A Longitudinal Neuroimaging Curriculum to Prepare Geriatric Psychiatry and Geriatric Medicine Fellows in the Assessment of Neurocognitive Decline

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The comprehensive evaluation of neurocognitive decline remains an important task for practitioners in geriatric psychiatry and geriatric medicine. Neuroimaging supports this role by bolstering clinical impressions, ruling out alternative causes for cognitive decline and differentiating among causes when there is clinical overlap. Imaging has also been incorporated into consortium criteria to increase diagnostic certainty such as for behavioral variant frontotemporal dementia [1]. Providers today have a variety of imaging modalities at their disposal ranging from routine magnetic resonance imaging (MRI) to evaluate structural changes to nuclear imaging in the form of positron emission tomography (PET) and single positron emission computed tomography (SPECT) to assess molecular changes in the brain [2]. As the incidence of neurocognitive decline rises and attention to treatment grows, providers will face greater demands for the use of imaging in clinical work [3, 4]. Thus, training in the appropriate use and interpretation of imaging needs to be emphasized in residency and fellowship programs.

Psychiatry and geriatric medicine training programs have historically struggled to incorporate neuroimaging within their curricula. In a survey of resident physicians across seven psychiatry programs within the USA, Medina and colleagues observed that less than 10% of respondents expressed comfort with radiologic neuroanatomy and only 6% felt comfortable interpreting MRI images [5]. This stood in contrast with a majority (80% or more) who expressed interest in improving their knowledge of neuroimaging and valued its role in psychiatry. In the same study, most residents reported receiving neuroimaging education through faculty in radiology or neurology across medical school and residency. Only 7% attributed didactics to faculty trained specifically in psychiatry and neuropsychiatry. Downar and co-workers interrogated this educational need by implementing a neuroimaging week for junior psychiatry residents [6]. The experience included didactics, case discussions, and skills-based sessions. They reported a statistically significant improvement between multiple-choice questionnaires administered at the start and conclusion of the course. Similarly, Lacy and Hughes offered a Neuroimaging in Psychiatry session as part of a broader Neuropsychiatry course [7]. Separate efforts by Lane et al. involving a longitudinal neuroanatomy course with neuroimaging as a subcomponent were well received by residents [8]. To our knowledge, there are no other published initiatives dedicated to neuroimaging skills for geriatric psychiatry and geriatric medicine trainees.

Drawing upon our understanding that comfort with neuroimaging is essential in the care of geriatric patients, we developed a longitudinal curriculum for residents and fellows training in geriatric psychiatry and geriatric medicine. The curriculum was administered jointly to trainees at Yale School of Medicine and University of Connecticut (UConn) School of Medicine. Sessions were facilitated by faculty and staff within geriatric psychiatry and prioritized clinically applicable knowledge. We determined that a flipped classroom approach enabled engagement over a traditional lecture format based on supportive evidence [9]. To facilitate information salience and emulation of everyday practice, classes were based on Adult Learning Theory [10]. Adherence to the principles of Adult Learning Theory was specifically achieved through concise learning objectives, use of pre-session activities, group problem solving, and case-based learning to encourage integration of knowledge with clinical experience.
This report outlines our experience teaching this curriculum over two sequential academic years and adapting the course to a virtual format due to the COVID-19 pandemic. Both subjective feedback and objective measures suggest that learners welcomed this addition to their training and saw an increase in their knowledge and confidence with the use of neuroimaging.

**Curriculum Design**

We created a longitudinal curriculum composed of 6 sessions, held approximately every 2 months over the training year. A course outline is provided in Table 1. We believed this format would have several benefits: (1) participants could incrementally apply knowledge in clinical care; (2) material could be revisited and tested across sessions; (3) trainees would have more time to complete pre-class assignments; and (4) participants would gather cases for discussion in later sessions. The course began with a review of neuroanatomy and culminated in faculty-driven and fellow-driven case reviews. Trainees were sent a pre-class assignment 1–2 weeks prior to each session. Examples of assignments include an independent review of neuroanatomy guided by a list of structures, or viewing a brief video prepared by the course moderators. Additional examples are also outlined in Table 1. As shown, a lecture style of presentation was limited, and instead group challenges were used to engage attendees. We speculated that group rather than individual activities would reduce participant anxiety given many trainees did not feel proficient with this material.

The curriculum was tailored to fellows in geriatric psychiatry and geriatric medicine. Trainees were recruited from Yale School of Medicine and UConn Health. Participation was also extended to general psychiatry residents and faculty. However, data collection was limited to fellows who attended the course longitudinally and were the primary audience. Participants completed pre- and post-class quizzes which tested key concepts from each session and additionally rated their confidence in the use of imaging skills. Feedback was also obtained to allow continuous improvement of the content and its presentation. The curriculum began with in-person sessions; however, due to the COVID-19 pandemic, it was quickly adapted to a virtual format and has been continued via the Zoom videoconferencing application.

The curriculum and associated data collection were exempted by the Yale Institutional Review Board and the UConn Institutional Review Board. Participants submitted quizzes using a self-generated code, which maintained confidentiality but allowed matching of pre- and post-class quiz submissions. Only matched quizzes were retained for data analysis and individual quiz scores computed as percent of all questions answered correctly. Pre- and post-quizzes were identical and included knowledge-based questions (number of questions was 10 for session 1, 8 for session 2, 5 for session 3, and 7 for session 4). Similarly, participants submitted their confidence on a continuous scale from 0 (least confident) to 100 (most confident). We used a one-tailed Wilcoxon matched-pair signed rank test for analysis, with a null

| Table 1 | The course outline and examples of pre-session and in-session content by topic |
|---------|--------------------------------------------------------------------------------|
| Course outline by session |  |
| Session | Subject |
| 1 | Neuroanatomy |
| 2 | Structural Imaging: CT/MRI |
| 3 | Molecular Imaging 1: Amyloid-PET and DAT-SPECT |
| 4 | Molecular Imaging 2: FDG-PET and Perfusion SPECT |
| 5 | Case Discussion 1: Faculty driven |
| 6 | Case Discussion 2: Fellow driven |
| Examples of course content by topic |  |
| Topic | Pre-session assignment | In session didactics | In session experiential |
| Neuroanatomy | Review anatomy using a list of structures | Navigate a routine MRI and localize structures | Compete in small groups to identify structures in multiple orientations |
| Structural imaging | Review a brief video on imaging modalities | Review concepts of size, signal intensity, and artifact on MRI | Identify abnormalities and diagnose cases in small groups |
| Molecular imaging | Complete online modules on Amyloid-PET or review a brief video on nuclear imaging | Review appropriate use and image acquisition for Amyloid PET, DAT SPECT, and FDG PET | Interpret pre-selected cases as a group in both molecular imaging sessions |

CT, computerized tomography; MRI, magnetic resonance imaging; Amyloid-PET, amyloid-positron emission tomography; FDG-PET, fluorodeoxyglucose-positron emission tomography; SPECT, single-photon emission computerized tomography.
The hypothesis of no increase in quiz score or confidence after completion of sessions. Outcomes were considered significant at \( p < 0.05 \). Statistical analysis was completed using IBM SPSS Statistics for Windows, version 28.0 (IBM Corp., Armonk, N.Y., USA). Assessments were captured for sessions 1 through 4, which had structured didactics and more explicit learning objectives. The pre-quiz was completed before any pre-class assignments and post-quizzes were completed immediately after the session.

**Results**

The curriculum was well attended by geriatric psychiatry, geriatric medicine, and rotating general psychiatry trainees. Fellows were asked to complete pre- and post-session quizzes composed of knowledge assessment and confidence ratings related to skills covered in each session (e.g., ability to use structural imaging for patient assessment). Participants submitted quizzes with unique, self-determined codes and only matching quizzes were used for data analysis. This provided us 19 quizzes distributed across four sessions for each of two academic years from 2019 to 2021.

Pooled data across two years of participation suggested a trend of improved mean quiz scores following each session (Fig. 1). Due to a small sample size, we initially compared pre- and post-class quiz scores across all sessions. Mean quiz score improved from 73.0 to 84.6% (all sessions, \( p = 0.001 \)). Across individual sessions, quiz scores improved from 83.3 to 88.3% (session 1, \( p = 0.13 \)), 68.8 to 78.1% (session 2, \( p = 0.13 \)), 70.0 to 90.0% (session 3, \( p = 0.08 \)), and 67.3 to 83.7% (session 4, \( p = 0.03 \)). The mean post-class quiz scores were higher for all sessions, although these improvements were only statistically significant at session 4.

Likewise, confidence ratings increased throughout course attendance. Across all sessions combined, confidence rose from 38.3 to 60.2 (all sessions, \( p < 0.0001 \)) as rated on a continuous scale from 0 to 100. Within individual sessions, confidence ratings improved from 38.5 to 50.7 (session 1, \( p = 0.01 \)), 43.8 to 78.8 (session 2, \( p = 0.03 \)), 47.3 to 49.3 (session 3, \( p = 0.33 \)), and 32.4 to 60.9 (session 4, \( p = 0.009 \)). The mean post-class confidence ratings increased for all sessions,
although these increases were statistically significant only at sessions 1, 2, and 4 (Fig. 1).

Discussion

Our report builds on the very limited published material describing structured neuroimaging education for trainees in geriatric psychiatry and geriatric medicine. To our knowledge, this initiative is the first of its kind in the use of a longitudinal in-class approach which has been shown to allow spaced repetition and application in day-to-day practice [11, 12].

We observed that the use of adult learning theory and experiential learning fostered greater engagement among participants. Engagement remained strong even after the switch to a virtual format for the course. A combination of digital tools including screen sharing, surveying, pop-up quizzes, and breakout rooms preserved engagement and group participation. Collaboration across campuses was additionally feasible through an online platform. Although developed as a necessity due to the COVID-19 pandemic, we now expect the virtual format to remain in use during future iterations of the course. For other institutions seeking to cultivate similar neuroimaging curricula, this format could support collaboration and wider distribution of such highly relevant clinical material. Ultimately, in our experience delivering the course, the material was well received and with a trend supporting knowledge acquisition and increased confidence throughout the course.

Increase in learner confidence was statistically significant when viewed across all sessions in combination. When dissected further, improvements were largest and statistically significant in sessions 1, 2, and 4 which focused on neuroanatomy, structural imaging, and fluorodeoxyglucose-positron emission tomography (FDG-PET) alongside perfusion SPECT. Change was not significant in session 3 where amyloid PET and dopamine transporter (DAT) - SPECT was reviewed. The small sample size for submitted assessments likely led to this being non-significant. However, the weaker effect of session 3 may mirror the findings from a previous report by Downer et al., where subjective comfort improved more profoundly in the domains of neuroanatomy and structural imaging as opposed to interpretation of PET and SPECT [6]. This pattern of greater improvements in confidence could be a result of less familiarity with molecular imaging as compared to structural imaging in medical school training and clinical practice. In other words, gains in subjective confidence may be higher when learners can apply teaching points to prior clinical scenarios. Such gains may also explain the jump in confidence from session 3 to session 4 where molecular imaging is rechallenged after being introduced in a prior class. Overall, the observed trends are both encouraging and suggest opportunities to bolster the curriculum with case-based discussion and image interpretation to increase learner confidence.

Consistent with increases in learner confidence, quiz performance improved for all sessions combined. Despite mean quiz score improvements in all sessions, the score increase was statistically significant only in session 4. This difference is most likely attributable to our small sample sizes for submitted assessments. Several factors contributed to the limited number of matched quizzes available for analysis. First, the size of geriatric fellowships across programs is typically small, with our relatively large programs aiming to train 4 geriatric psychiatry and 4 geriatric medicine fellows per year. A longitudinal curriculum also risks intermittent absence due to individual trainee schedules. In addition, we did not mandate or track quiz participation and instead requested the use of an anonymous but consistent trainee identifier. This contributed to loss of data when trainees either did not complete quizzes or changed their identifier, preventing matching of pre- and post-session quizzes. It was particularly notable that the change from in-person to virtual format had a disruptive effect on completion of post-session quizzes. In response, we now allocate time for assessments within sessions and prompt trainees to complete post-session quizzes. Lastly, we observed that pre-session quiz scores were consistently high (65% or greater) throughout the course and these high pre-session scores may have narrowed the margin for improvement. Despite the limitations in collecting learner assessments, the overall improvements in both learner confidence and quiz performance are encouraging indications of the effectiveness of this course.

Our course was limited in scope and only included imaging modalities commonly utilized for the evaluation of cognitive disorders. Due to time constraints, our course was deliberately focused on high yield topics with a deep evidence base and we did not address the use of neuroimaging in other psychiatric diseases. However, additional sessions could use the same approach to expand the course content. There were also limitations in the efficacy of assessments performed. To this point, our study was not designed to examine clinical behavior such as ordering of tests or imaging interpretation in a clinical setting. However, we anticipate that improved knowledge and confidence scores will translate to improvements in clinical practice, though this remains to be assessed in future studies. A future change to the quizzes would include increasing difficulty of the knowledge-based aspects to better demonstrate improvement.

In conclusion, the demand for cognitive disorder evaluations in an aging population is expected to grow. Providers must rely on a diverse set of tools for accurate assessment of cognitive decline and informative discussions with patients and families. In this realm, neuroimaging remains a vital augmentation of clinical history and exam. Yet, much like workforce shortages, training in neuroimaging lags across
trainees in geriatric psychiatry and geriatric medicine. Through experiential learning and group participation, trainees saw improvements in knowledge base and crucially increased confidence in neuroimaging skills. We believe this model can be readily adapted at other institutions and even distributed in a virtual format to better prepare trainees for practice.

Declarations

Disclosures APM reports grants or contracts from NIH, Eli Lilly, Genetech, Eisai, and Janssen Pharmaceuticals for work that is not related to this report. No other authors have anything to disclose.

Ethics approval The work presented here was granted exemptions by the Office of Human Research Ethics at Yale University and separately by the UConn Health Human Subjects Protection Program.

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