeks) was used to determine rotation completion. In the CBME curriculum, a resident often has 2 or more evaluations per week. The 2018 Resident Doctors of Canada National Resident Survey identified "evaluation fatigue" and "time burden" as the top 2 greatest challenges of CBME for both residents and preceptors with up to 71.4% of responders choosing these options.[14]

Solutions to address the frequency of assessments and the administrative burden this can place on residents and faculty in a competency-based curriculum have been proposed in the literature. For example, rather than relying on the entire department's attending physicians to continuously assess students, the bulk of assessments could be carried out by dedicated faculty advisors, who should all have formal training and protected academic time.[15,16] At Queen's University, these roles are filled by members of the Competence Committee and AAs.

In addition to faculty, residents can and should be assessed by other members of the health-care team, such as fellows, senior residents, and technologists, who can also fill out appropriate assessments.[17,18] Systematic analysis of the impact of increased formal learner evaluation on workflow and workload on all members of the health-care team in the Queen's Department of Diagnostic Radiology is in progress.

Certain EPAs and milestones can be attained independent of assessment forms. For example, popular online radiology modules, quizzes, and self-assessment modules have been used to complete the required milestones in the American competency-based curriculum.[18,19] Lastly, the development and use of online and mobile assessment tools have also streamlined the process of resident evaluation in the CBME era.[15,18,20] In the Queen's Radiology Residency Program, the use of the online application Elentra™ has curtailed the administrative burden of paper evaluations and allowed for immediate completion of point-of-care evaluations.

Although the CBME structure does require more effort and attention to assessment completion, we hope this will gradually transition to a more efficient process once staff and residents adapt to this new culture of assessment. Currently, assessments of new initiatives and formal program evaluations are forthcoming; however, anecdotal evidence at our institution does support the implementation of more frequent assessments. For example, one resident's weakness for independent call performance was quickly identified and addressed due to the higher frequency of evaluations; this might not have been captured as quickly in the prior evaluation system. Ultimately, one of the goals is to increase the quality of the feedback received by students throughout their training. Indeed, a total of 31.6% of residents felt that the greatest benefit of CBME for residents was that it "improves the frequency or timeliness of feedback" or "improves the quality of the feedback".[14]

The second challenge encountered is evaluating a resident at the level of their stage. Since the concept of expectations of a resident at each level can differ variably between evaluators, standardized criteria are required. Certain suggestions for resident expectations have been put forth, including from subspecialty societies such as the American Society of Neuroradiology curriculum.[21] In their curriculum, each neuroradiology rotation consists of knowledge-based and procedural skills benchmarks that a resident at a certain level is expected to have attained (R1-R4 or PGY2-PGY5). For example, an R4 is expected to be able to independently perform lumbar punctures, myelography, and cisternography with appropriate supervision.[21] Other examples of milestone-based curricular development include guidelines put forth for breast imaging and cardiothoracic imaging instruction.[22,23] Discrepancy rates between resident preliminary reports and subsequent faculty reports have also been used as benchmarks to evaluate and standardize resident performance by year of training and modality.[24-26] In this way, students above the average discrepancy rate of their year or a specific modality are identified for individualized remediation programs. By setting clear, explicit, and measurable expectations of residents at each level, the goals of CBME include uniformity of teaching, standardized assessment of each student, and easier identification of students who require remediation to meet expectations. In the development of the CBME curriculum at Queen's University, close attention has been given to developing the stage-specific milestones. This informs the assessment based on the milestone that is observed, not the expected level of performance which is subjective to each evaluator.

Another challenge is determining volumetric guidelines for case reporting and procedures. There are limited data in the literature to guide the creation of volumetric requirements. In the American system, the Accreditation Council for Graduate Medical Education (ACGME) requires that the number of cases preliminarily interpreted or dictated by a resident for various imaging exams are tracked in a case log system. They have put forward a required minimum number of cases for certain radiologic studies that each resident has to interpret prior to graduation.[27] For example, requirements include 1900 chest X-rays, 600 computed tomography abdomen/pelvis scans, and 350 ultrasound scans of the abdomen and pelvis.[27] Data from MATILDA, a multi-institutional academic trainee interpretation log database, show that radiology residents greatly exceed the minimum requirements set by the ACGME. The average radiology resident interpreted 16 800 examinations compared to the 3500 requirement.[28] A recent study showed a positive correlation between a resident's total volume of reported cases and their clinical performance, as measured by the major discrepancy rate between the resident's preliminary report and the final faculty interpretation of the report.[29] As the number of interpreted films exceeded 16 000, however, increasing volume of reported cases correlated with increasing diagnostic errors.[29] Reading more cases can lead to less time spent on each case, which has been shown to increase error rates.[30] Mental/physical fatigue and resident burnout are also factors to consider. For example, subjective assessments of fatigue and quantitative assessments of oculomotor strain at the end of long clinical workdays have been associated with diagnostic errors.[31] These studies highlight the balance that must be sought when determining case volume requirements. The volume guidelines at Queen's University are under periodic review through feedback from faculty and residents to determine whether they are appropriate and able to be obtained. For instance, volumetric expectations have been downgraded on multiple rotations.

CBME implementation at Queen's University is an ongoing and evolving initiative. The Diagnostic Radiology Residency Program is currently undergoing program evaluation from Queen's University, which consists of focus group interviews that will likely lead to further program improvement. Data analyses pertaining to the evaluation of our new initiatives are forthcoming, as well as discussion of the third and fourth stages, Core of Discipline and Transition to Practice, respectively.

Conclusions

Competency-based medical education represents a paradigm shift from time-based to outcome-based learning and assessment. It provides the promise of more incremental, meaningful feedback during resident training, allowing for early identification and management of resident weaknesses. It also provides more defined training objectives and sources of mentorship. However, the transition to CBME is not without its challenges. We have described the implementation of a novel CBME curriculum in the Diagnostic Radiology Residency Program at Queen's University, namely the Transition to Discipline and Foundations of Discipline stages, and the administrative process. Challenges encountered during this process include the increased frequency of assessments, establishing stage-specific learner expectations, and the creation of volumetric guidelines for case reporting and procedures. Implementation of solutions for quality improvements is ongoing and informed by continuous feedback from all stakeholders.

The early stages of implementing a CBME curriculum are time and resource intensive. In this regard, the creation of a CBME Program Lead position with protected time and administrative support has been essential. It is the responsibility of the Program Lead, in collaboration with the Program Director, to facilitate curricular transition, faculty development, new assessment models, and liaison with other CBME leads across the country. Whether this position will be needed in the future, or incorporated into the role of the Program Director, will be reevaluated once CBME is fully implemented. Administrators at all levels are encouraged to continue lobbying for the additional financial and human resources required to support the CBME Program Lead position and for the cultural shift in assessment that is required for successful implementation of CBME. The goal is to standardize the training of future physicians who are well equipped with the competencies necessary to provide better and more efficient quality care to the patients and communities they serve. The components and strategies discussed in the development of the Queen's Diagnostic Radiology Residency Program may guide the development of other CBME Radiology programs and CBME postgraduate programs in general.

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