Implementation of Competence by Design in Canadian Neurosurgery Residency Programs

This Thesis, **Implementation of Competence by Design in Canadian Neurosurgery Residency Programs**, presented by **Magalie Cadieux**, and Submitted to the Faculty of The Harvard Medical School in Partial Fulfillment of the Requirements for the Master of Medical Sciences in Medical Education has been read and approved by:

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Abstract

The Royal College of Physicians and Surgeons of Canada (RCPSC) recently redesigned the Canadian neurosurgery residency training curriculum by implementing a Competence by Design (CBD) training program centered around the assessment of Entrustable Professional Activities (EPAs). This mixed-methods study evaluated the potential benefits and pitfalls of CBD in Canadian neurosurgery residency education.

Two surveys were distributed at three-month intervals to all current first-year neurosurgery residents in Canada. The surveys assessed important educational components: knowledge of the key stakeholders of CBD, potential system barriers, and educational and psychological impacts on residents. Based on the longitudinal survey responses, semi-structured interviews were conducted with residents to investigate in-depth their experience with CBD in neurosurgery. The qualitative analysis followed an explanatory approach and a thematic analysis was performed by two coders.

The surveys had an average response rate of 82% (n = 25). Most residents self-reported that they understood retrospectively the concepts around the intentions of CBD ($p = 0.02$). The perceived benefits included an evaluation with added feedback that was clearer and more objective. Pitfalls included the amount of time needed to navigate through EPAs (90%) and residents forgetting to initiate the EPA forms (71%). None of the responses changed significantly over time.

During interviews, residents' key themes centered around the meaning of CBD, the feasibility of EPAs, the importance of assessor variability on EPAs, and a positive learning experience with feedback. Potential solutions identified by the residents to enhance their experience included learning analytics data availability, refinement of the mobile app, and dedicated time to integrate EPAs in the workflow.

This study was the first to assess the benefits and pitfalls of the CBD training program in Canadian neurosurgery programs in the context of an educational framework. In general, residents believed that the theoretical principles behind CBD were valuable to their learning and residency training despite the challenges described. However, in terms of technological ability and having enough time to request EPA assessments, significant barriers to success exist. Long-term studies are required in quality improvement to ease the usage of technology and to determine the definitive outcomes of CBD on residents' performance and ultimately, on patient care.

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List of abbreviations

CBD	Competence by Design
CBME	Competence-Based Medical Education
CME	Continuing Medical Education
EPA	Entrustable Professional Activity
IMG	International Medical Graduates
ITER	In-Training Evaluation Report
O-SCORE	Ottawa Surgical Competency Operating Room Evaluation
PGY	Post-Graduate Year
RCPSC	Royal College of Physicians and Surgeons of Canada
E.g.	For example

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1 Chapter 1: Background

The neurosurgical specialty training in Canada is rooted in traditional curricula with minimal major national reforms. In six years, neurosurgery trainees must become proficient in both the knowledge of neurological diseases and the concomitant skills required to treat those diseases. With these issues in mind, the Royal College of Physicians and Surgeons of Canada (RCPSC) recently redesigned the Canadian neurosurgery residency training curriculum by implementing a Competence by Design (CBD) training program in July 2019. As described by the Royal College itself, "CBD will ensure that residents succeed in different entrustable professional activities (EPAs) and milestones."[1] The rationale behind this change is to meet patients' needs in the 21st century and address criticisms of the traditional medical education including safe/observed practice, working with interprofessional teams, minimizing diagnostic errors, and communication issues. Another goal for CBD is to bring back some of the lost direct observation of trainees.[2]

As part of the assessment system for this new curriculum, neurosurgery trainees are evaluated by attending staff, and sometimes senior residents. These evaluations or observations determine the trainees' entrustability as well as provide direct feedback on how to improve their competency. Therefore, a trainee may have to perform the same EPA observation many times before they are deemed "competent." This process is a major change to how neurosurgical trainees were previously evaluated and received feedback as described in section 1.1.

The new CBD system may have unintended or unanticipated downstream consequences that are either positive, negative, or both. On the positive side, the delivery of feedback and constant assessment may build a faster autonomy in residents to perform surgical tasks as the trainees will have full responsibility for their own training. On the other hand, the grading they receive on EPAs may affect their self-confidence as it is rare for them to achieve a perfect performance from the

beginning. This need for improved performance may also increase work stress in a long-term setting. Neurosurgical attendings and senior residents will also have to be involved with this process, which may increase their daily workload. Other criticisms stated in an article by Holmboe and colleagues were that this new curriculum of evaluation would fail to promote excellence and that faculty were too busy to help in the implementation.[2]

Lastly, the CBD process requires significant faculty development to obtain valid and reliable EPA assessments as well as training regarding effective feedback delivery techniques. Each university will be responsible for the feedback training of the neurosurgical attending staff. The new CBD process has the opportunity to greatly improve the amount and quality of feedback that a trainee receives and may accelerate achievement of future performance goals, but it is unclear how to standardize the quality of feedback across many residency programs and instructors. The following sections will outline how CBD changed neurosurgery residents' assessments and will provide a general overview of competency-based medical education, views of the RCPSC on CBD, and traditional feedback delivery.

1.1 Canadian Neurosurgical Residency Pathway

To understand in-depth how the neurosurgery residency program is designed in Canada, an overview is necessary. A resident in neurosurgery must complete six years of residency. During the first two years of residency, the neurosurgery subspecialty is mixed with various core rotations such as neurology, internal medicine, trauma surgery, and intensive care specialties. Subsequently, full training in neurosurgery consists of 42 blocks, including pediatric and endovascular neurosurgery rotations. Depending on the program, there could be one to four residents per year of training. For example, the University of Calgary and the University of Toronto are considered to have the largest programs of neurosurgery in the country, accepting two to four residents per

year. In contrast, in the province of Quebec, there are four neurosurgical residency programs. However, only two medical students will get a position in two of those four programs based on an aleatory rotating schedule. Most first-year residents are medical students who have completed medical school at a Canadian university. However, some programs would hire International Medical Graduates (IMG) as well. Otherwise, the curriculum of a neurosurgical resident also includes a year of research or other scholarly activities for most of the programs. In their final year, the neurosurgical residents are called "Chief Residents" and are expected to know how to run a full neurosurgical service with a high volume of patients. They are also expected to provide teaching to the junior residents, which is inherently part of their job description. To graduate, a final-year neurosurgery resident must have complied with all of the RCPSC and CanMEDS roles' objectives (Fig. 2).[3]

Prior to CBD, the Canadian medical education system was based on a different type of resident evaluation. On a daily basis, informal evaluation happens in the operating room with a chief resident or an attending neurosurgeon. It also happens every time a consult is reviewed, when a treatment plan is proposed for a patient, during neurosurgical rounds, or even academic half-days. Informal feedback was given sporadically and every three months, each trainee received an in-training evaluation representing their performance on the neurosurgery service for these last months. Residents were graded using a Likert-scale on topics such as anatomical and neurosurgical disease knowledge, general technical skills appropriate for the post-graduate year (PGY) level, and professionalism. Ideally, this in-training evaluation report (ITER) was discussed with an attending neurosurgeon to clarify certain points or just to assure the understanding of a resident on their grading scale. Finally, the program directors would have met with the trainees on a bi-annual basis to check-in and discuss any issues.

1.2 Competency-Based Medical Education

The concept of competency-based medical education or competency-based training has been well described in the literature starting in 1978 with the World Health Organization.[4] Through the years, the concept acquired multiple synonyms, but its most recent definition comes from the glossary of Englander and colleagues where CBME is described as "an outcomes-based approach to the design, implementation, assessment, and evaluation of medical education programs, using an organizing framework of competencies".[5, 6] It is better known nowadays among Canadian surgical and medical residencies as Competence by Design (CBD). CBD is a hybrid model resulting from CBME. To properly define CBD, the RCPSC combined four themes: 1) focus on learning, 2) support of abilities, 3) graduate without knowledge gaps, and 4) timely and effective feedback.[1] To achieve these different themes and make it feasible in the hospital context, milestones and Entrustable Professional Activities (EPAs) were developed for all medical and surgical specialties. The concept of EPAs was initially introduced by Dr. ten Cate in 2005 and has several specific characteristics.[7] Indeed, as described by Dr. ten Cate, an EPA "must require adequate knowledge, skill and attitude, generally acquired through training, […] usually be confined to qualified personnel; should be independently executable; should be executable within a time frame; should be observable and measurable in their process and their outcome, leading to a conclusion ("done well" or "not done well")."[7] The latest definition of EPA was introduced by the International CBME Collaborators attempting to reduce the barrier concerning the ambiguity around the CBME language and semantic. This new definition is a consensus among many medical educators. An EPA should therefore be defined as "an essential task of a discipline (profession, specialty, or subspecialty) that an individual can be trusted to perform without direct supervision in a given health care context, once sufficient competence has been demonstrated."[5] In contrast

with the ITER previously described in section 1.1, the entrustability of a Canadian neurosurgery trainee is rated using the O-Score (Ottawa Surgical Competency Operating Room Evaluation).[8] This O-Score scale is an entrustability scale that has been designed specifically for assessing surgical competence (Fig. 1). The scale has since been adapted to fit into the CBD model.[9]

Level	Descriptor
1	"I had to do" i.e., requires complete hands on guidance, did not do, or was not given the opportunity to do
2	"I had to talk them through" i.e., able to perform tasks but requires constant direction
3	"I had to prompt them from time to time" i.e., demonstrates some independence, but requires intermittent direction
4	"I needed to be in the room just in case" i.e., independence but unaware of risks and still requires supervision for safe practice
5	"I did not need to be there" i.e., complete independence, understands risks and performs safely, practice ready

Figure 1. O-Score entrustability scale. The five levels of entrustability all have a different descriptor. This scale was adopted from Gofton et al.'s work.[8]

Overall, this means that competence can be defined for a person and an EPA is an action to achieve that competence. In the Canadian medical education system, EPAs are composed of certain milestones that must be attained to gain the expected competence. The schema illustrated in Figure 2 can help one's understanding of that process and provide an elaboration on this educational framework. Importantly, this framework is different from the American framework, where EPAs are encapsulated under milestones.

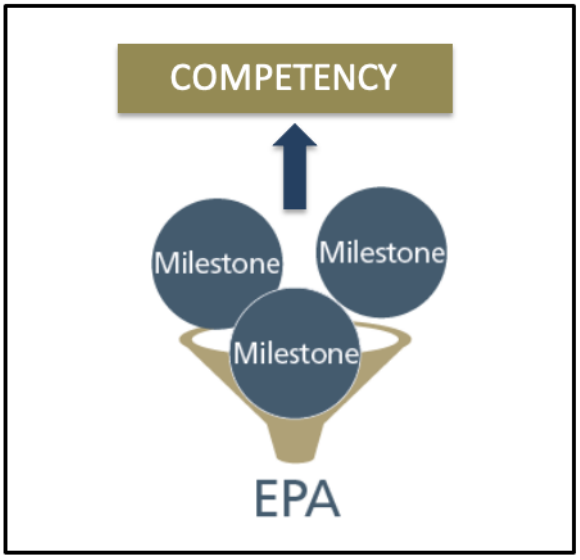

Figure 2. Competence by Design schema in Canadian Medical Education inspired by the design from the Royal College of Physicians and Surgeons of Canada. EPAs are shown at the bottom of the funnel. They are measurable and observable tasks comprised of many milestones. Once all milestones are reached in the funnel, a learner gets entrusted in a certain EPA. These entrustments lead to reach a certain competency meaning that a resident has now the ability to perform a certain task successfully.[10]

It took many years before CBD was implemented in Canada. In 2009, the University of Toronto adopted a pilot CBD curriculum within its orthopedic surgery residency program, and a full eight-year report of their experience and outcomes is now available. This report demonstrated that they were able to graduate some of their residents in four instead of five years.[11] However, they also faced some challenges related to the cost of maintaining a different curriculum, faculty development, and organization of feedback meetings. Since then, an anesthesiology program in the Netherlands adopted EPAs[12] and in 2017 the RCPSC launched the CBD curriculum, starting with otolaryngology (head and neck surgery) and anesthesiology residency programs. Canadian neurosurgery residency programs followed in 2019. Of note, it was decided by the CBD Specialty Committee that neurosurgery residency programs would not be shortened by the introduction of CBD despite the definition given by other programs. A six-year training was deemed too valuable to gain surgical experiences. The RCPSC concluded that it could be possible for a trainee to finish

their EPAs and complete the CBD program, but that a longitudinal surgical experience needed to be acquired.[1]

To successfully launch, the Canadian neurosurgery programs created a total of eleven foundation of discipline EPAs, forty-six core of discipline EPAs, and three transition to practice EPAs (see Appendix 5 for complete list). These names refer to EPAs as a junior trainee, middle level one, and finally, chief of neurosurgery close to starting an individual practice. Therefore, the final tasks included in transition to practice EPAs should be independently performed by the end of the residency program. Through them, all the CanMEDS roles of medical expert, communicator, collaborator, leader, health advocate, scholar, and professional are expected to be achieved as well (Fig. 3).[13]

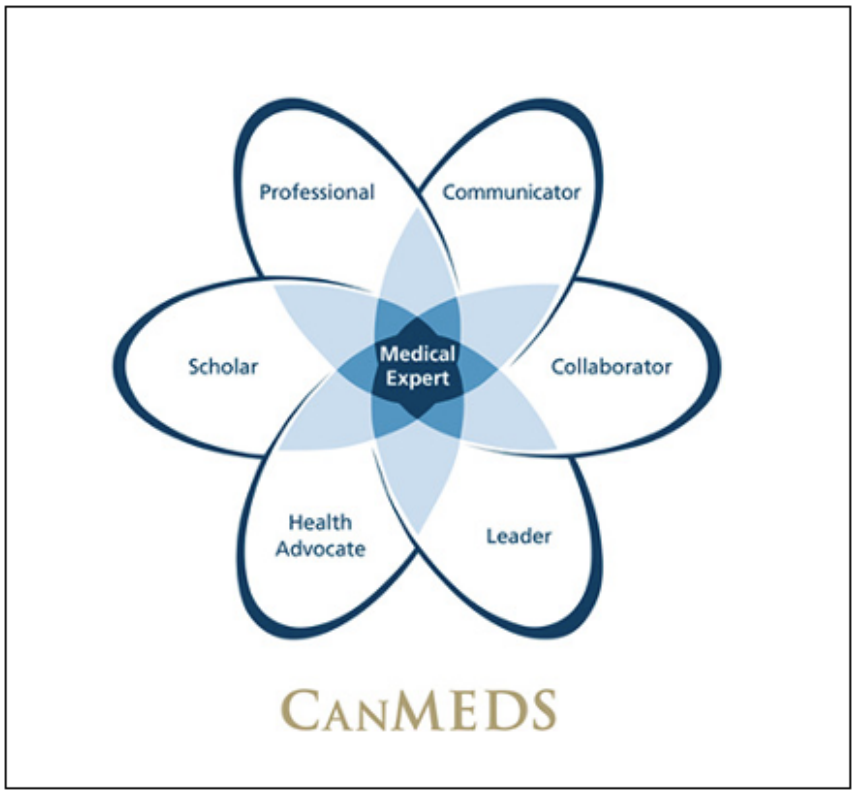

Figure 3. CanMEDS framework as described by the Royal College of Physician and Surgeons of Canada. There are seven CanMEDS roles within this framework: scholar, health advocate, leader, collaborator, communicator, professional, and medical expert. These roles are all integrated in the post-graduate medical education curriculum.

1.3 CBD as viewed by The Royal College of Physicians and Surgeons of Canada

The CBD transition is one of the 21st century's biggest changes to the Canadian medical education system per the RCPSC. The RCPSC website provides multiple videos and informative infographics for not only attending physicians but also trainees to educate them about CBD. The website explains the roles of the CBD Specialty Committees and the Competence Committees. The Specialty Committees are expected to formulate and review the EPAs related to their specialty. As per the Competence Committee rules, it needs to be chaired by someone other than the program director for that particular specialty, and it is expected to meet at least twice a year to review the residents' progress through their multiple EPAs and milestones. By 2021, it is expected that 43 medical and surgical specialties will have transitioned to CBD, and this will mark the end to over 100 years of the time-based model in Canadian medical education.[14]

1.4 Feedback delivery

As mentioned above, one of the RCPSC statements about CBD is that it will help residents to receive timely and effective feedback.[1] Indeed, feedback in medical education is an important topic as more than 600 articles exist in the literature as per a 2017 systematic review.[15] Feedback is defined as "a process whereby learners obtain information about their work in order to appreciate the similarities and differences between the appropriate standards for any given work."[16] Effectively giving constructive feedback is an art and requires practice and specific training to deliver well. In competency-based medical education, feedback should be based on observable actions, where the assessor can document progression of knowledge or skills.

The Kolb learning cycle, a conceptual framework for Kolb's experiential learning theory, is well within the scope of feedback and the CBD system.[17] For example, neurosurgery residents

engage in new neurosurgical tasks or EPAs. When given feedback by faculty or senior residents, they can reflect and acknowledge their strengths and weaknesses. Once a similar EPA presents itself as another opportunity to practice, the residents can apply their new learning and offer an improved performance based on the previous feedback. This approach emphasizes the close connection between constructive feedback and CBD training systems (Fig. 4).

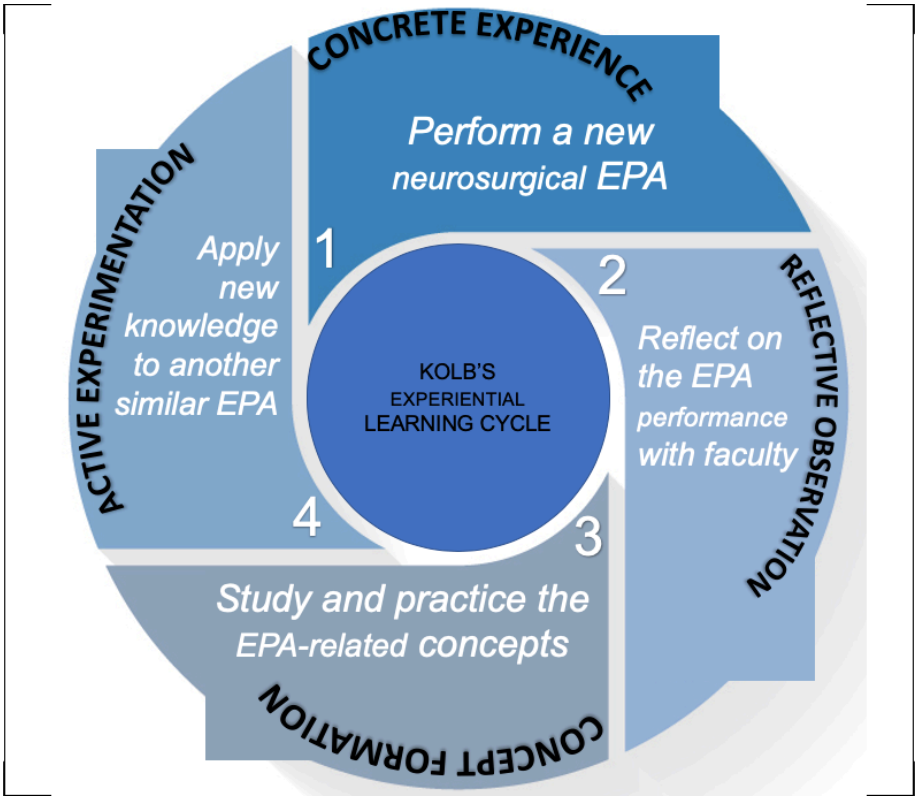

Figure 4. Kolb's Learning Cycle designed for neurosurgical EPAs. Design inspired by Schultz et al.[17] This educational framework recognizes the importance of improvement within EPAs based on received feedback. Learners would have a concrete experience (new neurosurgical EPA/task) where they would receive feedback from their attendings or senior residents and apply a reflective observation (reflect on EPA performance). They would then elaborate new concept formation (read/study concepts about EPA). Another opportunity for active experimentation (applying new knowledge to similar EPA) would occur to close the loop of the learning cycle.

1.5 Objectives of the Study and Hypotheses

Despite a large enterprise conducted by the RCPSC to initiate CBD, the RCPSC does not have any framework to evaluate the change itself and the impact it will have on new trainees. The main objective of this study was to fill this knowledge gap by identifying the downstream effects of the implementation of CBD on neurosurgical residents in Canada with two specific aims. The first aim was to look at the benefits and pitfalls of the CBD system as described by the resident physicians. We hypothesized that residents would identify more pitfalls at the beginning of the implementation process and that they would see the benefits of CBD in a delayed fashion as they acclimated to the new training system. As a second aim, we wanted to understand the residents' overall experience with CBD training and its effect on their learning environment during their first year of residency. We hypothesized that they would have an overall positive learning experience despite CBD being an add-on to their daily workload in neurosurgery.

2 Chapter 2: Methods and Data

2.1 Methodology introduction

This study was designed following a mixed-methods approach. Surveys were administered to Canadian first-year neurosurgical residents with subsequent explanatory qualitative research with semi-structured interviews. The data collection for both the surveys and interviews covered a period of six months from October 2019 to March 2020. This study was approved by the Conjoint Health Research Ethics Board (CHREB) from the University of Calgary (REB18-2000) and conjointly approved by the Office of Human Research Administration (OHRA) from Harvard University (SITE19-0048) as an oversight IRB.

2.2 Specific Aims

To reiterate, this study was looking at two different aims. The first aim was to recognize the benefits and pitfalls of CBD for the first-year neurosurgical residents. The second aim was to understand the residents' overall qualitative experience with CBD and its effect on their learning environment.

2.3 Methods

2.3.1 Aim 1 (To Recognize Benefits and Pitfalls) - Survey Design

Two surveys were designed for the purpose of determining the benefits and pitfalls of the CBD system as described by the resident physicians (Appendices 1-2). The first survey of 29 questions was created following five different themes that assessed three major facets of the six-steps approach to an educational program/curriculum implementation.[18] The three facets assessed were 1) key stakeholders' knowledge of CBD, 2) logistics of CBD, and 3) assessment of

educational and psychological impacts on residents after CBD. The five themes were 1) logistics and implementation readiness, 2) residents' knowledge of CBD, 3) key stakeholders' knowledge and attitudinal features, 4) impact of CBD on residents, and 5) potential system barriers and sources of stress. The majority of the questions used a Likert-scale (1=strongly disagree and 5=strongly agree). Demographic information (language, rotations done in training including neurosurgery) was collected but gender and age were omitted from analysis as within this targeted population, there was only 20% of female neurosurgery residents (5 out of 25) and the age gaps were very apparent both which could have caused a breach of anonymity. Finally, the survey questions were reviewed by an expert in quantitative methods and survey design (J.K) to assure conformity with Artino's method.[19] Artino et al. provided best practices in survey design and Likert-scale questions. Such tips included avoiding double-barreled or negatively worded item questions. The method also suggests conducting expert validation and pilot testing. The survey was built through Qualtrics (Qualtrics, Provo, UT) and piloted multiple times on three expert neurosurgeons.

The second survey (Appendix 2) had 48 questions with repetition of certain questions to allow a longitudinal analysis. Those questions were designed with the Skeff methodology from Stanford University[20] as this methodology is often used to minimize the effect of a response shift due to a certain intervention. For this case study, we tried to obtain a more accurate response by excluding the effect of CBD over time (intervention) in the participants' responses. Also, it is important to note that between the first and second survey, we discovered that chief residents were quite often requested to fill out EPA forms for first-year residents. Therefore, modifications were integrated into certain questions to differentiate between chief residents and neurosurgeon

attendings. The same survey expert (J.K) reviewed the survey questions. Once the survey was built on Qualtrics, it was piloted on three neurosurgeons and one general surgeon (Fig. 5).

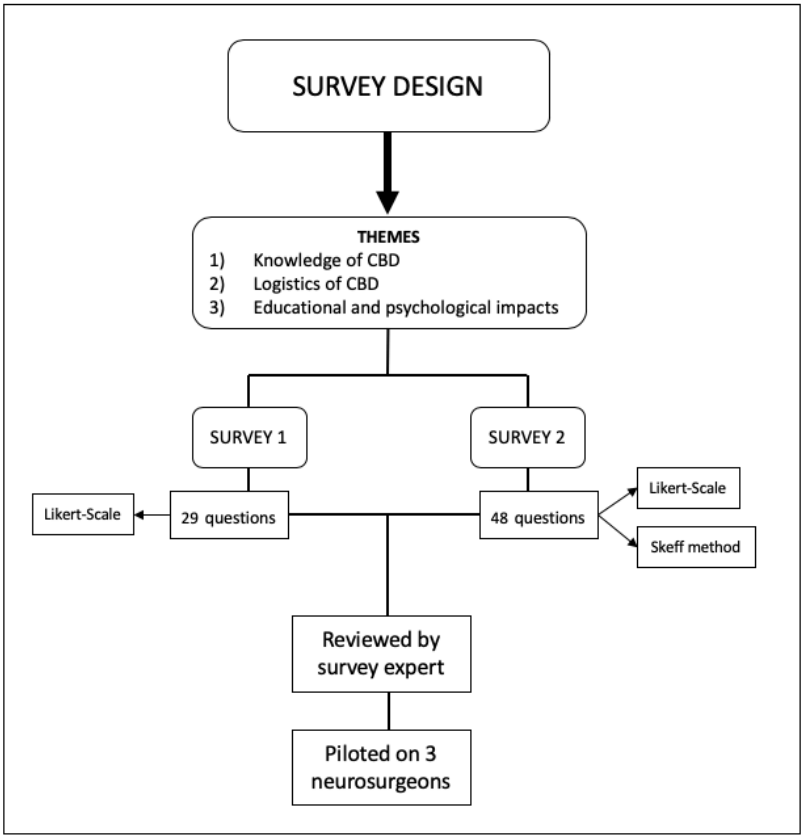

Figure 5. Survey design and methodology. This flowchart represents the design of the two surveys. Both surveys comprised of three themes. Each survey had different question designs (Likert-scale, Skeff methodology, open-ended questions), but both were reviewed and piloted accordingly.

2.3.2 Aim 1 (To Recognize Benefits and Pitfalls) - Study Flow with Survey Distribution

There was a total of 25 first-year neurosurgery residents in the twelve Canadian neurosurgical programs. An anonymous link was then sent to residents via their institution email addresses in mid-October 2019. The same link was re-sent every week for up to four weeks. During the fourth week of the survey activity, a link was also sent to program directors for them to distribute to their respective residents. At the beginning of January 2020, another link was sent to

the residents for them to fill out the second survey. It was felt that a total of three months between both surveys was adequate to capture any changes in residents' answers and for them to experience the process of CBD in a different training rotation environment (Fig. 6).

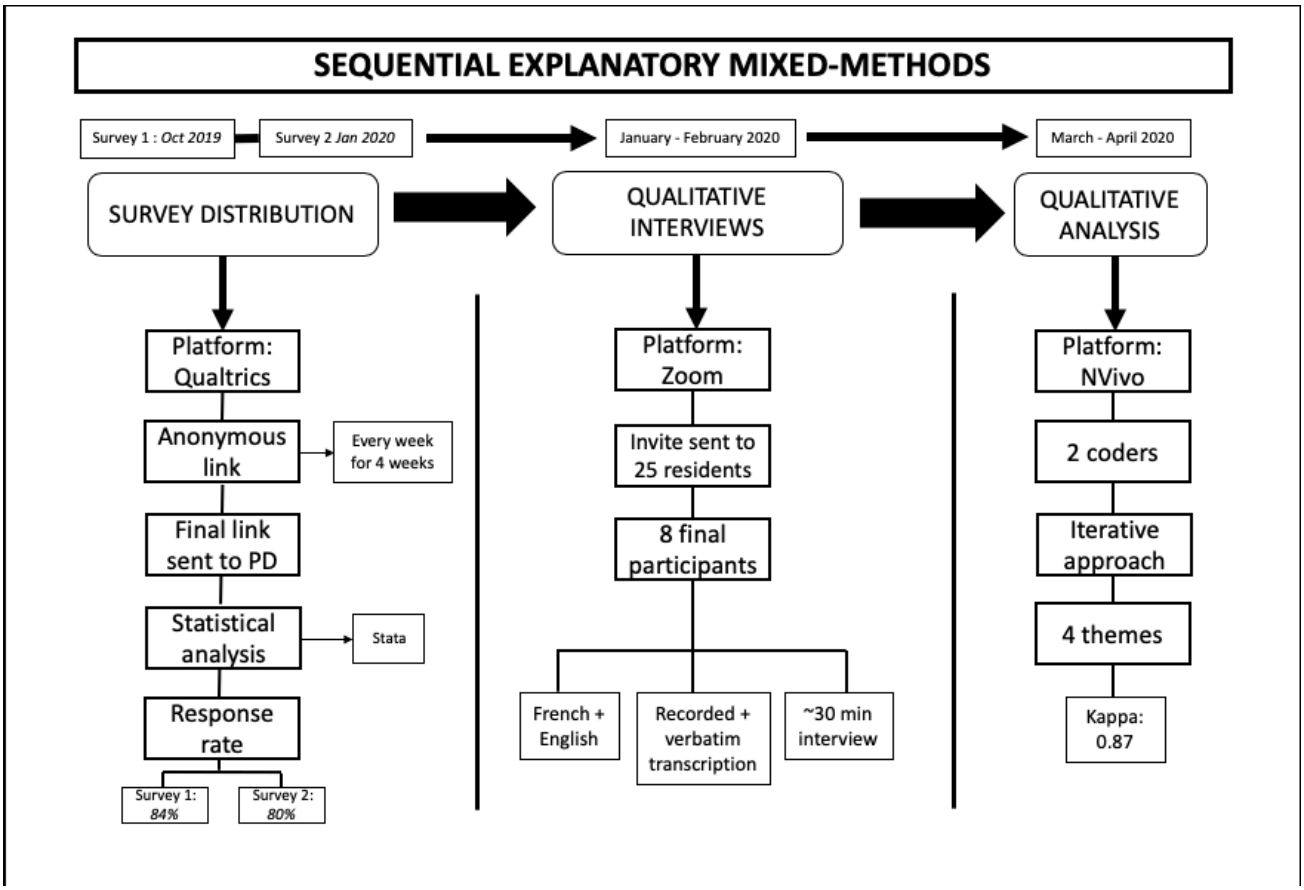

Figure 6. Chronological sequential explanatory mixed methods study design.[21] This schema shows the chronological steps towards the final stage of the study (qualitative analysis). It started in October 2019 with the distribution of a first survey and ended in April 2020 with the qualitative analysis of the interviews.

2.3.3 Statistical Analysis

Data was exported from Qualtrics and analyzed within the Stata.v16 software (Stata, College Station, TX). Likert-scale survey answers were analyzed as continuous variables and the mean was reported. To assess any changes over time within those Likert-scale questions, a paired *t*-test (two-

sided) was performed, and a *p*-value was reported. To assess any changes over time within the survey themes, a weighted mean was generated for survey 1 and survey 2 and a paired *t*-test was done. For questions pertaining to frequency of EPA completion, a median was reported. Similarly, when the participants were asked to select a range for a response, the mode of that range was used as a single value to represent their choice. For the comparison between the pre-, retro-pre-, and post-perspective questions, a paired *t*-test was performed. Lastly, the frequency of selected benefits and pitfalls was reported. Given that each participant provided responses at two time points for both benefits and pitfalls, a McNemar's test was used to assess differences in frequencies of the selected benefits and pitfalls over time. For statistical significance, a *p*-value of less than 0.05 and a confidence interval of 95% were considered.

2.3.4 Aim 2 (Residents' Overall Experience) - Interview Guide Design

A semi-structured interview guide of 13 questions was designed with probes to allow the participant to freely express more of their thoughts (Appendix 3). At first, an interview guide of seven questions without probes was drafted based on previous CBD research studies.[22, 23] Once the first survey responses became available, modifications were made to the guide based on the survey responses and the additional comments collected within the survey. The new questions included new components related to feedback experience, EPA score effects, time spent doing CBD tasks, and overall appreciation of CBD. This second version contained 11 questions with probes. The interview guide was then reviewed by an expert in qualitative research (L.T). Following the review, two new questions were added. One was about the perspective of CBD over time and the other was about the factors influencing the request of an EPA assessment. Each question and probe were refined to ensure the absence of misleading words. A final version was

piloted on an otolaryngology resident who was already in the process of CBD and a senior neurosurgery resident (Fig. 7).

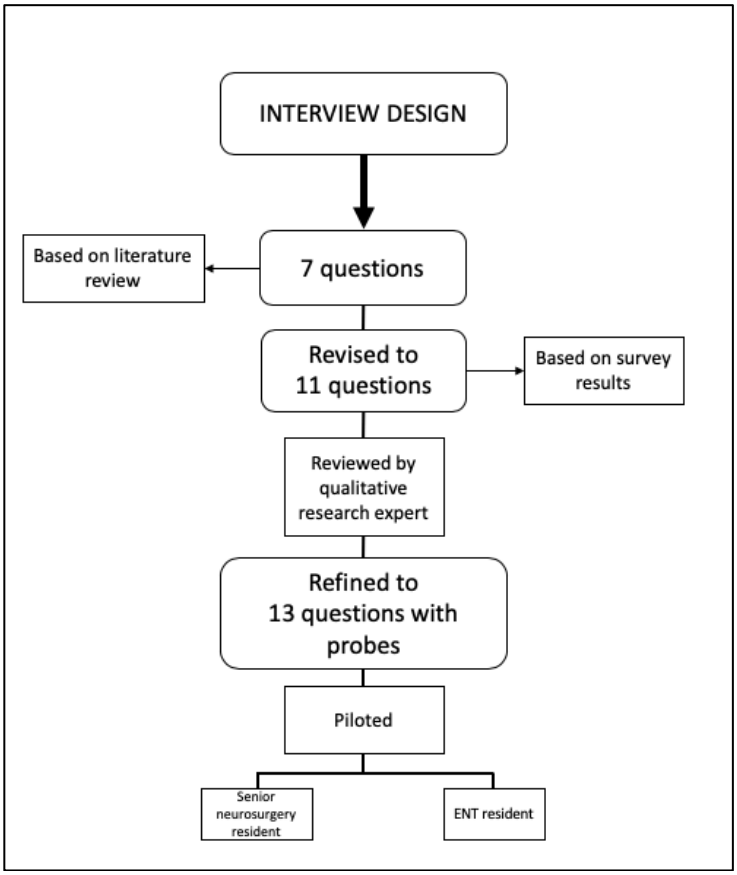

Figure 7. Qualitative interview design and methodology. This flowchart represents the thought process behind the semi-structured interview guide. It had 13 questions that were based on the responses obtained from the surveys. The interview guide was reviewed by a qualitative research expert and piloted accordingly.

2.3.5 Aim 2 (Residents' Overall Experience) - Interview Process

All first-year neurosurgery residents received an invitational email to participate in a 30-minute interview on Zoom, a virtual meeting platform (Zoom Video Communications, San Jose, CA). Once they expressed their interest, a time was scheduled for an interview at their convenience. The Zoom interviews were recorded through the software for future verbatim

transcription. French-speaking interviews were transcribed in French and then translated to English by the author. All interviewees had completed both surveys prior to the interview (Fig. 6).

2.3.6 Qualitative Analysis

The analysis followed an iterative approach. Two sample interviews were randomly taken from the set of interviews. Two coders (M.C, M.H) independently generated primary code names from the interview samples. The codebook was then created following a merge of the primary code names from both coders after a discussion between them (Appendix 4). Seventeen child nodes were generated from four parent nodes. Independent interview coding was conducted by both coders using QSR International's NVivo 11 software. Iterations were done to the code names once the coders met to discuss and reach agreement on the coding analysis. A Kappa score (measure of inter-rater reliability) of 0.87 was calculated representing an excellent agreement. Finally, a thematic analysis was completed by creating an overarching theoretical framework.

2.4 Results – Aim 1 (To Recognize Benefits and Pitfalls)

2.4.1 Descriptive Statistics of Participants

A total of 84% and 80% of participants responded to survey #1 and #2 respectively (*see table 1*). Both surveys were filled out by French- and English-speaking residents. All respondents had completed at least one neurosurgery rotation in the first survey (100%) while off-service rotations (i.e. general surgery, internal medicine, and trauma surgery) were more frequent in the second survey.

Table 1. Descriptive Statistics

Item	*n* (%)	
	At 3 months	At 7 months
Respondents	21 (84.0)	20 (80.0)
French speaking	2 (9.5)	2 (10.0)
Off-service rotations done so far in training		
• Critical care	1 (4.8)	4 (20.0)
• General surgery	0 (0)	7 (35.0)
• Internal medicine	2 (9.5)	6 (30.0)
• Neurology	2 (9.5)	3 (15.0)
• Trauma surgery	4 (19.1)	7 (35.0)
• Other	5 (23.8)	12 (60.0)

2.4.2 Reported Survey Items Agreement Over Time

The first theme, logistics and readiness to implementation, asked the participants about three specific items (*see table 2*). One of those items was not included in the second survey as it was a baseline question. On average, for both surveys, first-year neurosurgery residents agreed that there was support from their program director and head of division (mean for all items >3.90) with no statistical significance between their responses over time (*p*=NS).

Table 2. Resident Perceptions of Logistics and Readiness for Implementation of CBD Over Time

	At 3 months		**At 7 months**		***p*-value**
Logistics and readiness to implementation	$\bar{x}$	SD	$\bar{x}$	SD	
The program director provides guidance to implement CBD	4.14	0.79	4.00	1.12	0.83
The head of division or department is supportive of CBD	3.90	0.89	3.95	0.10	0.75
There is a Competence Committee assembled †	4.24	0.62	-	-	-

† Item was asked only on the survey at 3 months

The second theme, resident's knowledge of CBD, included three items on the first survey, and one baseline item was omitted for the second survey (*see table 3*). For the first survey, respondents agreed or strongly agreed that there was an orientation organized by their program to give more directions on and information about CBD. However, residents perceived understanding of CBD and EPAs was not strong in the first survey and did not improve by the second survey ($\bar{x}$ <3.52 for items 1 and 2). There was no statistically significant difference between their responses over time (*p*=NS).

Table 3. Resident's Knowledge of CBD Over Time

	At 3 months		**At 7 months**		***p*-value**
Resident's knowledge of CBD	$\bar{x}$	SD	$\bar{x}$	SD	
I understand how an EPA assesses my performance	3.48	1.17	3.40	1.19	0.36
I understand how an EPA is used to follow my progression	3.52	1.08	3.45	1.10	0.65
There was an orientation about CBD in neurosurgery †	4.38	0.50	-	-	-

† Items were asked only on the survey at 3 months

The third theme, key stakeholders' knowledge and attitudinal features, included three items in survey #1 and four items in survey #2 (*see table 4*). In the first survey, first-year residents did not know if attending surgeons were aware of CBD with a mean of 3.67±1.11, willing to complete the EPA forms requested of them ($\bar{x}$ = 3.24±1.04), or understood the entrustment scale on EPA form assessments ($\bar{x}$ = 2.95±1.12). By the second survey, residents agreed that their attendings were aware of CBD ($\bar{x}$ = 3.95±0.10) but thought that the attendings still did not understand the entrustment scale ($\bar{x}$ = 2.89±1.10). Also, residents did not notice any differences between the EPAs filled out by attendings or senior residents ($\bar{x}$ = 2.90±1.17). Again, there was a difference in the

variability of the responses, but no statistically significant difference between the responses over time (*p*=NS).

Table 4. Perceptions of Key Stakeholders' Knowledge and Attitudes Over Time

	At 3 months		**At 7 months**		***p*-value**
Key stakeholders' knowledge and attitudinal features	$\bar{x}$	SD	$\bar{x}$	SD	
Attending surgeons are aware of CBD implementation	3.67	1.11	3.95	0.10	0.54
My attendings understand the entrustment scale	2.95	1.12	2.89	1.10	0.36
Attending surgeons are willing to complete EPA forms	3.24	1.04	3.25	1.16	1.00
EPA assessments provided by attending physicians may be different than the ones by senior residents. †	-	-	2.90	1.17	-

† Item was asked only on the survey at 7 months

The fourth theme, impact of CBD on residents, was comprised of four items (*see table 5*). In the first survey, respondents did not know yet whether their portfolio was useful to gauge their progression in neurosurgery with an average of 3.19±1.08. Interestingly, by the second survey, interns disagreed with the usefulness of the portfolio ($\bar{x}$ = 2.65±1.14) although this was not a statistically significant difference from the first survey (*p*=NS). Residents were neither sure if EPAs within CBD were providing enough data for their progression to be properly assessed ($\bar{x}$ < 3.33) nor if attendings were giving them verbal feedback accordingly ($\bar{x}$ < 3.35). Finally, significantly less first-year residents encountered any barriers when they tried to access their portfolio (*p*=0.04).

Table 5. Impact of CBD on Residents Over Time

	At 3 months		At 7 months		*p*-value
Impact of CBD on residents	$\bar{x}$	SD	$\bar{x}$	SD	
My portfolio is useful to gauge my progression	3.19	1.08	2.65	1.14	0.11
Attendings give me verbal feedback	3.29	1.23	3.35	1.18	0.56
There is enough data for the competence committee to assess my progression	3.33	0.97	3.10	0.97	0.31
There are barriers to get access to my portfolio	2.57	1.16	2.95	0.89	0.04*

2.4.3 Comparison of Reported Survey Themes Between the Two Surveys

As illustrated in Table 6, there were no significant differences in any of the survey themes of logistics and readiness to implementation, resident knowledge of CBD, key stakeholders' knowledge and attitudes, and impact of CBD on the residents between the two surveys (*p*=NS).

Table 6. Theme Scores Over Time

	Mean rating				
	At 3 months		At 7 months		*p*-value
Survey theme	$\bar{x}$	SD	$\bar{x}$	SD	
Logistics and readiness to implementation	4.20	0.63	4.08	0.83	0.46
Resident knowledge of CBD	3.83	0.86	3.36	1.19	0.06
Key stakeholders' knowledge and attitudinal features	3.49	0.81	3.32	0.60	0.37
Impact of CBD on residents	3.14	0.74	3.06	0.69	0.65

2.4.4 EPAs in Number Between Chief Residents and Attendings

Residents reported the number of times attendings and senior residents were filling out EPA assessment forms. On average, residents received six assessment forms from attendings in the first survey compared to 10 assessment forms in the second survey (*see table 7*). The responses at 7 months were cumulative from the first and second survey.

Table 7. Frequency of EPA Assessments Completion by Attending Physicians and Senior Residents Over Time

	At 3 months		**At 7 months**	
Item	Median	Range	Median	Range
COMPLETION OF EPA REQUESTS				
Attendings				
Number of times they agreed	6	[0,20]	10	[0,57]
Number of times they agreed but did not do it	1	[0,10]	3	[0,15]
Number of times they refused	0	[0,4]	0	[0,3]
Senior residents †				
Number of times they agreed	-	-	10	[0,30]
Number of times they agreed but did not do it	-	-	0.1	[0,14]
Number of times they refused	-	-	0	[0,5]

† Items were asked only on the survey at 7 months

In table 8, a majority of residents reported that senior residents were providing verbal feedback more often than attendings with a range between 6 to 10 times. Similarly, residents felt that their actions related to an EPA task were being observed 80% of the time when a senior resident was asked to do so as compared to an attending neurosurgeon (40% of the time). In the second survey, participants reported that approximately 80% of the time, a senior resident evaluated them on EPAs instead of an attending (*see supplemental material – Survey 1 for complete list of questions*).

Table 8. Frequency (mode) of Feedback, Direct Observation and Other Variables Regarding EPAs Over Time

	At 3 months	At 7 months
Verbal feedback received after direct observation		
From attendings	1-5 times	1-5 times
From senior residents †	-	6-10 times
Percentage of time actions were directly observed to fill an EPA form		
By attendings	60%	40%
By senior residents †	-	80%
Percentage of the time a senior resident evaluates me with an EPA compared to an attending physician	-	80%
EPA assessment forms received in neurosurgery	1-5 times	11-15 times
*How often a request is made to complete an EPA**	3, 5	3, 5

† Items were asked only on the survey at 7 months

*1 More than once per day
2 Once per day
3 More than once per week, but not daily
4 Once per week
5 More than once per rotation, but not once per week
6 I have never requested an EPA at this point in my training

2.4.5 Time-Dependent Evolution of Residents' Perceptions on CBD

On the second survey (Post), residents rated their understanding of the intentions of CBD higher than they had rated it during the first survey (Pre); however, the pre/post mean ratings were not significant (p=NS). Indeed, residents had overestimated their perceived understanding of CBD's intentions at the start of residency, as their Retro-pre rating was significantly lower than their Pre (p=0.03). To accurately determine the influence of going through CBD on their perceived understanding of the intent of CBD, Retro-pre/Post comparison was performed, as the Retro-pre was a more reliable reflection of their initial understanding of CBD than their response on the first survey. The Post rating mean score was higher than the Retro-pre (p=0.02). These results can be found in table 9.

Residents were also asked to rate their anxiety level in relation to keeping up with the EPA demands. On the second survey (Post), residents rated their anxiety level higher than on the first survey (Pre), but no difference was found in the mean ratings (p=NS). However, an effect of underestimation of their anxiety level was demonstrated at the start of their residency as a significant difference was noticed between the Pre and Retro-pre mean ratings (p=0.05). To accurately determine the influence of going through CBD on their anxiety level rate, a Retro-pre/Post comparison was performed; no difference was found between the mean ratings (p=NS).

Table 9. Comparison of Original, 3 Month-Reflections and Final Ratings on CBD Items

Survey item	Pre mean ± SD	Retro-pre Mean ± SD	Post mean ± SD	Pre/retro-pre *p*-value	Pre/post *p*-value	Retro-pre/post *p*-value
Understanding of what CBD is intended to achieve	4.17 ± 0.92	3.60 ± 1.05	4.00 ± 0.59	0.03*	0.45	0.02*
CBD allows for abilities to be assessed fairly	3.28 ± 1.07	3.25 ± 0.91	3.11 ± 0.96	0.81	0.48	0.14
Anxiety about keeping up with EPAs	3.61 ± 1.19	3.90 ± 1.37	3.94 ± 1.16	0.05*	0.14	0.84

2.4.6 A Longitudinal Comparison of the Benefits and Pitfalls of CBD

Responding first-year residents identified “receiving more feedback” as the major benefit to CBD in the first survey (67%). However, in the second survey, the most selected benefit by 50% of the respondents was “having a clear performance assessment”. Of note, between the two surveys, this benefit did not really significantly change in frequency (p=NS). A list of all benefits elected by respondents is provided in table 10. There was no statistically significant change in benefits elected over time (p=NS).

Table 10. Frequency of Benefits Identified Over Time

Benefit item	***n* (%)**		***p*-value**
	At 3 months	At 7 months	
The evaluation is more objective	10 (47.6)	9 (45.0)	1.00
I have a more active role in my learning	11 (52.4)	9 (45.0)	1.00
I receive more feedback	14 (66.7)	8 (40.0)	0.22
There are improved relations with attendings	2 (9.5)	1 (5.0)	1.00
There is a clear assessment of my own performance	11 (52.4)	10 (50.0)	1.00
Other	4 (19.1)	3 (15.0)	1.00

In table 11, a list of pitfalls is identified. The pitfall most selected by residents was "time consuming" at 95% in the first survey and 85% in the second survey. Likewise, for a majority of residents, another pitfall that was commonly elected was "forgetting to initiate the forms" at 76% and 65% in the first and second surveys respectively. There was no statistical significance in the choice of pitfalls over time (p=NS).

Table 11. Frequency of Pitfalls Identified Over Time

Pitfall item	***n* (%)**		***p*-value**
	At 3 months	At 7 months	
It is too time consuming	20 (95.2)	17 (85.0)	0.50
It is too intimidating to ask the attendings	8 (38.1)	7 (35.0)	1.00
The evaluation form does not represent my true competence	10 (47.6)	12 (60.0)	0.45
I forget to initiate the forms	16 (76.2)	13 (65.0)	1.00
The attendings do not complete the forms	10 (47.6)	12 (60.0)	0.29
Other	6 (28.6)	4 (20.0)	1.00

2.4.7 Qualitative Comments from the Two Surveys

Within the surveys, residents were asked to provide any further comments they would have related to their experience with CBD so far. The most pertinent comments can be found in table 12. These comments were not part of the qualitative analysis but instead brought another perspective to residents' experience and provided a framework for the design of the qualitative interview questions. Some of these questions were based upon various key words found in the comments provided such as anxiety-provoking, challenging, and the fact that senior residents were completing EPA requests.

Table 12. Illustrative Comments from Two Surveys

Comments	
3 months	**7 months**
"*Great idea in theory. Has been challenging so far to complete and document EPAs in practice*"	*"I find it challenging with how busy the neurosurgery service is to request the EPAs, and more so to find an appropriate time to request them."*
"It's a great way for feedback. However, anxiety provoking."	*"Stressful due to time limit. Some programs spend a lot off service in medical blocks which rises a challenge to us to complete the surgical EPAs"*
"I believe it is not applicable to neurosurgery"	*"Requires buy in from preceptors, who tend to put it off to later and then never complete it."*
"The number of EPAs is excessive and burdensome."	*"The platform needs to be improved. You cannot change education with a backward platform."*
"All my EPAs have been completed by senior residents to this point. I have yet to ask staff but will be more active in this with my future blocks on service."	*"The homogeneous uncritical superficial thinking that everyone […] has done is laughable and would not withstand scrutiny if it were ever challenged thoughtfully and by competent people, but unfortunately no one can say anything about how absurdly wasteful and useless this process is because the people best placed to comment on this have no power and no one cares about their opinions or experience anyway."*

2.5 Results – Aim 2 (Residents' Overall Experience)

2.5.1 Themes Reported from Semi-Structured Interviews

A total of eight interviews were conducted with first-year neurosurgical residents. The interviews lasted between 30 to 42 minutes with an average time of 34 minutes. From the interviews, 4 key themes were derived: 1) Meaning of CBD to first-year neurosurgery residents, 2) Feasibility of using EPAs in neurosurgery, 3) Positive learning experience with feedback, and 4) Importance of assessor variability on EPAs (*see table 13*).

Theme 1: Meaning of CBD to First-Year Neurosurgery Residents

Residents provided their own understanding and meaning of CBD. Most of them recognized its usefulness in reinforcing patients' trust in their healthcare providers "*I think it's a reasonable way to evaluate where we are in our training, but I feel it's almost more of a way to make sure that the healthcare training system is accountable to society itself.*" (Participant 1) However, some residents believed that CBD lost much of its educational potential when it was treated as an administrative chore by faculty or supervising residents. In that situation, CBD can become identical to checklists or checkboxes that faculty can complete without giving them much thought "*I feel like staff sometimes do the checkmarks in a random way.*" (Participant 3) On the other hand, the participants acknowledged that CBD requires active participation by the learner as well "*CBD program is very self-directed*" (Participant 7). Most of the participants considered themselves adult learners, recognizing that they have to take full responsibility in their learning; "*being a resident, you are an adult, this is your learning*" (Participant 4). Therefore, some participants mentioned CBD as being stressful because of the necessity to see enough cases to be entrusted and having enough EPAs completed even though they do not control their schedules "*But I think unfortunately, one of the issues with CBME is you also have to see cases.*" (Participant 4). In general, the first-year neurosurgery residents' perception of CBD was very mixed and there is a belief that CBD is a necessary requirement with some ambivalence towards its educational value. One participant even said, "*I'm honestly just playing the game at this point*" (Participant 6) acknowledging his ambivalence towards CBD. When asked what he liked about CBD, another participant said that "*In fact, CBD is like brushing my teeth. When I was a kid, I hated brushing my teeth and now I am an adult, I don't love brushing my teeth, but I just do it. It's a necessary action.*" (Participant 7)

Theme 2: Feasibility of Using EPAs in Neurosurgery

Participants discussed the feasibility of using EPAs in neurosurgery. Despite the positive statements mentioned above, participants reported that the opportunities to get EPA assessments were limited due to the lack of control regarding which surgical cases they observe. Some participants also noted that EPA assessments may be missed when faculty and senior residents forget to fill out the assessment forms "*I think I'll have a bunch of EPAs that will get expired because my seniors from last block didn't do them. […] From 3 different people, I had 3 EPAs expired.*" (Participant 4) Also, for junior residents at larger programs, they tend to have less surgical exposure. Similarly, schedule conflicts related to time off-service or educational activities can prevent residents from seeing the overall number of requested cases. Additionally, some residents were dissuaded from even asking or thinking about EPA assessments due to the busyness of their daily routine and many tasks "*I find it more time consuming beyond like what in isolation just getting an EPA would take. Just trying to organize the other demands, juggling everything else, with time to scroll through to figure out which EPA is appropriate for that situation and how it should be filled out in kind of a thoughtful manner. Definitely time consuming.*" (Participant 8) Besides lack of time, another deciding factor for missed EPAs was past performance "*given how it is inconvenient for staff at this point, I am less likely to ask for an EPA if I don't think I am going to pass. […] Like if I don't feel like I am getting a 4 […] then I am not asking for it.*" (Participant 6) This strategy was recognized by some of the residents to not follow the true intent of EPAs and CBD. However, they deemed it too challenging to do things differently for neurosurgery "*In internal medicine for example, they had a problem where attendings would refuse to fill EPAs if it wasn't asked before doing the EPA. I think it's completely illogical for our reality because I would never be able to ask it in advance. I never know when the cranial trauma is coming in the hospital.*

In my reality, I don't see myself asking for an EPA in advance." (Participant 3) Though, many residents recognized that retrospectively requesting EPAs had effects on their evaluations and feedback comments "*If we have a bunch of patients back to back, usually I'll ask at the end of the shift or something and then I find typically that whoever is doing the EPA will fill it out kind of generically as oppose to in relation to a certain case or something that I specifically did.*" *(*Participant 2) Many challenges were also reported with the technology usage limiting the ability for residents to receive real-time feedback "*So, I can't use the app. I put all my EPAs on my laptop because I have an Android. […] I think that is also a problem because a lot of the EPAs, I'll put in a request, I mean I'll ask someone about it, but then I'll put the request later when I get home. Who knows when they are going to do the EPAs, maybe 2 days later? If I had the app on my phone, I can do it in real-time and they get it as well*." (Participant 4) Some also reported that it was difficult to follow their progression of EPA through their online portfolio and created their own visual method "*I have spent some nights like putting things into Excel documents to make sure I've got all of my EPAs. And reviewing everything to make sure I haven't missed some*" (Participant 1)

Theme 3: Positive Learning Experience with Feedback

Residents considered that the concept of EPA is an opportunity to obtain more detailed feedback as compared to the feedback without the assessment request "*I think there would be less substance to discuss about [cases] without the EPA process.*" (Participant 3) Residents felt that when they asked for an EPA form, faculty or senior residents were directly engaged in their learning and observing their actions more carefully "*I think the feedback that is actually documented in the EPAs, it feels like it's actually complete. It's not like "oh, you did a good job". It documents the circumstances in which you were working […] I think it's better overall like capturing that moment in time rather than a fleeting good job.*" (Participant 5) Further, residents

described various situations where they had feedback from an encounter with either their chief resident or faculty. Most often, the comments were verbally and informally given after a neurosurgical case or direct involvement in patient care. It was considered as more reliable by some "*I think I like the informal verbal feedback because it does seem the most honest. There is always kind of the thing of people seem to be more hesitant of what they put in writing so you can always get feedback verbally.*" (Participant 8) However, feedback, either verbal or written, had a higher psychological impact on the residents than the scores coming from the EPA entrustment scale's numbers. The residents also mentioned that obtaining feedback, no matter the type or delivery, helped them to improve their learning and performance in neurosurgery "*I think it's stimulating and it's not negative. It's more like I will have to improve on this step, or I will need to work harder on that one. I don't take it as negative. I see it as constructive criticism.*" (Participant 3)

Theme 4: Importance of Assessor Variability on EPAs

First-year neurosurgery residents' experience with the whole CBD process was directly affected by the variabilities existing within their different neurosurgical programs. For example, some of the neurosurgery programs in Canada do not have subspecialist neurosurgeons in peripheral nerve or endovascular specialties. However, the residents from these programs still need to complete the same peripheral nerve EPAs as their counterparts which would require institutions to make a financial investment to hire more neurosurgeons and help build their practice. This disconnect between the institutional finances and educational requirements has been noticed by the participants "*I don't know that our program has changed a lot in order to accommodate CBD.*" (Participant 7) Furthermore, faculty within the neurosurgery department were described as different as compared to non-neurosurgery faculty "*Yeah so the only time I have actually gotten*

staff to fill them out is when I am on a different service." (Participant 2) Residents explained that neurosurgeons are busier, sometimes unavailable, and not physically present when reviewing on-call cases; thus, they can become impatient with CBD and EPA requests tasks "*the attending is tapping their foot waiting.*" (Participant 8) For these reasons, many residents mentioned that they did not want to approach their senior residents or faculty with EPA requests. Also, program size variability appears to affect the frequency and quality of EPAs. In the larger programs where senior colleagues would more frequently assess junior residents, the trainees noticed a discrepancy or variability between faculty and senior residents' assessments "*For example, I had a staff do an EPA for a chronic subdural that I did and they said they didn't need to be there and I had a senior do it and they said that they had to walk me through all of it*." (Participant 4) However, a resident in a smaller program mentioned a different experience "*I think just being in a smaller program, we don't always have that junior-senior partnership in a lot of procedures so in a lot of circumstances it would be the staff. It's a great opportunity that way*." (Participant 5) More variabilities were further revealed when a few residents acknowledged their internal bias against older or more experienced faculty versus younger ones. "*I think most of the staff, especially younger staff, have [sic] ability to fill out the forms easily and just do them. I wonder about the older staff. That might be just my internal prejudice, […] I selfishly want to get on his good side and what I need to be focused on is being good intraoperatively and I can focus on the paperwork afterwards.*" (Participant 7) Lastly, the participants disclosed that neurosurgeons were always willing to teach and participate in their neurosurgical education, but that some were more inclined than others to participate in their education within CBD. Nonetheless, most of them were hopeful that this inconsistency between attendings would disappear with time "*Some staff might not believe*

as much in CBD by now, but after a year, when we will be able to compare 2 different R1s with their EPAs, I think people will buy-in." (Participant 3)

Table 13. Thematic analysis and quotes from first-year neurosurgery residents

Key themes	Illustrative quotes
Meaning of CBD to residents	"*In fact, CBD is like brushing my teeth. When I was a kid, I hated brushing my teeth and now I am an adult, I don't love brushing my teeth, but I just do it. It's a necessary action.*" Participant 7 "*I feel like staff sometimes do the checkmarks in a random way.*" Participant 3 "*But I think unfortunately, one of the issues with CBME is you also have to see cases.*" Participant 4 "*I'm honestly just playing the game at this point*." Participant 6 "*I think it's a reasonable way to evaluate where we are in our training, but I feel it's almost more of a way to make sure that the healthcare training system is accountable to society itself*." Participant 1
Feasibility of using EPAs in neurosurgery	"*I find it more time consuming beyond like what in isolation just getting an EPA would take. Just trying to organize the other demands, juggling everything else, with time to scroll through to figure out which EPA is appropriate for that situation and how it should be filled out in kind of a thoughtful manner. Definitely time consuming.*" Participant 8 "*given how it is inconvenient for staff at this point, I am less likely to ask for an EPA if I don't think I am going to pass. […] Like if I don't feel like I am getting a 4 […] then I am not asking for it.*" Participant 6 "*In internal medicine for example, they had a problem where attendings would refuse to fill EPAs if it wasn't asked before doing the EPA. I think it's completely illogical for our reality because I would never be able to ask it in advance. I never know when the cranial trauma is coming in the hospital. In my reality, I don't see myself asking for an EPA in advance.*" Participant 3 "*If we have a bunch of patients back to back, usually I'll ask at the end of the shift or something and then I find typically that whoever is doing the EPA will fill it out kind of generically as oppose to in relation to a certain case or something that I specifically did.*" Participant 2 "*I think I'll have a bunch of EPAs that will get expired because my seniors from last block didn't do them. I think it is a problem. From 3 different people, I had 3 EPAs expired.*" Participant 4

	"*So, I can't use the app. I put all my EPAs on my laptop because I have an Android. […] I think that is also a problem because a lot of the EPAs, I'll put in a request, I mean I'll ask someone about it, but then I'll put the request later when I get home. Who knows when they are going to do the EPAs, maybe 2 days later? If I had the app on my phone, I can do it in real-time and they get it as well*." Participant 4 "*I have spent some nights like putting things into Excel documents to make sure I've got all of my EPAs. And reviewing everything to make sure I haven't missed some*" Participant 1
Positive learning experience with feedback	"*I think it's stimulating and it's not negative. It's more like I will have to improve on this step, or I will need to work harder on that one. I don't take it as negative. I see it as constructive criticism.*" Participant 3 "*I think I like the informal verbal feedback because it does seem the most honest. There is always kind of the thing of people seem to be more hesitant of what they put in writing so you can always get feedback verbally.*" Participant 8 "*I think the feedback that is actually documented in the EPAs, it feels like it's actually complete. It's not like "oh, you did a good job". It documents the circumstances in which you were working […] I think it's better overall like capturing that moment in time rather than a fleeting "good job"*." Participant 5
Importance of assessor variability on EPAs	"*I think just being in a smaller program, we don't always have that junior-senior partnership in a lot of procedures so in a lot of circumstances it would be the staff. It's a great opportunity that way*." Participant 5 "*I think most of the staff, especially younger staff, have [sic] ability to fill out the forms easily and just do them. I wonder about the older staff. That might be just my internal prejudice, […] I selfishly want to get on his good side and what I need to be focused on is being good intraoperatively and I can focus on the paperwork afterwards.*" Participant 7 "*For example, I had a staff do an EPA for a chronic subdural that I did and they said they didn't need to be there and I had a senior do it and they said that they had to walk me through all of it*." Participant 4 "*Yeah so the only time I have actually gotten staff to fill them out is when I am on a different service*." Participant 2 "*Some staff might not believe as much in CBD by now, but after a year, when we will be able to compare 2 different R1s with their EPAs, I think people will buy-in.*" Participant 3

3 Chapter 3: Discussion

After almost a full year of the new CBD system, the experience of the neurosurgery first-year residents had both positives and negatives (Fig. 8).

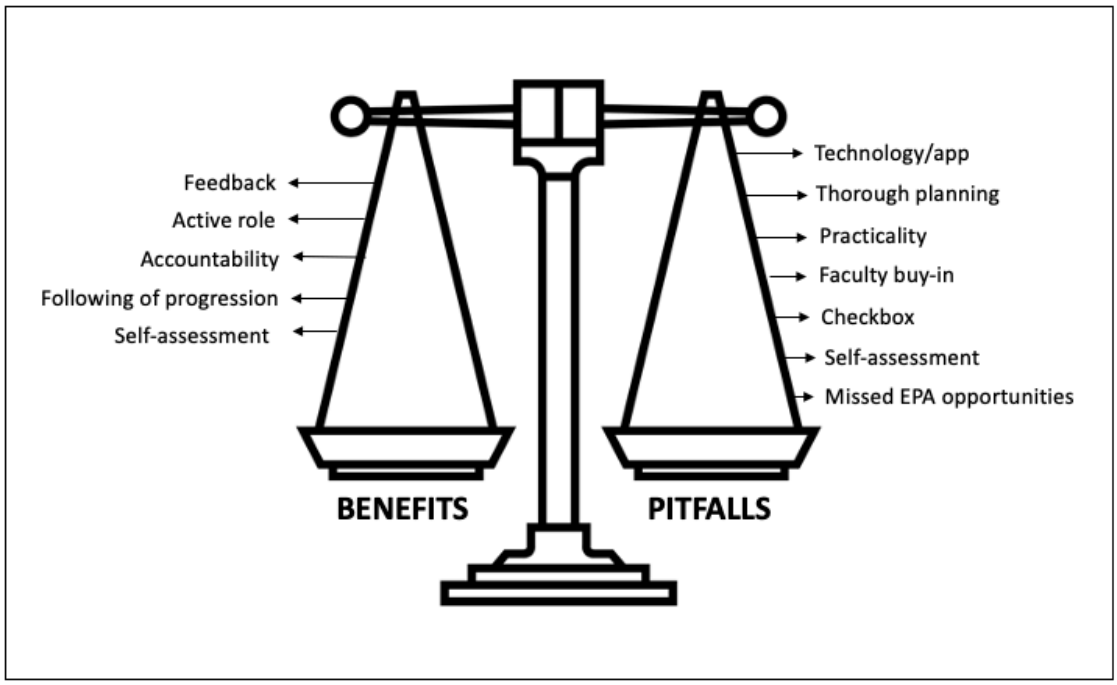

Figure 8. The balance between benefits and pitfalls. This figure of a measuring scale represents the importance of finding a balance between the benefits and pitfalls recognized by neurosurgery residents enrolled in CBD. Self-assessment has been considered on both sides of the scale. It is a benefit once it allows the learner to engage in the Kolb's learning cycle in their realization of EPAs. It is considered as a pitfall when self-assessment prevents the learner from asking for an EPA assessment form in fear of obtaining a low performance score.

3.1 Benefits of CBD for Neurosurgery Education

3.1.1 Perspective Over Time

A majority of residents in this study were either very positive about CBD or mostly neutral because some of them mentioned in the interviews that they had already experienced workplace-based assessments as medical students. They may have been less distressed by the change.[24, 25] They recognized the importance of the CBD revolutionary change in medical education and the

rationale behind it: improved public trust and accountability, emphasis on low-stakes examinations, and learning based on individualized needs.[26] Residents also acknowledged that there was no going back to a traditional time-based model and recognized the many benefits of CBD including increased rigorous assessments and feedback. These findings were similar to the ones in a study on American neurosurgery residency programs under the Accreditation Council for Graduate Medical Education (ACGME).[23] This ACGME Milestones study had also found that there was a possibility of identification of struggling residents earlier on, which was not mentioned in the results of this study. Lastly, most Canadian first-year neurosurgery residents in our study believed that the neurosurgical EPAs become more relevant with time and that they will be able to pass on this new model to their future junior residents when they become senior. This is a normal positive attitude towards change described by other researchers.[27, 28]

3.1.2 Residents' Role and Responsibilities

For first-year neurosurgery residents, EPAs appear to have a maximal benefit to their education if the resident takes full responsibility for their learning and progression. Contrary to a group of general internal medicine residents at Queen's University who claimed that EPA assessments should be initiated by faculty, neurosurgery residents were willing to initiate their own EPAs.[29] However, participants mentioned that this responsibility was sometimes difficult to uphold as their surgical role in the operating rooms wasn't always properly defined. A huge component of hierarchy in operating theatres and a less discussion friendly environment, may contribute to deterring first-year residents from asking for an EPA assessment in that specific context.[30, 31] Another element that contributed to residents' willingness to engage in the completion of EPAs was their understanding of what CBD was intended to achieve: a demonstration of competence in the essential skills of neurosurgery.[32] Not surprisingly, this understanding

significantly increased as their familiarity of the process did and as more EPAs were completed. In general, the first-year neurosurgery residents in this study felt that there was adequate preparation to launch CBD in each neurosurgery program across the country. Perhaps the readiness of the RCPSC Neurosurgery Specialty Committee emanated from the experiences with CBD that had launched in other programs several years prior.[11, 22, 33, 34]

Moreover, residents demonstrated having a lot of insight on behaviors that were probably going against the principles of CBD such as self-assessing their performance prior to asking for an EPA assessment in order to obtain a better score and asking for an assessment in a retrospective manner most of the time. Despite the RCPSC preparation, it is clear that the participants in this study still did not fully understand the definition and purpose of an EPA. The latter was recognized when some residents expressed their wish to add more EPAs to the neurosurgical list explaining that some EPAs did not reflect the CanMEDS framework. As per Dr. ten Cate, EPAs are designed to enable the translation of CanMEDS competencies into the workflow, but an EPA is not a CanMEDS role.[35] Likewise, EPAs do not necessarily reflect all of the components of work that one does in a hospital as they are considered to be more holistic in nature and include knowledge, attitude, and skill aims.[7] Importantly, residents who considered self-assessment as going against CBD principles were partially incorrect. Fair and transparent self-assessment is very much consistent with CBD principles. However, it is unclear if self-assessment training is taught to medical students, which may lead to self-protective self-assessment (i.e. avoiding one's weaknesses) and can therefore lead to residents missing opportunities to obtain constructive feedback as a way to avoid low EPA scores. However, self-assessment can also be a great exercise to improve future performances when it is done in a specific context and with the commentary of engaged surgeons.[36]

3.1.3 EPAs as a Vehicle for Constructive Feedback

Resident participants in this study all valued the feedback they received so far during their training. This feedback was further enhanced when an EPA was requested as they noticed a change in the quality of comments that were written. Comments were more substantive and descriptive of their actions. Many studies have shown that feedback interactions are complex, especially if constructive.[37-39] A systematic review of the literature showed that most of the research designs for feedback studies were on the first reporting level of the Kirkpatrick's Pyramid[15], which is the evaluation of reaction or satisfaction. In this study, when feedback was reported as not effective, most residents acknowledged that they had asked for feedback too late which did not help their attendings to recall specific cases. On the other hand, when resident respondents reported that the feedback was effective for their learning, it typically involved a discussion that helped them clearly understand what they did well and what they could improve. As reported by Kelly and colleagues, this empowerment and support of learners helped to establish an educational alliance for future encounters.[40] This process is also supported by existing research emphasizing the importance of the role of the learners in addition to that of teacher in the feedback process.[16]

Similarly, Desy and colleagues have noted that the feedback components of CBD often fit millennials' learning preferences and needs.[41] Indeed, millennials over other previous generations expect more feedback from their superiors to improve their progression. The results of this study demonstrated that the neurosurgery residents appreciated feedback from multiple sources and that they could learn from both their faculty and senior residents' varying wealth of knowledge. Interestingly, the results of this study differ from data from an internal medicine program at the University of Toronto.[33] In that study, it was found that residents felt that the quality of feedback had worsened as a consequence of CBD. This difference could be explained by the scope of EPAs

that are relevant to each specialty. It is possible that procedural and surgical EPAs are perhaps more measurable and better suit the true definition of EPA identified by Dr. ten Cate.[42] Also, the quantity/quality of baseline feedback present prior to EPA implementation could have impacted how residents perceived the given feedback resulting from the CBD process. For example, if feedback was delivered poorly or rarely in some neurosurgery programs before CBD, first-year residents may have felt any increased effort from faculty to provide constructive feedback was positive.

3.2 Challenges of CBD for Neurosurgery Education

3.2.1 Residents must take an active planning role to ensure CBD progression

The results of this study revealed that a fair amount of planning is required by resident physicians to ensure they achieve their progression goals in CBD. Similarly, barriers to achieving EPAs occurred because of the large number of requirements, missed opportunities, or forgetfulness to initiate the forms. Also, residents expressed challenges related to finding the appropriate time to request an EPA given the other time/work demands of a busy neurosurgery service. Although, keeping up with the EPA forms and requirements was not considered anxiety-provoking between the two surveys, the surveys' open-ended questions and the interviews noted that CBD was described as anxiety-provoking and stressful. Being overwhelmed with EPAs or finding the task of seeking feedback burdensome was found in two other Canadian internal medicine programs.[32, 33] Despite the fact that neurosurgery residents recognized the benefit of using CBD to assess their individualized progression, they felt that the tools put in place to monitor that progression were not adequate and some residents even designed their own spreadsheet to have a better visual of

their EPA completion. This issue may reflect a lack of technological preparation and availability from either the RCPSC or the neurosurgery programs within their respective university. On the RCPSC website and in a CBD cost analysis study, it is mentioned that the use of the RCPSC portfolio is not mandatory.[43] Thus, there is a wide range of technologies used by each institution. Nonetheless, the development of learning analytics data in medical education has shown a tremendous advancement and Canadian programs in CBD should follow that path with their portfolio platforms.[44, 45] Moreover, to help residents in planning and understanding their CBD progression, Rich and colleagues have proposed the use of academic advisors.[46] Not only could they help institutions' Competence Committees to gather high-quality data about their residents, but academic advisors could also serve as a bridge between the program director and the rest of the faculty to provide a more accurate assessment of residents' performance.

3.2.2 Importance of technology readiness

Medical education is confronted with a lot of changes related to new technology adoption. This also applies to CBD. The implementation of CBD needs to blend adequately within this technological era to facilitate a smooth transition. Unfortunately, as per the residents' viewpoints, this has failed. While they mentioned that there were no hurdles to getting access to their online portfolio, during the interviews, a majority of residents revealed their dissatisfaction with the way the phone application was working (One45). The online portfolio and the phone application were on two separate platforms. They were not necessarily linked together, especially if one had an Android versus an iOS device. As one can imagine, requesting EPAs for an on-the-go mobile application to receive timely feedback eases the process. However, delaying EPAs tasks until the evening to connect on a computer may interfere with productivity and precision of the feedback. The Federation of Residents of Quebec (FMRQ) reported difficulties with electronic platforms

during the implementation of CBD in the past and the same problems are now similarly occurring in Queen's University post-graduate medical education programs.[22, 47] However, Queen's University uses a different homegrown platform named Entrada. Stahl and colleagues have developed a mobile application for the integration of EPAs in a general surgery program workflow.[48] The results did not show any difficulties encountered with the application and there was a quality improvement survey sent out to continuously improve the application. The authors designed their mobile application based upon recommendations that technology usage within EPAs should be user-friendly and facilitate the documentation of their progress.[49] Ultimately, the RCPSC should perhaps invest in the creation of a seamless mobile application for an improved utilization and standardization instead of leaving this costly task to the universities across the country. It would also facilitate further quality improvement on a national level.

3.2.3 Limits related to faculty buy-in

Neurosurgery remains embedded in an environment where traditional apprenticeship with one-on-one mentorship is still happening in certain programs.[50] Although this model can be easily applied to CBD, our study showed that faculty involvement in residents' observations and evaluations of EPAs is fairly low. After almost a year into CBD, residents noticed that only 40% of attendings would observe their EPA-related actions as compared to 80% of senior residents. Moreover, residents disagreed that their attendings completely understood the EPA forms or their meaning. These factors may reflect limited faculty buy-in with the CBD change and may have negatively affected residents' learning when they requested an EPA. This attitude towards CBD implementation from neurosurgery attendings as perceived by residents is not different from what has been reported by Hanley and colleagues.[51] In a group of anesthesiologists from Dalhousie

University, they found three types of attendings' attitudes: innovator/early adopter, early/late majority, and laggards. The laggards were found to frequently claim that there was no evidence of any advantages of the new system over the traditional system in place. The term 'laggards' is derived from the Diffusion of Innovations theory.[52] It has been particularly used in medical sociology and can relate to a change of this magnitude such as CBD. Of note, it is difficult to convince laggards to change as the final outcomes from CBD will take several more years to realize.[53] Laggards will change their behavior when it becomes unacceptable or embarrassing not to. The influence of their peer neurosurgeons will come into play for them to finally adopt the CBD change as social norms have a great impact on behaviors.[54] A strong leadership will be required from the program and an emphasis on CBD positive effects on residents' evaluation should be emphasized.

3.2.4 Limits related to neurosurgery program

Furthermore, neurosurgery program leaders need to ensure that their program has enough variability to allow CBD progression with clear faculty development in the CBD process. As per the residents, variability in programs' structure or information given to faculty affected their CBD experience. Cheung et al. developed recommendations for institutional Competence Committees and hence, faculty development such as membership, release of available high-quality data on residents, attestation of a faculty coach, and continuous quality improvement.[55] Interestingly, the RCPSC offers online workshops and videos on "EPA Fast Facts" or "Coaching to Competence" as part of a faculty development initiative.[56] Unfortunately, none are related to neurosurgery specifically and it is not a mandatory activity. Another alternative could be a CBD incentivized

process where CME (Continuous Medical Education) credits would be available if various workshops related to CBD were completed.

3.3 Synopsis of first-year residents' perspective of CBD within the neurosurgery specialty

3.3.1 A proposed framework for neurosurgery specialty in CBD

The objective of this study was to identify the downstream effects of CBD on first-year neurosurgery residents as newcomers to the RCPSC medical education transformation. The results of this study demonstrated that there was a balance between pitfalls and benefits, but the pitfalls did not decrease over the course of the study as we hypothesized. Instead, new challenges presented themselves over time. The biggest challenge for the neurosurgery residents was understanding how to fit the daily neurosurgery schedule with EPA requests and plan ahead to properly assess their progression. To simplify these new tasks for the residents and efficiently incorporate them into their workflow, we propose a framework of conceivable solutions (Fig. 9). This framework is built upon the prior knowledge of a typical neurosurgery day, thorough review of the literature on CBD implementation barriers and the results of this study.

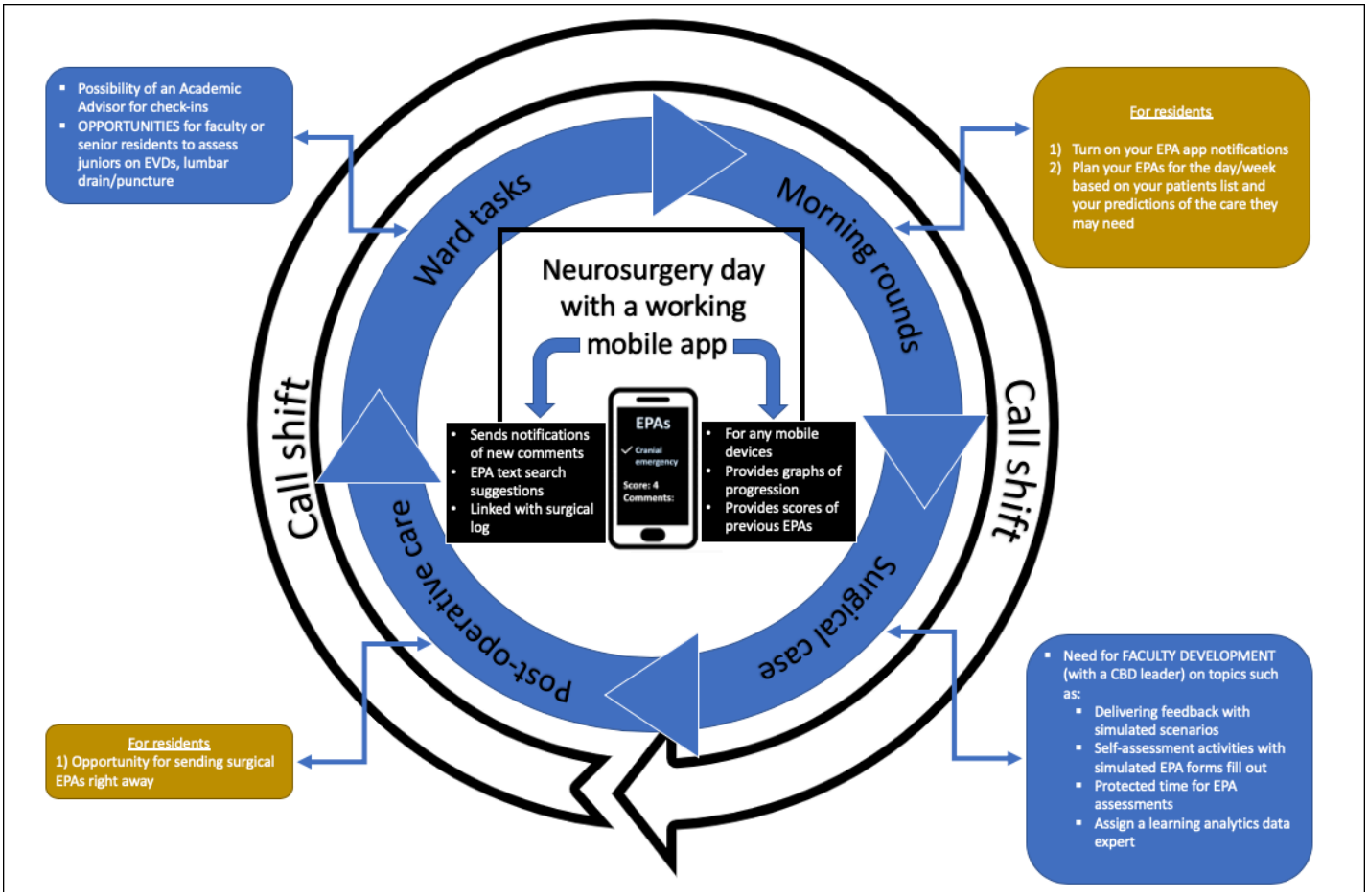

Figure 9. The Neurosurgical CBD Framework. This novel framework relies on a working mobile application to ease the integration of EPAs in neurosurgery residents' workflow. Recommendations for a better application are in the two black boxes. The blue circle is divided in four to represent the four different stages of a neurosurgical day. Preceding or during morning rounds, the neurosurgery resident should plan for potential EPA requests based on the list of patients and their care. During the surgical case, the results of proper faculty development led by a CBD expert and leader should be seen. After the surgical case and during the post-operative care (putting orders, assessing the patient after recovery from anesthesia), the neurosurgery resident should send their EPA assessment form. At the end of the day, during the afternoon/evening rounds, there should be a focus on EPA ward-tasks planned for the day. This is also a time for opportunities with either faculty or senior residents to provide direct observation and/or feedback. Lastly, the black arrow circle represents a resident with on-call duty. This shows an area of opportunities for requesting EPAs pertaining to emergency cases or specific cases.

3.4 Conclusion

This mixed-methods study was the first to assess the benefits and pitfalls of the CBD system in Canadian neurosurgery programs in the context of an educational framework. Overall, residents believed that the theoretical principles behind CBD including feedback and continuous

assessments were valuable to their learning and residency training. However, they described challenges such as the integration of EPAs in their busy daily schedule as well as technological ability and having enough time to request EPA assessments. Consequently, significant barriers to success still exist. To overcome these barriers, our study proposed a framework to guide the first-year neurosurgery residents throughout their journey in the CBD process. Finally, long-term studies are required in quality improvement of the exploited technology to facilitate the stakeholders' usage. Further research is also needed to determine the definitive outcomes of CBD on residents' performance and ultimately, on patient care.

3.5 Limitations

This study has several limitations. First, the sample size of 25 neurosurgery first-year residents is inclusive of all of the first-year neurosurgery residents in Canada but was relatively small compared to other medical specialties. To overcome this constraint, statistical tests were done accordingly for a smaller population with non-parametric distributions (i.e., using McNemar's test). In addition, after developing the first survey, new information became available concerning the way EPA assessment forms were requested and from whom they were requested. The first survey questions pertain only to attending physicians being asked to fill out EPA forms while in fact, senior residents played a huge role in junior residents' evaluation. Therefore, the second survey included questions that were differentiating attending physicians from senior residents. Unfortunately, this may have caused biases in obtaining an accurate longitudinal analysis related to these specific questions. In retrospect, this part of the study could have been done differently by obtaining a review of the survey from faculty involved at the level of the CBD Specialty Committee. This approach would have prevented senior residents from being omitted in

the first survey. However, the study should serve to remind neurosurgery programs how critical and influential senior residents have become in junior resident progression throughout the program, especially since the advent of CBD. The survey also presented a list of benefits and pitfalls for residents to select. This list was not exhaustive and may have missed important points related to the residents' CBD experience. An alternative way to have achieved this objective could have been by asking the survey respondents to specify a single benefit and or pitfall that was the most significant to them in an open-ended question. However, that method would have limited the breadth of novel benefits and pitfalls which would have limited further exploration during the qualitative interviews. Lastly, the surveys were distributed four months apart. This bias of time may have narrowed our findings as we could have found very different results if we had surveyed the residents at 3 and 15 months for example. It is possible that the survey at 7 months may have been too soon and that residents would not have recalled as many implementation pitfalls at a later time.

Concerning the qualitative interviews, the analysis may have been tainted with inherent biases from the primary coder, a neurosurgery resident (M.C). To overcome this bias, a second coder with an educational background (M.H) and a general surgeon (R.P) were part of the analysis. Frequently, both main coders reviewed and went back to the interview texts to confirm that they were not making any assumptions of the participants' words. Also, the interviews were done with residents who willingly volunteered to be interviewed. They may have had a different attitude than the average neurosurgery resident. They could have been either very satisfied or dissatisfied with the CBD process. This limitation would be difficult to address without mandatory interviews with all neurosurgery residents

Of note, it is important to mention that the results of this study might not be all specific or unique to CBD. Indeed, the sample population was a group of first-year residents experiencing many challenges as being in a new learning system but also new to residency. One could wonder if a first-year resident in the traditional learning system would experience the same challenges found in the CBD system. Therefore, it is possible that this study does not demonstrate true elements of causation solely related to CBD. To expand on that possibility, another study would have to include a comparison group from a cohort of residents still in the traditional system.

3.6 Future Research

As this research study focused on the first-year implementation of CBD in neurosurgery residency programs, three areas of research are worth exploring for future directions: 1) faculty development training, 2) new technology to ease usage of EPA forms piloting, and 3) long-term performance of neurosurgery residents within CBD system monitoring.

The results of the qualitative interviews showed that faculty were not on the same level of CBD knowledge from one program to another. It would be interesting to develop a uniform training for neurosurgery faculty. This training could include specific EPA-related feedback delivery tips: overview of EPAs description and meaning and simulation on how to appropriately grade trainees on EPA assessment forms. The involvement of a third-party observer assessing the current feedback delivery from faculty could help focusing on areas of feedback where training and tips could be required.[57] Furthermore, this kind of training should be offered by the neurosurgery CBD Specialty Committee rather than by each neurosurgery program to ensure standardization.

The launch of CBD seemed to have omitted important features concerning the phone application as well as the website utilized by trainees and faculty. It would be of interest to develop

various prototypes of phone application and get the residents' opinion on them. They are the main users and yet, most of them do not have a working application which was shown to limit their opportunities to get feedback on some EPAs. Also, research on learning analytics exists and applying it to CBD related technology could ease its usage.[44] It could also help with defining and visualizing the trainees' progression for themselves but also for their program directors. It would be interesting to evaluate how learning analytics can play a role in CBD.

Finally, a study designed to compare neurosurgery residents enrolled in CBD from those who have not been would be very valuable. Will there be any differences in oral or written examination scores or clinical outcomes? Moreover, despite the fact that CBD in neurosurgery was not designed to shorten the training, can trainees still be ready to become faculty earlier? This kind of study would require a long-term analysis of CBD effects on the current cohort of PGY1s and data collection from residents' evaluations should already be starting.

4 Appendices

Appendix 1. First survey sent to neurosurgical residents at 3 months into CBD

The purpose of this survey is to evaluate the opportunities and pitfalls related to competence by design in Neurosurgery. Questions related to your experience with this new evaluation process will follow. The survey should take between 3 to 5 minutes for you to complete and will be very valuable in further improvement of competence by design implementation.

→ To what extent do you agree with the following?

0=Strongly disagree 1= Disagree 2= I don't know 3= Agree 4= Strongly Agree

LOGISTICS AND READINESS TO IMPLEMENTATION

1. My program has a competence committee that is assembled.
0 1 2 3 4

2. My program director provides guidance to implement competence by design in our program.
0 1 2 3 4

3. The head of our division or department is supportive of competence by design implementation in our program.
0 1 2 3 4

RESIDENTS KNOWLEDGE OF COMPETENCE BY DESIGN

4. I received an orientation about competence by design in neurosurgery
0 1 2 3 4

5. I understand what competence by design is intended to achieve.
0 1 2 3 4

6. I understand how an entrustment scale is used to assess my individual performance during one direct observation. **0 1 2 3 4**

7. I understand how an entrustment scale is used by the competence committee to assess my progression through the competence continuum. **0 1 2 3 4**

KEY STAKEHOLDERS KNOWLEDGE AND ATTITUDINAL FEATURES

8. Most attending physicians in our residency program are aware that we have implemented a competence by design assessment system.

0 1 2 3 4

9. I believe my attendings understand the entrustment scale.

0 1 2 3 4

10. Most attending physicians in our residency program are willing to complete EPA assessments

0 1 2 3 4

11. How many times has an attending agreed to complete an EPA for you? _____

12. How many times has an attending agreed to complete an EPA and then not done it? (*the answer needs to be a number lower or equal as in question above*) _____

13. How many times has an attending refused to complete an EPA for you? _____

IMPACT OF COMPETENCE BY DESIGN ON RESIDENTS

14. My portfolio provides me with sufficient information to gauge how I am progressing in my learning.

0 1 2 3 4

15. My attendings give me verbal feedback when I ask them to complete an EPA assessment for me.

0 1 2 3 4 *I have never asked for an EPA assessment at this point

16. How many instances have you received verbal feedback about your performance/entrustability after direct observation with staff?

0 1-5 6-10 11-15 16-20 >20

17.Competence by design allows for my abilities to be assessed fairly

0 1 2 3 4

18.I am confident that the competence committee will have enough data to make an assessment of my progression over time **0 1 2 3 4**

19. What are potential benefits that you may attribute to competence by design? (*check applicable*)

- The evaluation is more objective

- I have a more active role in my learning
- I receive more feedback
- There are improved relations with attendings
- There is a clear assessment of my own performance
- Other

POTENTIAL SYSTEM BARRIERS/SOURCE OF STRESS

20. I encounter barriers when I try to get access to my portfolio

0 1 2 3 4

21. I am anxious about keeping up with my EPAs.

0 1 2 3 4

22. When an attending fills an EPA, what percentage of the time did you feel that they have directly observed your actions?

0 20 40 60 80 100

23. What are potential pitfalls that you may attribute to competence by design? (*check applicable*)

- Too time consuming
- It is too intimidating to ask the attendings
- The evaluation form does not represent my true competence
- I forget to initiate the forms
- The attendings do not complete the forms
- Other

GENERAL INFORMATION

24. How many residency EPA assessments have you received thus far in Neurosurgery rotations?

0 1-5 6-10 11-15 16-20 >20

25. How often do you request for a staff (attending physician or senior resident) to complete an EPA assessment for you?

More than once per day
Once per day
More than once per week, but not daily
Once per week
More than once per rotation, but not once per week
I have never requested an EPA assessment to this point in my training

26. Any final comments about your experience with competence by design so far?

_____

27. How many blocks of neurosurgery have you completed by the time of this survey?
_____

28. What are the rotations you have done in your training so far? (dropdown menu)
- Internal medicine
- Trauma surgery
- General surgery
- Neurology
- Critical care
- Neurosurgery
- Other

For future analysis in a second survey, the following question will be used to anonymously assess the changes in your perspective with CBD overtime.

29. What are the first three letters of your mother's first name? _____

Appendix 2. Second survey sent to neurosurgery residents at 7 months within CBD

This is a follow-up survey as part of a longitudinal study to assess the benefits and challenges related to competence by design in Neurosurgery. Thank-you for your participation in the previous survey. This follow-up survey should take between **5 to 7** minutes for you to complete and will provide valuable longitudinal data to continue to improve the competence by design process.

→ To what extent do you agree with the following?

0=Strongly disagree 1= Disagree 2= I don't know 3= Agree 4= Strongly Agree

LOGISTICS AND READINESS TO IMPLEMENTATION

1. My program director continues to provide guidance to implement competence by design in our program.

0 1 2 3 4

2. The head of our division or department is supportive of competence by design implementation in our program.

0 1 2 3 4

RESIDENT KNOWLEDGE OF COMPETENCE BY DESIGN

3. When our program began to use competence by design, I understood what competence by design was intended to achieve.

0 1 2 3 4

4. Now, I understand what competence by design is intended to achieve.

0 1 2 3 4

5. Compared to when competence by design initially began in our program, my CURRENT understanding of what competency by design is intended to achieve has increased.

0 1 2 3 4

6. I understand how an entrustment scale is used to assess my individual performance during one direct observation. **0 1 2 3 4**

7. I understand how an entrustment scale is used by the competence committee to assess my progression through the competence continuum. **0 1 2 3 4**

KEY STAKEHOLDERS KNOWLEDGE AND ATTITUDINAL FEATURES

→ The following questions pertain to **attending physicians** only.

8. Most attending physicians in our residency program are aware that we have implemented a competence by design assessment system. **0 1 2 3 4**

9. I believe my attendings understand the entrustment scale.
0 1 2 3 4

10. Most attending physicians in our residency program are willing to complete EPA assessments.
0 1 2 3 4

11. How many times has an attending physician agreed to complete an EPA for you?
_____

12. How many times has an attending physician agreed to complete an EPA and then not done it? (*the answer needs to be a number lower or equal as in question above*) _____

13. How many times has an attending physician refused to complete an EPA for you?
_____

14. My attendings give me verbal feedback when I ask them to complete an EPA assessment for me.
0 1 2 3 4 *I have never asked for an EPA assessment

15. How many instances have you received verbal feedback about your performance/entrustability after direct observation with attending physicians since the last 3 months?

0 1-5 6-10 11-15 16-20 >20

16. When an attending fills an EPA, what percentage of the time did you feel that they have directly observed your actions?
0 20 40 60 80 100

→ The following questions pertain to **senior residents** only.

17. I believe my senior residents understand the entrustment scale.
0 1 2 3 4

18. Most senior residents in our residency program are willing to complete EPA assessments.
0 1 2 3 4

19. How many times has a senior resident agreed to complete an EPA for you? _____

20. How many times has a senior resident agreed to complete an EPA and then not done it? (*the answer needs to be a number lower or equal as in question above*) _____

21. How many times has a senior resident refused to complete an EPA for you? _____

22 My senior residents give me verbal feedback when I ask them to complete an EPA assessment for me.

0 1 2 3 4 *I have never asked for an EPA assessment

23. How many instances have you received verbal feedback about your performance/entrustability after direct observation with senior residents since the last 3 months?

0 1-5 6-10 11-15 16-20 >20

24. When a senior resident fills an EPA, what percentage of the time did you feel that they have directly observed your actions?

0 20 40 60 80 100

25. What percentage of the time does a senior resident evaluate you with an EPA compare to an attending physician? _____

26. I noticed that EPA assessments provided by attending physicians may be different than the ones provided by senior residents.

0 1 2 3 4

IMPACT OF COMPETENCE BY DESIGN ON RESIDENTS

27. My portfolio provides me with sufficient information to gauge how I am progressing in my learning.

0 1 2 3 4

28. When our program began to use competence by design, I felt that my abilities would be assessed fairly. **0 1 2 3 4**

29. Now, I feel that competence by design allows for my abilities to be assessed fairly.

0 1 2 3 4

30. Compared to when our program began to use competence by design, my CURRENT feeling about my abilities being assessed fairly through competence by design has increased.

0 1 2 3 4

31. I am confident that the competence committee will have enough data to make an assessment of my progression over time **0 1 2 3 4**

32. What are potential benefits that you may attribute to competence by design? (*check applicable*)

- The evaluation is more objective
- I have a more active role in my learning
- I receive more feedback
- There are improved relations with attendings
- There is a clear assessment of my own performance
- Other

POTENTIAL SYSTEM BARRIERS/SOURCE OF STRESS

33. I encounter barriers when I try to get access to my portfolio
0 1 2 3 4

34. When our program began to use competence by design, I was anxious about keeping up with my EPAs.
0 1 2 3 4

35. Now, I am anxious about keeping up with my EPAs.
0 1 2 3 4

36. What are potential pitfalls that you may attribute to competence by design? (*check applicable*)

- Too time consuming
- It is too intimidating to ask the attendings
- The evaluation form does not represent my true competence
- I forget to initiate the forms
- The attendings do not complete the forms
- Other

GENERAL INFORMATION

37. How many residency EPA assessments have you received thus far in Neurosurgery rotations?
0 1-5 6-10 11-15 16-20 >20

38. How often do you request for a staff (attending physician or senior resident) to complete an EPA assessment for you?

More than once per day

Once per day
More than once per week, but not daily
Once per week
More than once per rotation, but not once per week
I have never requested an EPA assessment to this point in my training

39. Any final comments about your experience with competence by design so far?
_____

40. Compared to when your neurosurgery program first began to use competence by design, how has your overall opinion about it changed?

Much worse Worse Unchanged Improved Much improved

41. How many blocks of neurosurgery have you completed by the time of this survey?
_____

42. What are the rotations you have done in your training so far? (dropdown menu)

- Internal medicine
- Trauma surgery
- General surgery
- Neurology
- Critical care
- Neurosurgery
- Other

The following question will be used to anonymously link today's responses with your previous survey responses to understand changes in your perspective with CBD.

43. What are the first three letters of your mother's first name? _____

Appendix 3. Interview guide

Hi, I want to personally thank-you for taking the time to participate in this interview. I want to let you know that everything discussed here will be kept confidential and will be reviewed only by the study team, which is based in Boston. Therefore, you are more than welcome to speak freely or skip a question if you feel uncomfortable.

As you may already be aware, Competence by Design training has been introduced in all Neurosurgery residency programs in Canada. However, to date, there has not been any formal assessments on how Competence by Design, has impacted residents in terms of their experiences with the training approach. Being among the first cohort of neurosurgical residents to be evaluated with Competence by Design, your responses will be invaluable. My primary goal with this interview is to better understand the potential impacts that Competence by Design have had on you. The questions of this interview are somewhat related to the answers obtained from the survey you previously recently completed. The themes obtained from the interviews conducted for this project will be utilized to generate recommendations for improving the Competence by Design process.

1. In your own words, how would you describe Competence by Design training?

   Probes: -What do you see as its purpose?
   -How does it feel day-to-day to be in such system?
   -What role do you think you play as a resident in competence by design?

2. What does a high score on an Entrustable Professional Activity (EPA) assessment mean to you? What about a low score?

3. What impact does an EPA score have on you?

4. What do you like about Competence by Design?

5. What do you not like about Competence by Design?

   Probes: -Do you find it time consuming?
   -What is time consuming about it?
   -Is there anything stressful or anxiety provoking about the process?
   -In what way?

6. Has your perspective on Competence by Design changed over time?

   Probes: -How has it changed?
   -Why has it changed?

7. How do you decide on which cases to ask for an EPA assessment from your staff or senior resident?

Probes: -What factors make a specific case favorable for you to ask for an EPA assessment?
- What factors deter you from asking for an EPA assessment?

8. In the past few months, can you remember a specific occasion when you asked for an EPA assessment form and it was a positive learning experience. Can you describe it for me?

9. In the past few months, can you remember a specific occasion when you asked for an EPA assessment form and it was a negative learning experience. Can you describe it for me?

10. Have you seen any changes in the quantity and quality of feedback that you receive when having an EPA assessment form completed?

    Probes: -What forms of feedbacks do you prefer? e.g. written, verbal, formal, informal etc.
    -Who do you ask the most to give you feedback? Attendings? Fellows? Chief residents?
    -How do you feel when you receive feedback?

11. Can you describe a situation where you got feedback and it went well? What about one situation where it didn't go well?

    Probes: -Why did it go well or not well?
    -Can you elaborate on the feedback content and the overall encounter?

12. How much time do you spend doing tasks related to Competence by Design?

    Probes: -Does that amount of time seem reasonable to you?
    -Do you find the tasks to complete for CBD overwhelming?

13. If there was anything you could change or improve related to your learning perspective in the Competence by Design process, what would that be?

    Probes: -Given that you said XYZ, is there anything you would want to change about the feedback received?
    -What about the app to get access to your portfolio?
    -What about the whole process for neurosurgery specifically?

Again, thank you for your time. It was a pleasure meeting you and having the opportunity to have this encounter.

Appendix 4. Codebook for qualitative analysis

Child node	Definition	Quote
PARENT NODE 1: EXPERIENCE WITH CBD (Competence by Design is the overall reform in the evaluation of residents)		
1. Checking boxes	Residents describe the process of CBD as if it was like checking boxes or a checklist to assure things are getting done.	*"I do like that it's a way to, you know, check things off, but with a surgical log, I feel like I'm already checking things off."*
2. Resident-driven role and responsibility	Residents describe CBD where they feel very autonomous in their learning progression with the responsibility depending on them to move forward.	*"Just relying on others to pass on that knowledge, it's by definition passive approach whereas CBD gives you a lot of autonomy to say, "I feel that I could benefit from more focus in this area"."*
3. Acknowledgement of minor pitfalls and negative components	Residents describe some pitfalls or negative components of CBD that they have experienced so far.	*"It doesn't bother me all that much like I will get it done. But it's there, it's there. It's just another thing."*
4. Public accountability and trust	Residents describe their perspective that CBD will allow to train competent neurosurgeons for the public and patients to rely on.	*"[…] you are competent in all the domains rather than very strong in some and weak in others rather and feel that it is how you average out a competent neurosurgeon in the end"*
5. Individualized training progression	Residents describe CBD as a progression in their learning of knowledge and skills. This progression is described as continuous over the years of training.	*"It's essentially an opportunity to progress through the linear training at a rate, you know, that is individualized to you."*
6. Time impacting residents' perspective	Residents express their perspective towards the process after being involved with it for several months.	*"But now I think being 6 months into the program and seeing how approachable our staff are and how hard our program director is working on making sure this is meaningful to us as well."*

PARENT NODE 2: PERSPECTIVE ON EPAS (Entrustable Professional Activities are tasks within a discipline)		
1. Planning is needed	Residents describe the necessity of planning to meet the requirements of EPAs and that it takes time. They do so by using log system, Excel documentation or computer/phone app.	*"I have spent some nights like putting things into Excel documents to make sure I've got all of my EPAs."*
2. Importance of self-assessment	Residents describe self-assessing their performance related to an EPA before asking faculty for an assessment form.	*"If I felt I asked for suturing skin and I didn't do a great job suturing skin, that would be a great time to ask, "how would you have done things differently", but I don't know if I would ask for an EPA."*
3. EPA completion	Residents describe obtaining or not the completion of EPAs based on rotations, opportunities that arise during that rotation.	*"Sometimes, there will be an opportunity for something that was unexpected and oh that's actually a good EPA"*
4. Faculty feedback changed by EPA formal request	Residents describe that asking an EPA assessment is an opportunity for detailed feedback coming from faculty or chief residents.	*"They will describe the circumstances in which the task was perform, they will provide very meaningful feedback and where appropriate, they will offer opportunity or reminder for the next time or they will acknowledge something that was done well"*
5. Score expectations and effect	Residents describe the expectations as well as the effect that a high or low EPA score has on them.	*"I mean at this stage I expect all the scores to be very low unless it is something that like I am confident that I am doing, that I should be doing by myself like a lumbar drain or like I should be able to get EVDs now for example"*
6. Assessment limitations	Residents describe EPA assessment limitations including technology with the app, scope of EPA, and events that deter them from having an assessment.	*"Yeah, it works for sending EPAs, it's not great for reviewing EPAs. That I go online and check onto my one45 account."*
PARENT NODE 3: OVERALL FEEDBACK EXPERIENCE		
1. Feedback improving learning progression	This describes how residents utilize feedback given to them to improve on their learning progression.	*"I know where I can improve, and I am hoping for guidance on those pieces specifically and if there are some other aspects that I haven't caught on to and I can improve in I am more than happy to receive feedback on that item."*

2. Characteristics related to feedback	Residents describe the characteristics related to the feedback they usually receive on neurosurgery.	*"I think the feedback that is actually documented in the EPAs, it feels like it's actually complete. It's not like "oh, you did a good job"."*
PARENT NODE 4: STAKEHOLDERS ENGAGEMENT AND IMPACT		
1. Residents' EPAs within workflow	Residents describe their daily workflow related to CBD process or the request of EPAs and assessments.	*"So, I mean I don't think about it on a day-to-day basis."*
2. Impact of evaluator variability	Residents describe the ease or the difficulty in obtaining completed EPA forms from faculty and residents depending on willingness, attitude, and knowledge about CBD.	*"Like the staff have been kind of 50/50 on doing them for me. Mainly because we had one presentation at the beginning of the year and then everyone kind of forgets until I remind them."*
3. Impact of program variability	Residents elaborate on the differences of CBD in their program compared to others.	*"I think just being in a smaller program, we don't always have that junior-senior partnership in a lot of the procedures so in a lot of circumstances it would be the staff. It's a great opportunity that way"*

Appendix 5. List of EPAs from the Royal College of Physicians and Surgeons of Canada

Transition to Discipline

1. Performing and reporting the history and physical exam for patients with a neurosurgical presentation
   - The focus of this EPA is the application of the clinical skills acquired in medical school in the new setting of Neurosurgery residency.
   - This EPA includes performing a complete history and both general and neurological examinations, documenting these findings and presenting the case to a supervisor.
   - It does not include determining the site of a lesion, nor developing plans for investigation or management.

Foundations:

1. Assessing patients with a neurosurgical presentation
   - This EPA focuses on performing a complete clinical assessment including history, physical exam and interpretation/ordering of investigations to complete the assessment and/or in preparation for surgery.
   - This may include further imaging as well as laboratory or electrodiagnostic investigations, as appropriate.,
   - It includes determining the anatomic localization of a lesion and formulating an appropriate diagnosis
   - It does not include decision making regarding surgical candidacy or other management
   - The EPA may be observed in any common neurosurgical conditions

2. Providing initial management for patients with a cranial emergency
   - This EPA focuses on clinical assessment and management including indications for imaging, appropriate timing of escalation of care, acuity of intervention or monitoring, and provision of specific initial treatment such as medical therapy and management of increased cranial pressure. This also includes appropriate disposition of the patient
   - This does not include definitive management, such as decisions for surgical or other intervention
   - Patient presentations relevant to this EPA include traumatic head injury, raised intracranial pressure, intracerebral hemorrhage and subarachnoid hemorrhage

3. Providing initial management for patients with a spinal emergency
   - This EPA focuses on clinical assessment and initial management. This includes performing a relevant history and physical exam, ordering and prioritizing investigations, recognizing urgent presentations on imaging, recognizing patients with an unstable injury, making decisions about patient disposition (ICU, other), identifying patients with indications for surgery and mitigating secondary injury.
   - This does not include definitive management of the spinal emergency
   - Patient presentations include traumatic spine injury, cauda equina syndrome or cord compression of any cause.

4. Managing complications of neurosurgical conditions for hospitalized patients, including post-operative complications
   - This EPA focuses on common complications in patients on the neurosurgical ward. This includes patients admitted for observation or medical management as well as patients in the post-operative phase of their care
   - This includes complications such as electrolyte imbalance (SIADH, DI, etc.), neurological deterioration (e.g. seizure, focal deficit), meningitis, brain abscess, CSF leak, wound complications as well as post-operative bleeding, hematomas or infections.
   - This EPA includes patient assessment, selection and interpretation of investigations and initial treatment.
   - This EPA should be observed in cases of moderate or high complexity. Low complexity cases are not sufficient for the observation of this EPA

5. Assessing patients with common neurologic conditions
   - This EPA focuses on differentiating the site and cause of the neurologic lesion through the performance of

the clinical assessment and interpretation of investigations
- This EPA may be observed in any type of patient assessment (e.g. consult, follow-up) and in any clinical setting (i.e. ambulatory clinic, emergency room, hospitalized patients, EMG lab)
- This may include patients with a range of known neurologic conditions as well as patients with undifferentiated presentations of neurologic disease

6. Providing initial management for patients with an acute stroke
   - This EPA focuses on the rapid assessment, triage and initial management of patients with an acute stroke
   - This includes effective and efficient facilitation of access to imaging, coordination of the acute stroke team and assessment of suitability to receive active intervention (i.e. thrombolytic therapy or endovascular intervention)

7. Inserting CSF drains and ICP monitors
   - This EPA focuses on the safe and effective, placement of an external ventricular drain/intracranial pressure monitor, and performance of a lumbar puncture/placement of lumbar drain
   - This includes assessing the need and urgency of the procedure, obtaining consent, preparing necessary equipment, preparing the patient, performing the procedure, documenting the procedure and providing appropriate post-procedural orders.
   - The observation of this EPA is divided into two parts: direct observation of specific surgical skills within a procedure; a log of procedures to demonstrate the breadth of experience

8. Applying external spinal fixation and/or traction
   - This includes assessing the need and urgency of performing the application of halo ring/tongs, obtaining consent, preparing necessary equipment and performing the procedure
   - This EPA may be observed in patients with any indication for spinal stabilization and any technique of spinal traction
   - The observation of this EPA is divided into two parts: direct observation of specific surgical skills within a procedure; a log of procedures to demonstrate the breadth of experience

9. Performing burrhole drainage of a chronic subdural hematoma
   - This EPA includes all aspects of the performance of this procedure, from start to finish, including selection of operative site.
   - The observation of this EPA is divided into two parts: direct observation of specific surgical skills within a procedure; a log of procedures to demonstrate the breadth of experience

10. Performing the technical skills of a supratentorial craniotomy
    - This EPA includes opening and closing the scalp and temporalis muscle (as appropriate), creating and connecting burrholes (adequate handling of perforator and craniotome), and creating a dural opening and closure
    - This EPA does not include making the decision to perform the procedure or creating the plan for the procedure
    - The observation of this EPA is divided into two parts: direct observation of specific surgical skills within a procedure; a log of procedures to demonstrate the breadth of experience

11. Performing midline posterior subaxial spinal column exposure and closure
    - This EPA may be observed during a procedure at any level of the spinal column and consists of exposure of the dorsal spine up to the lamina while preserving the facets and minimizing soft tissue disruption, and appropriate closure of the fascial layer
    - The observation of this EPA is divided into two parts: direct observation of specific surgical skills within a procedure; a log of procedures to demonstrate the breadth of experience

Core:

General

1. Managing the neurosurgery service
   - This EPA focuses on the effective management of the team of junior learners (residents and/or students) providing care for an inpatient service as well as related administrative tasks
   - This also includes working effectively with the other health care professionals on the ward as well as other services (e.g. critical care, consulting physicians)

2. Providing definitive management for patients with a cranial emergency
   - This EPA builds on the skills of Foundations to add the skills of interpreting investigations, making the decision regarding for intervention and selecting the appropriate intervention as well as communicating with the family regarding the diagnosis, prognosis, plan and informed consent, as appropriate. This may also include consultation with other services and prioritization/triage of patient management
   - Patient presentations relevant to this EPA include traumatic head injury, raised intracranial pressure of any etiology, intracerebral hemorrhage and subarachnoid hemorrhage

3. Providing definitive management for patients with complications of neurosurgical conditions
   - This EPA builds on the skills of Foundations to add the skills of making the decision regarding the need and urgency of intervention, and selection of the appropriate intervention as well as communicating with the family regarding the diagnosis, prognosis, plan and informed consent, as appropriate. This may also include consultation with other services
   - This EPA focuses on common complications in patients on the neurosurgical ward. This includes patients admitted for observation or medical management as well as patients in the post-operative phase of their care
   - This includes complications such as neurological deterioration (seizure, focal deficit) meningitis, brain abscess, CSF leak, wound complications as well as post-operative bleeding, hematomas or infections.

4. Leading discussions with patients and/or their families in emotionally charged situations
   - This EPA focuses on the application of communication and conflict resolution skills to address difficult situations
   - This EPA may be observed in any scenario that is emotionally charged. Examples include breaking bad news; disclosing an adverse event; dealing with a patient complaint

5. Providing neurosurgical consultation for patients with a CNS infection
   - This EPA focuses on the clinical assessment and management, including selection of appropriate antibiotics, consultation with other services as required (infectious disease, radiology) and decision regarding surgical management as appropriate, including timing or urgency

6. Providing neurosurgical consultation for patients with a CSF related disorder
   - This EPA focuses on decision making regarding suitability for surgical intervention
     This EPA includes patients with hydrocephalus (obstructive, communicating, normal pressure hydrocephalus), Chiari malformations, syrinx, arachnoid cyst and shunt related problems

7. Discussing and documenting informed consent for neurosurgical procedures
   - This EPA includes effective communication with the patient and family in the discussion of consent for a surgical procedure
   - This EPA may be observed in the clinical or simulation setting

8. Performing common craniotomies
   - This EPA refers to performing the setup, positioning, skin incision/closure, bone work, and dural opening and closure
   - This EPA focuses on convexity, pterional and posterior fossa craniotomies
   - This EPA may be observed in craniotomies performed for any indication
   - The observation of this EPA is divided into two parts: direct observation of specific surgical skills within a procedure; a log of procedures to demonstrate the breadth of experience

9. Providing surgical management for patients with a head injury
   - This EPA focuses on performing the procedures of decompressive craniotomy and repair of a skull fracture
   - The observation of this EPA is divided into two parts: direct observation of specific surgical skills within a procedure; a log of procedures to demonstrate the breadth of experience

10. Providing surgical management for patients with a CSF related disorder
    - This EPA includes procedures related to shunts (ventriculoperitoneal (VP); ventriculopleural, ventriculoatrial (VA), lumboperitoneal), posterior fossa decompression for Chiari, endoscopic third ventriculostomy and arachnoid cyst fenestration
    - This EPA may include pediatric cases
    - The observation of this EPA is divided into two parts: direct observation of specific surgical skills within a procedure; a log of procedures to demonstrate the breadth of experience

11. Documenting operative procedures (JC)
    - This EPA focuses on the application of communication skills in the preparation of an operative report
    - This includes a synthesis of the procedure and pertinent clinical findings
    - The documents submitted for review must be the sole work of the resident

12. Developing and executing scholarly projects
    - This EPA includes using appropriate methods, analyzing results, critically reflecting on the findings and disseminating results in some format. It may include obtaining grant funding and preparing a manuscript for publication.
    - This may include basic or clinical science related to neurosurgery or neurosciences, or medical education research
    - The achievement of this EPA may be observed via submission of a manuscript suitable for submission to a peer reviewed journal, or presentation of the project at a peer-reviewed local, regional, provincial or national scientific meeting

13. Contributing to quality improvement and educational initiatives
    - The observation of this EPA is divided into two parts
    - The quality improvement aspect focuses on the review of a case or series of cases, with an analysis of the quality of care provided and identification of factors that may lead to improved quality of care. This may be a resident presentation at Morbidity and Mortality rounds, a report, an abstract or other form of submission
    - The teaching aspect focuses on clear, accurate information delivery targeted to the audiences' needs. This may be observed in any formal teaching activity (e.g. grand rounds)

Functional

14. Assessing patients' candidacy for advanced functional procedures
    - This EPA focuses on establishment of a management plan which may include observation, medical therapy or referral for surgical intervention. This includes clinical assessment, interpretation of relevant investigations and the development and communication of a management plan.
    - Patient presentations may include movement disorders (e.g. Parkinson's disease, tremor and dystonia), epilepsy and pain and/or spasticity.

15. Providing neurosurgical consultation for patients with trigeminal neuralgia and other neurovascular compression syndromes
    - This EPA focuses on establishing a management plan which may include observation, medical therapy or surgical intervention. This includes clinical assessment, interpretation of relevant investigations and the development and communication of a management plan with the patient.

16. Performing a stereotactic procedure
    - Applying the safe principles of stereotaxy (avoidance of vessels, sulci, ventricles etc.), basic knowledge of DBS planning (locating AC/PC etc.) frame based and frameless stereotaxy principles
    - The observation of this EPA is divided into two parts: direct observation of specific surgical skills within a procedure; a log of procedures to demonstrate the breadth of experience

17. Performing surgical management of trigeminal neuralgia and other neurovascular compression syndromes
    - This EPA includes performing microvascular decompression or percutaneous rhizotomy for the management of neurovascular compression syndromes
    - The observation of this EPA is divided into two parts: direct observation of specific surgical skills within a procedure; a log of procedures to demonstrate the breadth of experience

Peripheral

18. Providing neurosurgical consultation for patients with disorders of the peripheral nervous system
    - This EPA focuses on patient assessment, interpretation of relevant investigations, including electrodiagnostics, and determination of suitability for surgical intervention
    - This EPA may be observed in clinic or on the inpatient service

19. Performing peripheral nerve decompression procedures (JC)
    - This EPA focuses on routine carpal tunnel and ulnar decompression procedures.
    - This EPA includes appropriate landmarking for the incision, identification of the nerve, complete release, avoidance of complications (anatomical variations, recurrent branch), closure of the incision and provision of discharge instructions
    - The observation of this EPA is divided into two parts: direct observation of specific surgical skills within a procedure; a log of procedures to demonstrate the breadth of experience

20. Performing sural nerve and/or muscle biopsy (JC)
    - This EPA includes landmarking for the incision, identifying the nerve, performing a biopsy appropriately, and avoiding complications
    - The observation of this EPA is divided into two parts: direct observation of specific surgical skills within a procedure; a log of procedures to demonstrate the breadth of experience

21. Perform resection of common peripheral nerve tumor (SC)
    - This EPA includes exposure of the nerve (including normal nerve above and below), effective use of the nerve stimulator, full (360 degrees) exposure of tumor, identification of normal fascicles, intracapsular resection, avoidance of complications and recognition of variant pathologies (MPNST, neurofibroma, perineuroma)
    - This EPA may be observed in a patient with spinal nerve root tumour or any other peripheral nerve tumour
    - The observation of this EPA is divided into two parts: direct observation of specific surgical skills within a procedure; a log of procedures to demonstrate the breadth of experience

Spinal

22. Providing neurosurgical consultation for patients with non-urgent spinal conditions
    - This EPA include patients with degenerative spinal conditions, neoplastic spinal conditions (both intradural and extradural), and congenital and deformity conditions.
    - This EPA focuses on patient assessment, interpretation of relevant investigations, assessment of spinal stability, determination of suitability for surgical intervention and appropriate selection and timing of intervention.
    - This EPA may be observed in the clinic, emergency department or an inpatient unit.
    -

23. Providing definitive management for patients with spinal emergencies
    - This EPA builds on the competencies achieved in Foundations in the initial assessment and management of patients with spinal emergencies.
    - This EPA focuses on the decision making regarding surgical intervention, and includes an assessment of spinal stability, risk and surgical candidacy, and the appropriate selection and timing of intervention.
    - This also includes communication with the family regarding diagnosis, prognosis, plan and informed consent as well as consultation with other services and prioritization/triage of patient management
    - Patient presentations relevant to this EPA include traumatic spine injury, cauda equine syndrome or cord compression of any cause

24. Performing lumbar laminectomy (JC)
    - This EPA focuses on the performance of a primary lumbosacral laminectomy and decompression of the neural elements.
    - This includes proper patient positioning, level confirmation, and removal of the lamina while preserving uninvolved ligaments and dural integrity. It includes midline and lateral recess decompression.
    - The observation of this EPA is divided into two parts: direct observation of specific surgical skills within a procedure; a log of procedures to demonstrate the breadth of experience

25. Exposing the anterior cervical spine (JC)
    - This EPA focuses on the performance of anterior sub-axial cervical spine exposure.
    - This includes patient positioning, identifying the correct level and applying knowledge of the anatomy of the anterior neck structures to achieve appropriate exposure for subsequent decompression and fusion.
    - This EPA does not include cervical discectomy, or instrumented fusion
    - The observation of this EPA is divided into two parts: direct observation of specific surgical skills within a procedure; a log of procedures to demonstrate the breadth of experience

26. Performing lumbar microdiscectomy (SC)
    - This EPA focuses on the performance of a lumbar microdiscectomy, with appropriate use of the microscope with regard to position, zoom, focus and interaction with the assistant.
    - This includes appropriate patient positioning, correct level identification and performance of the laminotomy, nerve root mobilization and disc removal.
    - This EPA does not include endoscopic or percutaneous techniques
    - The observation of this EPA is divided into two parts: direct observation of specific surgical skills within a procedure; a log of procedures to demonstrate the breadth of experience

27. Performing posterior cervical or thoracic decompression (SC)
    - This EPA focuses on the performance of a cervical or thoracic laminectomy and decompression of the neural elements.
    - This includes proper patient positioning, level confirmation, and removal of the lamina while preserving uninvolved ligaments and respecting the spinal cord. This also includes wider postero-lateral thoracic decompression for anterior pathology, which involves resection of the facet joints and pedicle.
    - This EPA does not include instrumented fusion
    - The observation of this EPA is divided into two parts: direct observation of specific surgical skills within a procedure; a log of procedures to demonstrate the breadth of experience

28. Performing anterior decompression – cervical (SC)
    - This EPA focuses on the performance of an anterior cervical decompression with a discectomy or vertebrectomy.
    - This EPA does not include instrumented fusion
    - The observation of this EPA is divided into two parts: direct observation of specific surgical skills within a procedure; a log of procedures to demonstrate the breadth of experience

29. Performing procedures utilizing spinal instrumentation including posterior subaxial; posterior thoraco-lumbar; occipito-cervical; anterior cervical (SC)
    - This EPA focuses on spinal instrumentation and fusion and includes -Instrumentation of the spine at the following level: occipito-cervical, anterior and posterior cervical, posterior thoracic and lumbar, as well as lumbar interbody instrumentation
    - The observation of this EPA is divided into two parts: direct observation of specific surgical skills within a procedure; a log of procedures to demonstrate the breadth of experience

30. Providing surgical management of intradural lesions – tumours; dural AVF (SC)
    - This EPA focuses on surgical management of intra-dural spinal pathologies.
    - This includes all required steps to address intra-dural pathologies including intra-medullary lesions.
    - The observation of this EPA is divided into two parts: direct observation of specific surgical skills within a procedure; a log of procedures to demonstrate the breadth of experience

Vascular:

31. Providing neurosurgical consultation for patients with non-urgent cranial and spinal vascular conditions
    - This EPA focuses on patient assessment, interpretation of relevant investigations, natural history, determination of suitability for surgical intervention and risk optimization for the surgical or endovascular procedure
    - This includes plans for ongoing monitoring of patients that are not (or not yet) surgical candidates.
    - This EPA may be observed in the ambulatory clinic, emergency department or inpatient ward

32. Providing neurosurgical consultation for patients with urgent cranial and spinal vascular conditions
    - This EPA builds on the competencies achieved in Foundations in the initial assessment and management of patients with cranial and spinal emergencies.
    - This EPA focuses on the decision making regarding surgical and endovascular interventions, and includes an assessment of risk and surgical candidacy, the appropriate selection and timing of intervention and management of complications.

33. Performing carotid endarterectomy
    - This EPA focuses on the technical performance of cranial vascular neurosurgical procedures. This includes patient positioning, selection of operating instruments, neuromonitoring where appropriate, anesthetic considerations and intraoperative imaging
    - The observation of this EPA is divided into two parts: direct observation of specific surgical skills within a procedure; a log of procedures to demonstrate the breadth of experience

34. Performing surgery for patients with an intracranial aneurysm
    - This EPA focuses on the clipping of a simple aneurysm
    - The observation of this EPA is divided into two parts: direct observation of specific surgical skills within a procedure; a log of procedures to demonstrate the breadth of experience

35. Performing surgery for patients with spontaneous intracerebral hemorrhage with or without an underlying vascular malformation
    - This EPA focuses on the technical performance of the evacuation of an intracerebral hematoma with or without definitive management of the source of bleeding. This includes patient positioning, selection of operating instruments, neuromonitoring where appropriate, anesthetic considerations and intraoperative imaging
    - The observation of this EPA is divided into two parts: direct observation of specific surgical skills within a procedure; a log of procedures to demonstrate the breadth of experience

Oncology:

36. Providing neurosurgical consultation for patients with simple brain tumours (JC)
    - This EPA includes taking a focused history and performing a physical examination, arranging and interpreting appropriate imaging (including staging as appropriate), developing a differential diagnosis and formulating a management plan as well as engaging the interprofessional oncology team and communicating the pertinent information to the patient
    - This EPA includes common intra-axial primary and secondary malignancies, convexity extra-axial tumours and pituitary adenomas

37. Providing neurosurgical consultation for patients with complex brain tumours (SC)
    - This EPA includes taking a focused history and performing a physical examination, arranging and interpreting appropriate imaging (including staging as appropriate), developing a differential diagnosis and formulating a management plan as well as engaging the interprofessional oncology team and communicating the pertinent information to the patient
    - This EPA includes skull base lesions, intraventricular tumours, lesions in the pineal region, acoustic neuromas and primary intra-axial tumours in eloquent brain

38. Performing surgery for patients with simple intra-axial brain tumours (JC)

Key features:

- The EPA focuses on planning, positioning, appropriate utilization of surgical adjuncts (navigation), and the surgical procedure
- This EPA includes supratentorial and infratentorial non-eloquent intra-axial tumours as well as convexity extra-axial tumours (e.g. meningioma)
- The observation of this EPA is divided into two parts: direct observation of specific surgical skills within a procedure; a log of procedures to demonstrate the breadth of experience

39. Performing surgery for patients with complex brain tumours (SC)
    - The EPA focuses on planning, positioning, appropriate utilization of surgical adjuncts (navigation), and the surgical procedure
    - This EPA include patients with complex meningioma (e.g. involving venous sinus or sphenoid wing) or skull base tumour, primary posterior fossa tumour or eloquent intraaxial brain tumour
    - The observation of this EPA is divided into two parts: direct observation of specific surgical skills within a procedure; a log of procedures to demonstrate the breadth of experience

40. Performing surgery for patients with pituitary tumours (SC)
    - The EPA focuses on planning, positioning, appropriate utilization of surgical adjunctions (navigation), and performing the surgical procedure
    - This EPA includes the trans-nasal approach to the sella (may be microscopic or endoscopic)
    - This EPA does not include craniotomies for sellar pathology
    - The observation of this EPA is divided into two parts: direct observation of specific surgical skills within a procedure; a log of procedures to demonstrate the breadth of experience

Pediatrics:

41. Assessing and providing initial management for pediatric patients with a neurosurgical emergency
    - This EPA includes traumatic cranial or spinal injury as well as other emergencies
    - This EPA focuses on assessing the urgency of the presentation, initiating further investigations and management to stabilize the patient and identifying patients that require surgical intervention

42. Assessing pediatric patients being considered for neurosurgical intervention
    - This EPA focuses on performing an age appropriate neurosurgical consultation and discussing surgical options.
    - This EPA may be observed with any presentation, and in any clinical setting
    - This includes a range of diagnoses: hydrocephalus, craniosynostosis, congenital malformations and

tumour.

43. Managing the care of hospitalized pediatric patients
    - This EPA includes all aspects of care for hospitalized neurosurgical patients, including progressing the care plan, discharge planning and communication with family.

44. Performing CSF shunt procedures in pediatric patients
    - This EPA may be observed in an initial procedure or a revision
    - The observation of this EPA is divided into two parts: direct observation of specific surgical skills within a procedure; a log of procedures to demonstrate the breadth of experience

45. Performing a craniotomy in an infant/toddler
    - The observation of this EPA is divided into two parts: direct observation of specific surgical skills within a procedure; a log of procedures to demonstrate the breadth of experience

46. Performing spine procedures in pediatric patients
    - The observation of this EPA is divided into two parts: direct observation of specific surgical skills within a procedure; a log of procedures to demonstrate the breadth of experience

Transition to Practice

1. Managing an out-patient clinic
    - This EPA focuses on the overall performance in an ambulatory setting rather than care of individual patient conditions. This includes:
        - Managing schedule with appropriate number and variety of patients (new patients and follow up patients; spots left open for emergency consults)
        - Wait list management
        - Time management in office setting
        - Completing dictations in timely manner
        - Reviewing test results/acting on results appropriately and in timely manner
        - Working effectively with the staff and/or other learners in the clinic

2. Coordinating, organizing and executing the surgical day of Core procedures
    - This EPA integrates the resident's surgical abilities for individual cases with their abilities to function effectively as a surgeon; managing a case load, prioritizing, supervising junior learners and working effectively with other health professionals
    - The observation of this EPA is divided into two parts: surgical competence and working effectively with the interprofessional team

3. Contributing surgical expertise to interprofessional neurosurgery teams
    - This EPA focuses on shared decision making with other health care professionals, working effectively as a member of an interprofessional team. Examples include tumour board, endovascular team or epilepsy team.
    - This EPA includes contributing surgical expertise to the team discussion, advocating for the patient and demonstrating professional behaviour

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