Effective and Engaging Active Learning in the Medical School Classroom: Lessons from Case-Based Collaborative Learning

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ABSTRACT: Large group collaborative teaching approaches are rapidly gaining popularity in undergraduate medical education. The case-based collaborative Learning (CBCL) pedagogy was instituted for pre-clerkship teaching at Harvard Medical School in 2015 with subsequent implementation at other medical schools. CBCL emphasizes inductive reasoning, integrates basic and clinical sciences, stimulates curiosity, and fosters teamwork. Given the ongoing educational evolution, guidance on designing and facilitating collaborative learning sessions, such as CBCL may benefit faculty in their instructional design efforts. This perspective article describes strategies to create effective collaborative sessions using CBCL as an example. We reviewed the literature and summarized ten years of experience in CBCL teaching through the lens of contemporary theories of teaching and learning. The recommendations are organized into three main domains: Instructional Design, Facilitation, and Professional Transformation, each aligned with the theoretical principles of CBCL. The recommendations provide a conceptual model to assist faculty in designing engaging and effective class materials and support students' professional transformation during collaborative learning sessions.

KEYWORDS: active learning, flipped classroom, case-based collaborative learning, instructional design, undergraduate medical education

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Introduction

Collaborative learning has a long tradition in medical education, often relying on student-directed, small group formats like problem-based learning (PBL). Over the last decade, more structured, team-based approaches such as team-based learning (TBL) or case-based collaborative learning (CBCL) have gained momentum.[1,2] This trend is driven by various factors. For one, small group learning formats proved hard to implement, yielding variable learning experiences.[3] Second, the flexible, student-directed nature of small group formats like PBL is designed for exploration. This can be inefficient and create challenges in conveying the inherently large core content that presents undergraduate medical education.[3] Third, over the last two decades we have seen a confluence of advances in technology, coinciding with key lessons from the science of learning that emphasizes active learning and critical thinking.[4,5] This has led to the advent of the flipped classroom format and a flurry of educational innovations trying to apply the science of learning to how we teach and learn.

Based on these challenges, in 2015, a novel instructional approach, case-based collaborative learning (CBCL), was implemented in the Harvard Medical School Pathways curriculum.[1] CBCL is designed on four principles: 1) Enhancing critical thinking and deep understanding, 2) Ensuring longitudinal and vertical integration between the basic and clinical sciences, 3) Fostering curiosity and engaging learners in self-directed learning, and 4) Supporting students in their professional transformation to self-directed learners.[1] Foundationally, CBCL is a constructivist strategy, focusing on social interactions to build meaningful and lasting learning.[6] CBCL integrates self-directed learning strategies of the flipped classroom with the contextual, constructivist and social aspects of team-based learning (TBL), problem-based learning (PBL), and case-based learning (CBL).[1] Therefore, best-practices for CBCL are relevant to other active learning pedagogies.

Creating a successful CBCL session comes with challenges. The rapid expansion of medical knowledge requires faculty to judiciously select core concepts and cases that balance breadth and depth of their field.[3] Faculty's cognitive biases, such as the expert blind spot, can make it difficult to gauge learning activities at the right level for novices.[7] In addition, effectively integrating basic and clinical sciences, while encouraging inductive reasoning, critical thinking, and fostering curiosity are challenges that faculty need to keep in mind when designing cases for in-class discussion.[8,9] Effective facilitation is crucial in case-based learning, requiring a group of well-prepared, committed educators with training in the CBCL method who can support collaborative efforts among teams and facilitate balanced large group discussions.[10]

From the student perspective, self-regulated learning (SRL) skills have been identified as a modifier for the success of flipped classroom formats such as CBCL.[11] SRL describes how learners assess and adapt their learning needs and strategies. It is a cyclical process with three distinct phases: 1) forethought, 2) performance, and 3) self-reflection,[12] that are mirrored by the three instructional phases of 1) preparation, 2) class discussion, and 3) consolidation in CBCL. Students need to develop self-directed learning skills to prepare for class, effectively contribute during class, and consolidate after class. This process catalyzes the students' professional identity formation and adaptive expertise development.[1,13]

In this perspective article, we present recommendations, based on educational theories, literature review and informed by our experience as course directors and facilitators in CBCL over the past decade.

The recommendations are organized into a conceptual model for CBCL with three domains that organically arose from our discussions – 1) instructional design and content (preparatory materials and in-class cases), 2) facilitation (in-class discussion), and 3) professional transformation (continuous professional identity and adaptive expertise development in students). While this perspective focuses on CBCL, the principles are applicable to other collaborative learning formats.

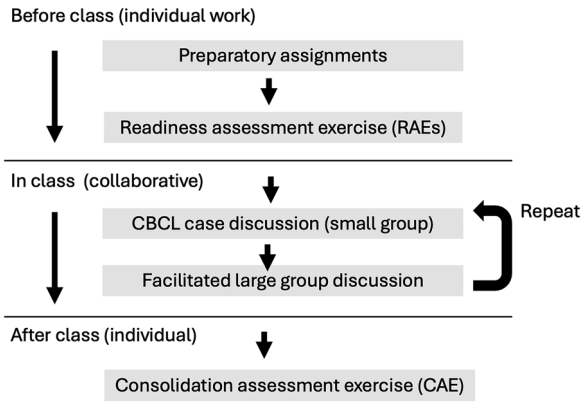

Figure 1. Summary of the CBCL pedagogy and the activities students participate before, during, and after a CBCL session. Note: This figure has been simplified from A Step-by-Step Guide to Case-Based Collaborative Learning (CBCL) by Besche et al, published by Springer International Publishing, in 2022, with permission.[14] The original figure can be found in A Step-by-Step Guide to Case-Based Collaborative Learning (CBCL), on page 2.

Method

This paper is based on our experience in teaching in the pre-clinical curriculum in the Pathways MD program at Harvard Medical School from 2015 to date. In order to address variation in implementation of the CBCL teaching method, we invited all pre-clinical CBCL course-directors and co-directors to compare experiences and identify best practices. All 11 members of this group had major responsibility in designing course content, facilitating case discussions and overseeing other course faculty. Their academic rank ranged from lecturer or instructor to full professor. Meetings were conducted virtually every month for about 1 year. The format of the discussion was iterative. Three members of the group (HCB, KF, BAC) took the lead in identifying common themes between meetings, and investigating links of these themes to educational theory. The emerging theoretical framework and recommendations were refined iteratively in group discussions, with candidate ideas evaluated, refined or rejected based on their perceived relevance and generalizability.

Recommendations for instructional design: ensuring preparatory materials and in-class cases build on each other effectively

In CBCL, as in other flipped-classroom approaches, students complete preparatory assignments consisting of readings or videos before class. For one hour of in-class case discussion, ~ 1–1.5 h of prep work is required. To provide students with feedback on their degree of preparation, each prep assignment concludes with an open-book, low-stakes readiness assessment exercise (RAE) consisting of brief multiple-choice questions. In class, faculty facilitators present a clinical vignette to students that is designed to apply the concepts covered in the prep assignments in the context of a new case. The case is broken up by a set of questions. The students work through the first question associated with the case, first individually, then in groups of four students. After each small group has come up with answers, the class convenes as a whole and discusses what the small groups have found. This large group discussion is orchestrated by a faculty facilitator who ensures that consensus is reached and the key learning points are covered. The cycle of small-group large-group discussion is repeated iteratively until the class has worked through the full case (Figure 1).[1,9] For a more detailed description of the CBCL method including examples of RAEs, case vignettes, and other materials we refer the reader to our step-by-step guide to CBCL.[14]

Provide scaffolding for preparatory assignments. Scaffolding is the instructional design practice of providing novices with frameworks that help them organize their thinking[15,16] . When preparing for CBCL, students are in the *forethought phase* of the SRL cycle trying to anticipate the key concepts needed in class. Preparatory learning objectives, keywords, summaries or flowcharts, can guide students in this process. They serve as "advance organizers," guiding the learner toward the most important concepts and enabling them to track their progress. Students appreciate various resources, from videos to readings to live lectures.[17] If videos are preferred, narrated PowerPoints chunked in 5–10 min segments are very effective.[18] We recommend to select preparatory resources that are well aligned with preparatory learning objectives, and use optional resources judiciously. The main goal is to keep the materials focused and manageable for students.

Design in-class cases for optimal task complexity. A successful case first leaves students with questions then leads to intense debate in their small groups and, after wrestling with misconceptions as a class, concludes with a satisfying sense of "discovery" and deeper understanding. CBCL case questions are open-ended and often have more than one correct answer. This invites students to explore possible pathways or mechanisms of diseases and generate their own hypotheses using inductive reasoning.[1] A good CBCL case is just difficult enough that all team members must put their heads together: letting them struggle is critical to deepen understanding.[19] Designing cases for optimal task complexity means the task builds on general principles presented in preparatory assignments but then allows students to apply, analyze, and/or evaluate what they have learned in alignment with Bloom's taxonomy of learning.[20] This prompts them to recall prior knowledge and experiences, elaborate on ideas, and teach each other. Consistent with theories of collective learning, students describe the most engaging cases as those requiring their collective intelligence and collaborative analytic thinking.[21]

Provide worked examples. A worked example, which presents the full solution to a problem, invites students to carefully review the solution rather than generate one on their own. This allows novices to trace the way experts are thinking.[22] While collaborative learning fosters critical thinking by allowing students to elaborate on and investigate their own understanding with others,[21] this may lead individual students to over-rely on their peers. Therefore, we recommend to provide opportunities for students to assess their individual understanding. We routinely include readiness assessment exercises (RAEs) to prepare *before* class, as well as consolidation assessment exercises (CAEs) to consolidate key points *after* class.[14] Completion of RAEs and CAEs is self-paced, and both are a required component of the course. RAEs are in multiple-choice format, and CAEs have open-ended questions that ask students to articulate their thinking. After completing these exercises, students are provided with detailed answer explanations that serve as worked examples. Together, RAEs and CAEs bookend the individual responsibilities of students to come to class prepared and to identify and consolidate key learning points. Cognitive load theory supports this instructional design: the testing effect enhances learning and long-term retention, and worked examples allow novices to close their learning gaps.[23] Consistent with this notion, pre-class testing has been shown to enhance the effectiveness of flipped classroom formats.[11]

Seek real-time feedback from students to understand effectiveness. Balancing the preparatory workload, getting the complexity of case materials "just right," and aligning preparatory and case materials is challenging. It can be difficult for expert faculty to gauge workload and task complexity as will be experienced by novices.[7] We developed two strategies to receive timely and specific feedback on the learning experience without causing survey fatigue. Each year, students select a group of "educational representatives" that are tasked to connect with faculty in real-time, allowing for adjustments and better communication during CBCL courses.[24] We also routinely embed multiple-choice items in the RAEs for each session to collect feedback on workload and effectiveness of prep resources.[25] Both of these interventions illustrate a deeper shift in our culture that happened when we implemented CBCL at scale. By design, active learning formats like CBCL create a need to understand the day-to-day learning experience of students more thoroughly compared to less interactive teaching modalities.[19] This shift cannot be underestimated as it underlines that content expertise alone is not sufficient in designing effective CBCL curricula, foundational understanding of the learning process is equally important.

Recommendations for facilitation: ensuring collaborative critical thinking

CBCL case discussions unfold in three phases: first, students think and commit to an answer to a case question individually, next students discuss their thinking in small groups of 3–4, finally, all groups in the room debrief, facilitated by a faculty member.[9] Small group discussions typically take 5–10 min. CBCL sessions are led by one or up to three faculty members from related disciplines to integrate basic and clinical science principles.

Faculty do *not* facilitate the small group discussion, instead faculty walk through the room, are available for questions, and observe (eg, How are students approaching the problem? Are there misconceptions? What was their preparation?). During the large group discussion, the faculty facilitator focuses attention on key concepts, fosters a sense of community, and enables everyone to construct knowledge together. Doing

this well requires a shift from "covering" content to assessing students' thinking, sharpening students' reasoning by making the faculty reasoning explicit and ultimately guiding students to discovering and building on foundational principles needed to solve the problem.

Facilitate to "raise the barn": creating the collaborative group process. During the large group debrief, we recommend that faculty elicit responses from as many small groups as possible until all ideas are expressed. Once a thought is presented, it belongs to the whole class to confirm, refute, or expand. Developed by McCormick and Kahn, this concept is called "raising the barn".[26] By avoiding both immediate validation and correction of student responses, faculty can engage the group in collaborative reasoning using and building on difficult concepts. The facilitator's most important task is to emphasize reasoning over the correct answer. In addition, this type of discussion opens a space for students to assess their own learning. In the cyclical process of self-regulated learning, the performance phase refers to processes that occur *during* task completion.[12] In CBCL, the performance phase is when students solve problems in class. Through discussions with peers and faculty, students identify and correct misconceptions while developing a deeper understanding. In this setting, the number of misconceptions raised and dispelled is more important than the number of correct answers given. Successful active learning is always a co-creation of solutions to problems between teacher and learner, and as facilitators, our role is to "conduct" a symphony of thinking.[27]

Frequently emphasize take-home points. As novices, students need help distinguishing the more important concepts from less relevant details.[23] In a discussion-based format many different ideas will be expressed, and some students may feel overwhelmed. Knowing that faculty will summarize take-home points iteratively throughout class frees students to focus on active listening instead of scribbling notes on every word exchanged. We therefore recommend conducting discussions with a reliable rhythm of case or problem introduction, small group discussion and debrief, followed by synthesis of the main points by the facilitator. This ensures students can catch up before shifting to the next problem. Another helpful strategy is taking notes on a whiteboard as it augments the audio of the discussion with a visual aid.[23] Identifying and emphasizing the thread that weaves through all the discussions is critical for successful facilitation. If students repeatedly ask clarification questions and seem unable to move on, it is important to pause and regroup until the confusion has been resolved. We suggest thinking about the group debrief in two phases. First, the facilitator prompts the group to unwind the thread and examine every fiber (relevant concepts mentioned by the group), and then the facilitator rolls the fibers back into one encompassing thread (the facilitator connects the concepts and clarifies misconceptions.)

Teach the teacher. CBCL large-group discussions work well with groups of 20–40 students. If you run your course in sections, ensuring a consistent approach by the faculty is critical. Variation in facilitation between sections plays a significant role in student perception, even in the absence of tiered grading, students may be sensitive to differences in content that is discussed in sections. To mitigate this variation, we provide faculty with a facilitator guide that includes a detailed description of essential discussion topics for the class. The facilitator guide has the following sections: 1) suggested timeline for small group work and large group debriefs, 2) answer explanations that indicate the desired depth and breadth of the discussion, 3) list of common misconceptions that may arise and suggestions for how to probe for them, 4) pointers for how to integrate with prior classes or to preview concepts that will be covered elsewhere. The facilitator guides provide a common framework but can be augmented with individual faculty reflections.[28] A detailed facilitator guide also ensures the classwork is aligned with the preparatory assignments, as it requires consideration of how the discussion may unfold.

Nurture broad participation by modeling vulnerability. The most important qualities the facilitator can bring to the classroom are curiosity about how the students think and the ability to embrace uncertainty.[29] It is important to signal that all contributions are valued.[30,31] If students get stuck, nudge them to explain what doesn't make sense; if a facilitator doesn't understand the basis of a student's comment, deeper probing is required. In these moments, modeling uncertainty with curiosity and humility leads students to emulate this stance in their small group discussions. When students begin to build on each other's responses, it is an excellent sign that a healthy collaborative learning environment has been established in which students value each other for their contributions and listen actively. That leaves us with the most important moment: a student asks a question, and the facilitator doesn't know the answer. If this relates to a key concept, acknowledge the unknown and promise to follow up later. If it is a tangent, encourage students to investigate themselves and share what they learn. If the discussion lands on gaps in the current state of clinical and scientific knowledge, pause and compliment the group. Nothing is a better indicator of a high-quality discussion than identifying the boundary between what is known and unknown.

Recommendations for professional transformation: engage students in self-reflection

Collaborative learning is a complex process. Students must navigate the challenges of social interactions while integrating

new content with their existing knowledge. This social domain is easily overlooked when focusing on content and delivery, yet it holds critical aspects of professional growth and transformation. In adapting CBCL as the dominant method of preclerkship instruction in the foundational medical sciences, we have learned to be more explicit with our learners (and faculty) about managing the collaborative learning environment and be more reflective about how students engage with learning as complex human beings.

Coach students in study skills/self-regulated learning. Students' self-regulated learning skills have been identified as a modifier for success in flipped classroom settings.[32] While students admitted to medical school are accomplished learners, medical school still presents an adjustment due to the fast pace and high volume of content. In addition, CBCL requires students to prepare and consolidate daily in order to participate effectively in case discussions. A common challenge for students is learning how to focus their preparation on the most important concepts, as opposed to memorizing every detail.[25] Similarly, learning how to listen actively in class and to take notes selectively (as opposed to transcribing the discussion) is a skill students need to develop. Reflection is critical to the cycle of self-regulated learning but may not be a priority for students.[12] We have found that many students need to adapt their study strategies significantly from what worked for them in college. Therefore, we explicitly discuss study strategies and coach students in using the self-regulated learning framework during their preparation and in-class.[33]

Develop class norms that emphasize how one's own learning serves the collective. Medical students have excelled as individuals and competed against many candidates to be admitted. Transitioning to collaborative learning, where we want to hear from everyone and focus on reasoning and critical thinking more than "being the one that is the first to know the answer," is an adjustment. Many students quickly embrace this mindset and express joy in learning which can be an influential motivating factor, particularly in a pass/fail setting. However, for students to freely share their thinking, including when confused, requires that they don't feel judged. Students need to be able to focus on learning without considering the potential negative consequences of their misunderstandings on their social standing with peers and faculty.[34] To facilitate this, we engage the class in a discussion about the norms and expectations they want to set for their classroom. For example, the student with advanced knowledge should hold back at times in providing the answer to allow classmates to engage in productive struggle. Another valuable norm is that students may always "phone a friend" when confused; such instructions can assist in creating a lighthearted and collegial atmosphere. We suggest that class norms developed at the beginning of the year are shared in

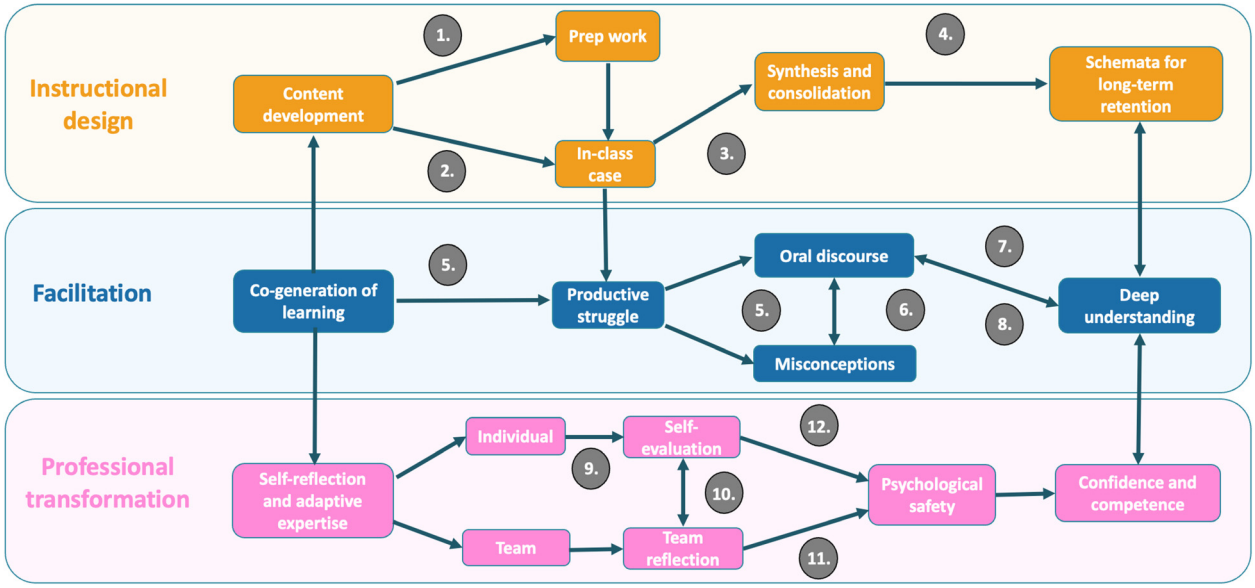

Figure 2. The conceptual model for CBCL instruction arose from iterative conversations about our experience with CBCL course design over the last decade. The recommendations are arranged according to three main domains: Instructional design, Facilitation, and Professional transformation. The figure shows the interconnected nature of the domains and the individual recommendations to guide faculty in designing successful CBCL sessions. The numbers indicate the following recommendations: (1) Scaffold your prep assignment. (2) Design for optimal task complexity. (3) Provide worked examples. (4) Seek real-time feedback from students to understand effectiveness. (5) Facilitate to "raise the barn": creating the collaborative group process. (6) Emphasize take-home points. (7) Teach the teacher. (8) Nurture broad participation by modeling vulnerability. (9) Coach students in study skills/self-regulated learning. (10) Develop class norms that emphasize how one's own learning serves the collective. (11) Encourage and normalize teamwork skills for all students. (12) Encourage self-assessment and the development of adaptive expertise.

writing as a class "charter" and then periodically re-visited as needed.

Encourage and normalize teamwork skills for all students. Students spend ~40–50% of CBCL in-class time working in their teams of 3–4. Two factors are critical for productive team discussions: preparedness of team members and effective team dynamics. Students' experience in CBCL teams can vary, and they don't always have the knowledge or skills to improve the team process.[35] There can be many reasons for a team to struggle (eg, one person not preparing, someone talking over others), however, students may feel it is not their place to correct a peer's behaviors. To encourage and normalize teamwork as a skill everyone needs to learn, we introduce the students to the concept of psychological safety[36,37] and how balanced participation and ostentatious listening are the two key behaviors to ensure a healthy team dynamic.[31,36] Encouraging students to use tools like concept mapping during their classroom discussion can also be helpful in structuring the team discussions.[38] We recommend providing time for students to set team norms and to check-in with each other during the course.[35,36] While we have not implemented this in our program, peer feedback or peer assessment might be another useful tool to support students in developing their teamwork skills.[39] Although classroom teams are different from clinical teams, the predictable and sheltered nature of the class makes it a safe training ground for clinical interactions by helping students build critical interpersonal skills and learn how to manage "professional conflicts."

Encourage self-assessment and the development of adaptive expertise. The aim of forming a professional identity within medical education is to help students develop a self-view which internalizes the core values, beliefs, and behaviors of the medical profession leading to consistent actions within the health profession community. This process occurs on personal and collective levels, encompassing the integration of individuals into suitable roles through socialization and reflection.[13] In the cyclical self-regulated learning process, *self-reflection* refers to processes that occur *after* each learning effort.[12,40] In CBCL self-reflection and self-assessment happen after class, when students complete the CAEs and reflect on their progress toward achieving learning goals. In addition, the adaptive expertise framework balances complementary 'efficient' and 'innovative' dimensions of practice.[41] Adaptive experts can efficiently use their past knowledge and experiences and innovatively create new knowledge and ideas in response to novel problems.[41–43] In a CBCL session, creating cases with multiple solutions can foster students' creativity and invite them to apply concepts and knowledge to routine solutions while recognizing when problems require new solutions.

Conclusions

This perspective article presents recommendations for supporting medical school faculty in designing and implementing flipped-classroom, team-based, collaborative approaches using the CBCL pedagogy as an example that includes aspects of general collaborative learning. It builds on relevant educational theories that address constructivism, cognitive load, critical thinking, self-directed learning, adaptive expertise, professional identity formation, and our ten years of experience teaching in this format. The recommendations are interconnected theoretically and practically (Figure 2). They are intended to help faculty make informed yet practical decisions as they design course materials that aim to transform students from college graduates to medical doctors caring for patients. We have found that well-crafted case discussions are intellectually enriching for both faculty and students and transform the classroom into a learning community where the sum is more than its parts.

Active learning requires active faculty development. During our discussions we discovered that, even among our most experienced CBCL teachers, implementation and interpretation of this case-based method varied. Developing a shared mental model was critical. The ensuing discussions were deeply rewarding and helped in advancing our own adaptive expertise mirroring the professional transformation we hope to inspire in our students. Effective active learning cannot be created in isolation. We have found that iterative discussions of both case content and overall CBCL instructional design among colleagues are the most effective and enjoyable faculty development tools at our disposal and not only serve the students but also helps create a precious sense of community and identity among faculty.

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Henrike Besche, PhD was the principal investigator and lead author of this manuscript.
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Krisztina Fischer, MD, PhD, MMSc conducted the literature review, drafted sections, and edited the manuscript.

Consent

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Ethics

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