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Research Article

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Radiology Residents' Reporting Volumes and Outcomes on Standardized Testing

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Abstract

Purpose: Preparation for in-training and licensing examinations is a key component of radiology residency, with potential long-term career impacts. While case volume is often emphasized in training, its relationship with examination outcomes remains unclear. This study aimed to determine whether the quantity of reported cases during residency relates to performance on the American College of Radiology Diagnostic Radiology In-Training (ACR DXIT) examination and Objective Structured Clinical Examination (OSCE) in post-graduate year 4 (PGY-4) or post-graduate year 5 (PGY-5).

Methods: A retrospective analysis was conducted using data from 17 radiology residents who graduated from a Canadian institution between July 2014 and July 2024. Total reporting volumes over five years of residency were obtained via mPower Clinical Analytics for Power Scribe 360. ACR DXIT percentile scores and OSCE percentages in PGY-4 and PGY-5 were collected. Statistical analyses were performed in R to assess correlations and regression patterns.

Results: No statistically significant correlations were found in either year between total reporting volumes and ACR DXIT or OSCE scores (all p-values > 0.05). Weak trends were observed but did not reach statistical significance. Similarly, non-linear models showed no significant associations.

Conclusions: Contrary to prior studies, these findings suggest no clear relationship between radiology residents' reporting volumes and examination performance. All residents reported a relatively high volume of studies, which may have contributed to a ceiling effect. These results underscore the need for further research regarding factors influencing examination outcomes. Broader investigations into other educational variables and studying factors may help inform best practices in radiology education.

Keywords

Radiology, Diagnostic, Examination, Residency

Introduction

Upon completion of medical school, medical graduates are matched to a residency program to train to become specialists in their desired field for two to five years, or possibly longer. In Canada, diagnostic radiology residents are normally administered the written ACR DXIT examination annually and typically partake in in-house oral OSCEs at least annually, to prepare residents to succeed at their final Canadian licensing examination [1, 2]. OSCEs are widely used station-based assessments designed to evaluate practical radiology skills, including image interpretation and clinical reasoning [3]. They are standardized examinations with sufficient reliability for use in the objective assessment of resi-

dent competency in almost all fields of Canadian post-graduate medical training [4]. At the present study's institution, residents rotate through nine 14 min stations; each is scored with structured checklists and rating scales by trained examiners, which mirrors the format of the Royal College Examination in Diagnostic Radiology [5]. Station scores are combined and averaged to generate a total performance score, with the pass mark set at or above 70% correct [5]. Licensing upon completion of residency requires passing both the written and applied portions of the Royal College of Physicians and Surgeons of Canada (RCPSC) Examination in Diagnostic Radiology [5].

There is currently evidence to support a positive relationship between ACR DXIT examination scores and RCPSC examination outcomes. In a Canadian retrospective study by Orton and McInnes [6], ACR examination scores of 67 radiology residents at the University of Ottawa were compared with their RCPSC examination outcomes. It was determined that there was a moderate positive correlation between scores on these two examinations, highlighting how performance on evaluations during training is indicative of one's likelihood to pass their final licensing examination. As mentioned previously, the authors emphasized the importance of ACR examination scores in allowing program directors to identify residents who are at risk of failing their RCPSC examination early [6]. However, the factors contributing to poor outcomes on both examinations have not been solidified in the literature on these groups of trainees. An American retrospective study by Baumgartner and Peterman [7] produced similar results, finding that residents who scored highly on the written component of the American Board of Radiology (ABR) Core examination (written in a resident's third year of study as part of the ABR certifying examination for full licensure) had significantly higher scores on ACR in-training examinations compared to those with lower scores.

The existing literature also provides insight into the various factors that impact radiology residents' in-training examination scores. In a study by Adusumilli et al. [8] including 81 radiology residents, subjective rotation evaluations by program faculty members on both overall performance and general knowledge were positively correlated with their yearly ACR in-training examination scores. Further, a positive correlation was also reported between favorable evaluations and higher ABR Core written examination scores [8]. Similarly, a pilot study by Kwan et al. [9] investigated the impact of residents' case volumes on their relative knowledge (determined by a relative knowledge ranking) and their ACR DXIT percentile score. This study determined that higher case volumes were significantly associated with higher relative knowledge rankings, and higher relative knowledge rankings were also significantly associated with higher ACR DXIT percentile scores [9]. A retrospective cohort study by Agarwal et al. [10] also examined how case volume relates to clinical performance via major discordance rate of findings as compared to staff final reports, in which a non-linear correlation was observed. An upper threshold of approximately 16,000 interpreted cases across residency appeared to serve as the positive correlation limit with statistical significance; past this number of reported cases, a significant negative correlation was found [10].

More specifically pertaining to this study's objective, a retrospective study by Poyiadji et al. [11] collected data from 52 radiology residents from a single institution on their cumulative case volume and their in-training examination scores. It was determined that case volume, as well as the total number of subspecialty rotations, was positively correlated with DXIT examination scores for neurological and breast imaging only [11]. Interestingly, all other subspecialty case volumes were not shown to have a significant relationship to DXIT examination scores [11].

Finally, the most prominent study on the topic of case volumes and resident licensing examination performance is one by Nickerson et al. [12]. A curvilinear relationship was found up to a threshold of approximately 11,000 cases before becoming negative, which mimics the previously cited study by Agarwal et al. [10] for clinical performance evaluations [10, 12]. This study has therefore posited that a higher volume of reported cases (to a limit) does improve ABR Core examination outcomes, and therefore one's likelihood of becoming eligible to write their ABR certifying examination [12].

It is difficult to identify a set paradigm that concretely defines how best to prepare for both in-training and licensing residency examinations. However, a position statement released in 2003 on behalf of the Association of Program Directors in Radiology (APDR) in the United States suggested that protected time away from clinical case reporting duties to study would be counterproductive for ABR Core examination success [13]. Recently, the Accreditation Council for Graduate Medical Education (ACGME) acknowledged that some protected study time is beneficial for resident wellbeing, but that any prolonged time away (exceeding three months or impacting radiology residency education) should be prohibited [14]. Without a successful ABR in-training core examination, a resident would be unable to obtain certification to practice; this further reinforces the aforementioned literature regarding success on in-training examinations predicting licensing examination outcomes.

In-training and licensing examinations are a major component of a radiology residency program, and outcomes on these examinations can change the trajectory of one's entire career. Yet, there are considerable limitations in the literature surrounding reporting volume and the potential impact of this on a resident's examination success. The objective of this review was to identify if reporting volumes by residents (as logged clinical duties, and therefore indirect examination preparation) has any impact on either ACR DXIT examination scores, in-house OSCE scores, or both, in PGY-4 and PGY-5.

Methods

This study was a retrospective review using preexisting data originally stored via mPower Clinical Analytics software version 4.0.7 (Nuance Communications Inc., Burlington, Massachusetts, USA) for PowerScribe 360 software version 20.03.1 (Nuance Communications Inc., Burlington, Massachusetts, USA). This study received full ethical approval by the local Health Research Ethics Board (file #2024.058). Data from 17 previous radiology residents who had graduated at a Canadian institution between July 2014 and July 2024 were

collected, including total case volumes (which included x-ray, computed tomography, magnetic resonance imaging, ultrasound, and fluoroscopic cases) over five years of training (adjusted for leave for two residents), ACR DXIT examination percentile scores in PGY-4 and PGY-5, and PGY-4 and PGY-5 spring OSCE percentage scores. As a percentile, the ACR DXIT scores illustrate the residents' scores relative to their peers in the same stage of training (cohort). It is important to note that the ACR DXIT examination and OSCE assess different domains of resident performance, and in this study their results were analyzed separately and interpreted in parallel rather than as directly comparable measures with respect to their relationship with case volumes. Data were excluded from radiology residents who had graduated prior to 2014 or after 2024. The relevant data were accessed from mPower and de-identified by assigning each resident a unique anonymous identification letter. The independent variables under examination were the number of reported cases by each resident throughout their entire residency training and their year of training. The dependent variables were their ACR DXIT examination and OSCE scores. Statistical analysis of the final dataset was performed using R software version 4.4.2 (The R Foundation for Statistical Computing, Vienna, Austria). The threshold for statistical significance was set at a p-value of < 0.05 for all analyses.

There were no educational or career implications for any residents whose reporting or examination data were accessed and analyzed, particularly in the context of having this data de-identified. Further, RCPSC examination outcomes were not investigated in this study due to the small volume of residents who had failed the exam and the potential for identifying these residents.

Results

The descriptive statistics of the variables under study are summarized in table 1 for both PGY-4 and PGY-5 examination scores, including means, standard deviations (SD), and ranges. For PGY-5, ACR DXIT scores were available for 14 of the 17 included residents; 3 residents were excluded from this analysis due to not having written the ACR DXIT that year secondary to the COVID-19 pandemic. The mean total number of reported cases over five years of residency training was 15,468 (SD = 2,319), with a range of 12,230 to 20,580 cases among the residents. PGY-4 ACR DXIT scores ranged from 2nd to 89th percentile, with the mean being 37th percentile (SD = 25.5). PGY-4 spring OSCE scores as a percentage ranged from 41% to 84%, with a mean score of 65.4% (SD = 12.2). PGY-5 ACR DXIT scores ranged from 6th to 74th percentile, with the mean being 44th percentile (SD = 23.2). PGY-5 spring OSCE scores ranged from 54% to 92%, with a mean score of 70.6 (SD = 11.3).

Correlation analyses were conducted to investigate any patterns or trends in the relationships between reporting volumes and ACR DXIT percentile scores and/or OSCE scores in both PGY-4 and PGY-5. In PGY-4, a weak negative correlation was observed between reporting volume and ACR DXIT scores (r = -0.185, p = 0.530), as well as OSCE scores (r = -0.186, p = 0.521) (Figure 1 and figure 2). This suggests that a higher number of total cases reported throughout residency could possibly weakly contribute to lower in-training examination scores, but this was not a statistically significant relationship. A moderate positive correlation was found between PGY-4 ACR DXIT and OSCE scores (r = 0.369, p = 0.071).

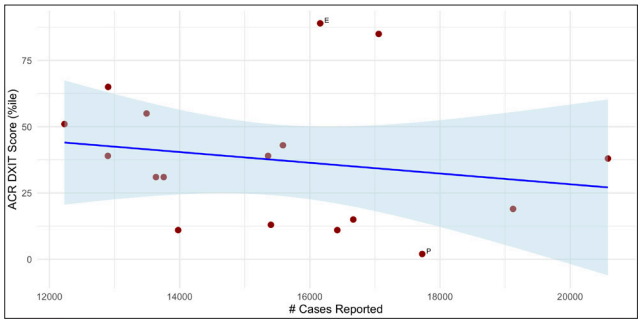

Figure 1: Scatterplot depicting the correlation between total number of cases reported and ACR DXIT scores in PGY-4.

Note: # Cases reported represents the numerical value for the total number of cases reported throughout five years of post-graduate radiology residency training. ACR DXIT score (%ile) represents the numerical value for the percentile score on the ACR DXIT examination. Regression line represents the best-fit linear relationship between case volume and examination scores. Shaded area indicates the 95% confidence interval for the predicted values. Letters indicate individual resident identification codes with scores in the lowest or highest 5th percentile for visual emphasis. N = 17.

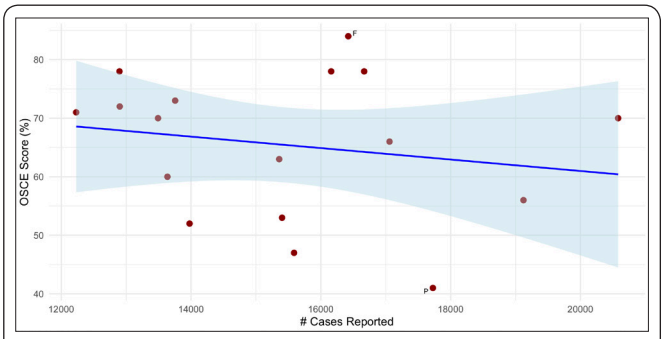

Figure 2: Scatterplot depicting the correlation between total number of cases reported and OSCE scores in PGY-4.

Note: # Cases reported represents the numerical value for the total number of cases reported throughout five years of post-graduate radiology residency training. OSCE score (%) represents the numerical value for the percentage score on the OSCE. Regression line represents the best-fit linear relationship between case volume and examination scores. Shaded area indicates the 95% confidence interval for the predicted values. Letters indicate individual resident identification codes with scores in the lowest or highest 5th percentile for visual emphasis. N = 17.

Table 1: Descriptive statistics of reporting volumes and examination outcomes among residents.

Measure	PGY-4 mean (SD)	PGY-5 mean (SD)	PGY-4 range	PGY-5 range
Total no. of reported cases	-	15,468 (2,319)	-	12,230 - 20,580
ACR DXIT score (%ile)	37 (25.5)	44 (23.2)	2 - 89	6 - 74
OSCE score (%)	65.4 (12.2)	70.6 (11.3)	41 - 84	54 - 92

Note: No significant differences were found between PGY-4 and PGY-5 residents in either ACR DXIT or OSCE scores (p = 0.518 and p = 0.191) respectively.

Similarly, in PGY-5, no significant correlations were found, with a weak negative correlation observed between reporting volume and ACR DXIT scores (r = -0.096, p = 0.743) and a weak positive correlation observed between reporting volume and OSCE scores (r = 0.022, p = 0.934) (Figure 3 and figure 4). However, a strong positive correlation was found between PGY-5 ACR DXIT scores and OSCE scores (r = 0.866, p < 0.001), which was notably stronger compared to PGY-4.

Linear regression analyses were also conducted to determine any potential relationships between the above variables in both PGY-4 and PGY-5. In the assessment of the impact of reporting volume on ACR DXIT scores in PGY-4, no significant association was found, with a small negative regression coefficient for volume (p = 0.478, r = -0.00200, R^2 = 0.0340, F = 0.529). The effect of reporting volume on PGY-4 OSCE scores also yielded no significant association and a small negative regression coefficient for volume (p = 0.475, r = 0.000980, R^2 = 0.0345, F = 0.536). Similarly, in PGY-5, reporting volume was not a significant predictor of ACR DXIT scores (p = 0.743, r = -0.0011, R = 0.0090) or OSCE scores (p = 0.941, r = -0.00014, R = 0.00050).

Given the non-linear relationship found between reporting volumes and major discordance rate as a measure of clinical performance and ABR core examination pass rates [10, 12], a quadratic regression model was also applied to determine if any such relationships existed between reporting volumes and ACR DXIT scores, as well as OSCE scores, in PGY-4 or PGY-5. In PGY-4, no statistically significant values were found between reporting volumes or its quadratic term and ACR DXIT scores (p = 0.713 and p = 0.753, respectively; R^2 = 0.0410), or OSCE scores (p = 0.484 and p = 0.518, respectively; R^2 = 0.00640), indicating that a non-linear relationship between these variables did not exist in this sample. In PGY-5, similar findings were observed. No significant non-linear association was found between reporting volumes or its quadratic term and ACR DXIT scores (p = 0.294 and p = 0.285, respectively; R^2 = 0.111), or OSCE scores (p = 0.126 and p = 0.124, respectively; R^2 = 0.202).

Finally, paired t-tests were conducted to compare the ACR DXIT and OSCE scores between PGY-4 and PGY-5 residents. Both analyses revealed no significant difference between the two groups (ACR DXIT: t (13) = -0.665, p = 0.518; OSCE: t (16) = -1.37, p = 0.191).

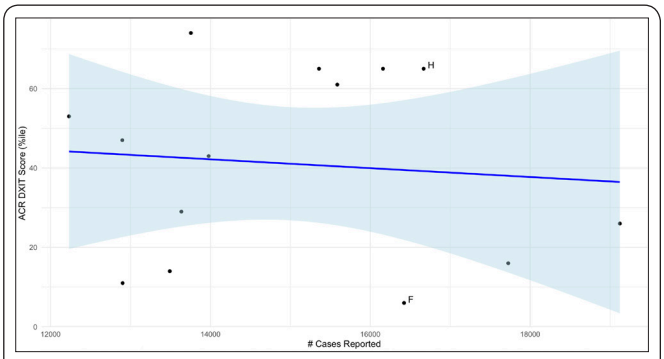

Figure 3: Scatterplot depicting the correlation between total number of cases reported and ACR DXIT scores in PGY-5.

Note: # Cases reported represents the numerical value for the total number of cases reported throughout five years of post-graduate radiology residency training. ACR DXIT score (%ile) represents the numerical value for the percentile score on the ACR DXIT examination. Regression line represents the best-fit linear relationship between case volume and examination scores. Shaded area indicates the 95% confidence interval for the predicted values. Letters indicate individual resident identification codes with scores in the lowest or highest 5th percentile for visual emphasis. N = 14.

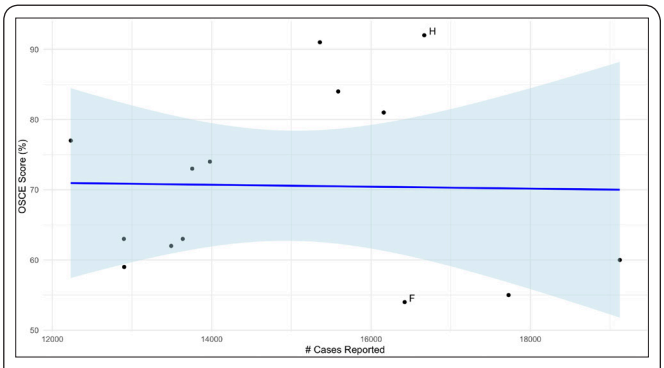

Figure 4: Scatterplot depicting the correlation between total number of cases reported and OSCE scores in PGY-5.

Note: # Cases reported represents the numerical value for the total number of cases reported throughout five years of post-graduate radiology residency training. OSCE score (%) represents the numerical value for the percentage score on the OSCE. Regression line represents the best-fit linear relationship between case volume and examination scores. Shaded area indicates the 95% confidence interval for the predicted values. Letters indicate individual resident identification codes with scores in the lowest or highest 5th percentile for visual emphasis. N = 14.

Discussion

The findings of the present study, indicating no statistically significant relationships between residents' reporting volumes and outcomes on standardized testing, are incongruent with those of the few previous studies in this area. A study by Poyiadji et al. [11] determined a significant positive association of reporting volumes with ACR DXIT scores in neurological and breast radiology subspecialties only, but not any other subspecialties; this study did not examine the overall impact in general postgraduate medical education residency training. Meanwhile, a study by Nickerson et al. [11] examined reporting volumes of general radiology residents and their association with ABR Core examination pass rates, which was significantly positive. Further, a study by Kwan et al. [9] suggested a significantly positive association between case volumes and overall resident knowledge; overall resident knowledge was also significantly positively associated with ACR DXIT scores. Yet, in this population sample, it appeared that reporting volumes did not have any significant impact on ACR DXIT percentile or OSCE scores.

This may indicate that case volume is not likely to be the lone predictor of examination performance. Further, the smaller sample size of this study as compared to the larger sample sizes within the previously cited studies may contribute to these differences in findings. This study was conducted at a Canadian institution with fewer residents than other programs, which limits the study's power; the outlined results should be interpreted considering this inherent drawback. However, this divergence is noteworthy, as it suggests that the relationship between case volumes and ACR DXIT outcomes may not be consistent across different institutions or contexts. By con-

tributing an additional Canadian dataset, this study provides nuance and balance to the existing literature on the topic.

An additional consideration is that a prior American study suggested an upper threshold of approximately 11,000 reported cases before the point of diminishing returns on examination performance [12]; meanwhile, all residents in the present study reported over 12,000 cases. This may partially explain why reporting volumes were not found to significantly correlate with in-training examination performance, as this could serve as a potential ceiling effect where reporting cases beyond this point confers only minimal, if any, additional benefit. This also limits our ability to examine the impact of lower-case volumes on examination outcomes, which would be an important focus of novel studies. Thus, this concept represents an important contextual factor which should be examined further in future studies with larger cohorts and a wider range of case volumes.

However, a strong and significant positive correlation was observed between PGY-5 ACR DXIT scores and OSCE scores ($p < 0.001$) as compared to PGY-4, which was only moderately positive and not statistically significant. This suggests that for PGY-5 residents, those performing better on one examination tended to also perform better on the other. Meanwhile, PGY-4 residents did not display the same appreciable trend. This may be postulated to be due to PGY-5 residents having increased experience and better abilities to integrate knowledge with examination-taking skills, making their scores more consistent across various exams. As well, by PGY-5, residents may begin to focus more time and energy into studying in preparation for their licensing examinations as compared to in PGY-4, when this is likely a lesser priority.

It is also important to consider a methodological limitation whereby cumulative case volumes were measured at the end of residency and were not available by individual post-graduate year. Therefore, PGY-4 and PGY-5 examination scores were correlated with total case volumes over all five years of training. This may have introduced temporal misalignment, as PGY-4 scores could theoretically have been influenced by cases completed after the exam. However, given that the correlations observed for PGY-4 were weak and non-significant, this limitation is unlikely to have notably affected the interpretation of the trends. The strong and significant correlation observed in PGY-5 remains robust, as these residents had completed most of their cases by the time of examination; however, this clarification is important to note when interpreting these findings.

There are a few possible explanations for these findings. Namely, individual studying efforts and methods for various examinations are likely to be quite different among radiology residents in a single program. This study focused only on case volume as a predictive factor; however, residents' processes of studying for these examinations are likely varied and multifactorial. One study raised an interesting point about this by explaining that increasing case volume alone may not be enough to yield higher in-training examination scores, at least in a subspecialized environment [11]. It was suggested that perhaps, since these in-training examinations are not weighted as heavily as final licensing examinations for residents' success and future careers, they may not be motivated to prepare as vigorously [11]. Further, the present study and previous studies in this area did not control for the type of cases reported by residents; the total number of reported cases was aggregated across all imaging modalities, rotations, and case complexities. Prior literature suggests that the relationship between case volumes and examination performance may vary by subspecialty or type of case [9, 11]. Correlation and regression analyses were used without adjustment for potential confounders such as cohort year, rotation schedules, or individual study habits, as these variables were not available for analysis within the confines of the study's scope. Future studies could strengthen the analysis by stratifying case volumes by modality, rotation, or case complexity and by employing mixed-effects or longitudinal models to account for clustering and time-dependent variation. This would allow for a more nuanced and robust evaluation of how different types of clinical experiences impact in-training and licensing examination outcomes.

Interestingly, no statistically significant differences were found in either ACR DXIT or OSCE scores from PGY-4 to PGY-5. This indicates that despite having an additional year of residency training, both examination scores did not significantly improve. However, an overall upward trend in scores on both exams from PGY-4 to PGY-5 was observed, which could be proposed to be due to increased reporting exposure. Regarding the ACR DXIT scores, 9 of the 14 residents who wrote the examination in both years (64.3%) showed an upward trend. For OSCE scores, 11 of the 17 total residents (64.7%) showed an upward trend.

Despite these factors, the previously referenced position statements by the APDR and ACGME place a heavy importance on case volume in radiology residents' preparation for standardized examinations [13, 14]. These have recommended that continuing with case reporting duties up until the point of an in-training or licensing examination would be more beneficial for maximal relevant case exposure as compared to protected studying time [13, 14]. Although this may align with some of the existing literature, the results of the present study oppose this premise, given that case volumes were not significantly associated with examination scores.

When considering the implications of medical resident education and performance on critical training and licensing examinations, it is important to have a broad depth of high-quality research by which to model residency programs. In a medical student survey by Yang et al. [15], competency-based medical education in residency and a requirement for exposure to case reporting were viewed favorably by 70% of respondents, which is in alignment with the position statements set forth by the APDR and ACGME [13-15]. As well, a study by Labranche et al. [16] involving surveys of recent radiology residency graduates on preparation for practice yielded responses emphasizing a need for higher case volumes in residency; one response read, "I was not trained to perform in terms of volume. There should be more emphasis on how many exams we interpret during training". This perspective highlights that examination scores represent only one dimension of resident development, and adequate case exposure is

also likely essential for long-term career success, even if the present study did not find a significant association between these variables. In reality, preparing residents for the realities of modern radiology practice and ever-increasing imaging utilization may indeed require training under similarly high expected case volume standards. Future longitudinal studies should therefore examine both educational and career outcomes when evaluating the impact of case volumes.

Finally, this study relied on ACR DXIT examination scores as a surrogate outcome measure of RCPSC examination performance due to the privacy and ethical concerns created by a small number of residents having failed the latter. A prior Canadian study demonstrated a moderate correlation between ACR DXIT scores and RCPSC examination results, though this was not completed recently and predates important recent changes and trends in radiology training, case volumes, and the introduction of asynchronous learning [6]. Thus, the authors acknowledge the need for future novel studies to ideally include RCPSC examination outcomes in their analyses of the impacts of reporting volumes upon standardized testing performance.

Conclusion

In-training and licensing examinations are critical factors involved in a radiology resident's medical education and future career success. The current research has shown that residents view these evaluations with a high level of perceived importance. The changes enacted by the APDR in 2003 and the ACGME in 2013 on clinical duties requirements in preparing for board examinations speak to the fact that there is still dissent within the specialty on how best to structure residency programs for success. The present study found that reporting volumes did not have any significant associations with ACR DXIT examination or OSCE scores. Further, residents' scores on both examinations did not significantly differ from PGY-4 to PGY-5, though a general upward trend was observed.

To properly structure Canadian programs, more research is required to inform curriculum development. If reporting volumes are a key factor in in-training examination performance, further evidence must be produced for postgraduate medical education programs and residents themselves to reference in their studying and clinical duties. We acknowledge that larger, multi-institutional Canadian studies would provide more generalizable insights into the relationship between resident case volumes and examination or career outcomes; nonetheless, the present single-institution dataset represents an important starting point for future studies or critical reviews. Overall, residency programs and future studies should consider that case volumes are only one factor in standardized examination scores and should also investigate the role of individual studying strategies, program-specific preparation resources, and varied experience with clinical presentations and pathologies.

Acknowledgements

None.

Conflict of Interest

None.

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