Development and Implementation of a Medical School Course Integrating Basic, Clinical, and Health Systems Sciences

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ABSTRACT

OBJECTIVE: In recent years, significant steps have been made in integrating basic science and clinical medicine. There remains a gap in adding the third pillar of education: health systems science (HSS). Core clerkships represent an ideal learning venue to integrate all three. Students can experience the value of integrating basic science as they learn clinical medicine in environments where HSS is occurring all around them.

METHODS: We outline the creation of Sciences and Art of Medicine Integrated (SAMI), a course that runs parallel with the clerkship year and integrates basic science and HSS with clinical medicine. A complete description of the planning and implementation of SAMI is provided. We include the participants and educational setting, the goals and objectives, and the structure of each session. To encourage the integration of basic science, HSS, and clinical medicine, students utilize a series of tools, described in detail. Examples of each tool are provided utilizing a case of a patient presenting with obstructive sleep apnea.

RESULTS: We successfully implemented this course with positive reception from students.

CONCLUSION: This course represents a step not only toward the integration of HSS with basic science and clinical medicine but also an advancement in training future clinicians to provide high-value care. Future curricular development must consider the validation of a measure of clinical reasoning that assesses a student's ability to think in a cognitively integrated fashion about basic science, HSS, and clinical medicine demonstrated by enhanced justification of clinical reasoning and a more holistic approach to planning patient care.

KEYWORDS: cognitive integration, curriculum development, undergraduate medical education, high-value care, health systems science, master adaptive learner

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Introduction

The importance of integrated curricula in medical education has been widely accepted by medical schools and accrediting bodies.[1] In 2013, the Liaison Committee on Medical Education (LCME) updated accreditation standards for U.S. medical schools to emphasize a cohesive curricular structure that coordinates content across all years of medical school.[2] The structure of the integrated curriculum has evolved through various patterns and combinations including programmatic, course, session, and most recently learner-level cognitive integration.[3–5]

A goal of the integrated curriculum is cognitive integration, a learner's internal understanding of the relationship between concepts. This goal requires a curriculum to have a strong emphasis on cognitive integration as a teaching and learning strategy[7] and supports the importance of cognitive integration as a learner-level process activated within the integrated curriculum.[8] Cognitive integration in medical education requires students to explicitly elaborate on the relationship between clinical features and basic science mechanisms through self-explanations to promote a learner's development of a coherent mental representation of a disease.[9] The foundation of cognitive integration requires that integration occur within the learner's mind rather than within the curriculum.[10] In other words, cognitive integration is a psychological process powered by the integrated curriculum. Evidence has shown that students exposed to cognitive strategies that integrate clinical medicine and basic science have greater retention, more coherent understanding of clinical conditions, and more effectively solve clinical problems.[11–13] While the process of cognitive integration is at the level of the individual student, the process must be embedded within a curricular structure to promote student learning.

Robust literature describes formalized curricular and pedagogical strategies designed to promote cognitive integration. The University of Toronto's Medical School reported the use of program-level components focused on re-introducing basic science concepts during learning in clinical settings.[10] They used these strategies within small groups or limited lectures and included the use of causal networks and integrated explanations. The Vanderbilt School of Medicine developed "Integrated Science Courses," which emphasize active and experiential learning through traditional classroom learning, clinical experiences, reading, online modules, and self-directed learning.[14] Over the last several years, additional institutions have reported integrating basic science and clinical medicine during the clerkship year.[15]

Given the recent definition of the integrated curriculum as a trans-disciplinary delivery of foundational and applied sciences,[1] medical educators have extended their efforts toward integration that includes Health Systems Science (HSS). In 2020, Gonzalo et al provided a call to action to incorporate HSS with basic science and clinical medicine to better align medical education across the continuum of undergraduate medical education to graduate medical education.[6] Integrating knowledge of basic science and clinical medicine allows healthcare providers to accurately diagnose and identify treatment options, but diagnosis and treatment are not enough. Delivering high-value care requires providers to master the environment in which medicine is practiced. HSS defines this environment.

The problem we seek to address is the lack of structured curricular approaches for learners to integrate all three requirements for high-value care: basic science, HSS, and clinical medicine. We designed a curriculum to promote cognitive integration of all three areas. In what follows, we outline our approach to creating and implementing the "Sciences and Art of Medicine Integrated" (SAMI) course.

Methods

We describe a curriculum created in 2018–2019. Launched in the summer of 2019, SAMI has now been running for four years. All Case Western Reserve University School of Medicine students participate during their core clerkships. Data for this study was approved for dissemination under the IRB-approved CWRU Medical Education Data Registry (IRB# 20211086). The CWRU Medical Education Data Registry collects written consent for the use of de-identified data from student feedback surveys.

Educational setting and participants

SAMI is a weekly course that runs in parallel with the core clerkships. It takes place in the classrooms and low-fidelity simulation center of the medical school. Students with different clerkship schedules are organized in small groups of nine, thereby creating teams with diverse clinical experiences. Groups are facilitated by clinician educators including residents, fellows, attendings, physician assistants, and retired clinicians. Both the small groups and their facilitators remain consistent throughout the academic year.

Program description

The planning and ongoing administration of SAMI requires a collaborative team of individuals that includes clinician and basic science educators, HSS and communication experts, bioethicists, clerkship directors, and current medical students. The overall goals of the course are to:

- Improve clinical reasoning through the integration of basic science and HSS with clinical medicine.
- Strengthen history and physical exam skills by providing students feedback on weekly standardized patient encounters.
- Enhance humanism through reflection, discussion, and communication skills practice.
- Foster students' engagement with a patient's personal and systemic context of illness.

Session-level objectives are consistent week-to-week. As an example, these are the learning objectives for the session involving a patient presenting with obstructive sleep apnea:

- Outline an approach to the necessary history and focused physical exam for a patient presenting to an emergency department with fatigue.
- Create a differential diagnosis for a patient presenting with fatigue.
- Define the causal mechanisms that underlie the key clinical features of obstructive sleep apnea.
- Outline the work-up and treatment of obstructive sleep apnea.
- Develop an approach to the assigned targeted treatment intervention of successful weight loss.

Planning the curricular content

Building the SAMI curriculum began by identifying which diseases to include. Most diseases were selected based on clinical conditions commonly encountered during core clerkships. Additional clinical conditions were recommended by clerkship directors. We then defined the patient for each session. Patients were assigned a variety of ages, from neonates to geriatric patients. To further mirror the clerkship experience, we varied patient presentation location between clinics and emergency rooms/urgent care. Patient sex was only specified when necessary to the disease (eg, pre-eclampsia and pulmonary embolus in pregnancy) to facilitate recruiting standardized patients. To integrate HSS, at least one of the World Health Organization's social determinants of health (eg, education, unemployment, working life conditions, housing)[16] or one of the five cross-cutting domains of HSS (leadership and change agency, teamwork and interprofessional education, evidence-based medicine and practice, professionalism and ethics, and scholarship)[6] were mapped to the clinical conditions planned for each SAMI session and written into the patient scenario (ie, standardized patient script). These elements of HSS are reviewed and acknowledged formally throughout the session.

Finally, we planned the "art of medicine" components for each session with the help of fourth-year medical students who were essential in identifying this content and approach to delivery. For example, the students specifically validated the value of reflection and storytelling to debrief clerkship experiences. They also identified clinical skills for which additional exposure is needed: practical skills like discharge planning and sign-out and advanced communication skills including delivering bad news and leading care conferences.

Pedagogical approach: a SAMI session

We committed to a highly structured, 3-h session (Table 1). All materials are provided in real-time; students do not complete any preparatory work and have no post-session assignments.

Check-in. Each SAMI session begins with a 15-min unstructured check-in. This time presents an opportunity for group bonding through storytelling, debriefing clerkship experiences, and discussing career planning. Students are unfacilitated to allow candor and privacy.

Table 1. SAMI session structure.

DURATION (MIN)	SAMI SESSION PROCESS
0:00–0:15	Check-in
0:15–0:30	Pre-encounter strategizing/preliminary differential diagnosis
0:30–0:45	Standardized patient encounter
0:45–0:55	Student patient presentation
0:55–1:10	In-depth differential diagnosis development
1:10–1:45	Integrated illness script and mechanism of disease map: creation
1:45–1:55	Integrated illness script and mechanism of disease map: teaching
1:55–2:10	Care delivery: work-up and treatment of the prototypical disease
2:10–2:25	Care delivery: targeted treatment intervention for the patient
2:25–2:55	Case conclusion
2:55–3:00	Check-out
3:00–3:20	1:1 Student facilitator feedback on standardized patient encounter

Patient encounter. Students receive a one-line patient description with age, chief complaint, and vital signs. Each group creates an initial differential diagnosis and strategizes which historical questions and physical exam maneuvers are "musts" for the chief complaint. The case is then revealed through a standardized patient encounter. One student from each group interviews and examines the patient while the rest watch a live stream. Utilizing standardized patients allows for an interactive curriculum that also provides students additional practice with focused histories and physical exams. After the SAMI session, the student who performed the patient encounter reviews the recorded encounter with their facilitator and receives one-on-one feedback.

Patient context of illness. After completing the patient encounter, students discuss the patient's context of illness. To facilitate this discussion, we created a Context of Illness Tool to help students more fully explore who their patient is and describe the context in which the patient's illness occurs, from individual to population and health systems perspective. Students consider each patient detail and place it into one of four domains: biological, psycho-emotional, social, and systems/society. The biological domain includes details that positively and negatively influence the patient's health, for example, physical attributes, pre-existing conditions, genetic influences, and habits. The psycho-emotional domain includes details about the patient's psychological and emotional state and their approach to/beliefs about health. The social domain includes details that positively and negatively effect the patient's ability to care for themselves and their family. This includes details like their social and family relationships and their physical and work environments. The systems/societal domain includes details that impact the patient's interaction with their world, for example, being uninsured, a victim of unfair housing practices, or living in a food dessert. The Context of Illness Tool also encourages students to consider unknown details that are critical to fully appreciating the patient's context and their interaction with the broader system of healthcare. A sample Context of Illness Tool for a patient presenting with fatigue due to as-yet undiagnosed obstructive sleep apnea is shown in Figure 1.

Differential diagnosis. Students then create an in-depth differential diagnosis. During the creation of their differential diagnosis, facilitators frequently ask, "Why?" This encourages students to think out loud and learn from each other's clinical reasoning. "Why?" also allows facilitators to identify gaps in reasoning. The differential diagnosis discussion concludes with the students selecting the top three diseases from their list.

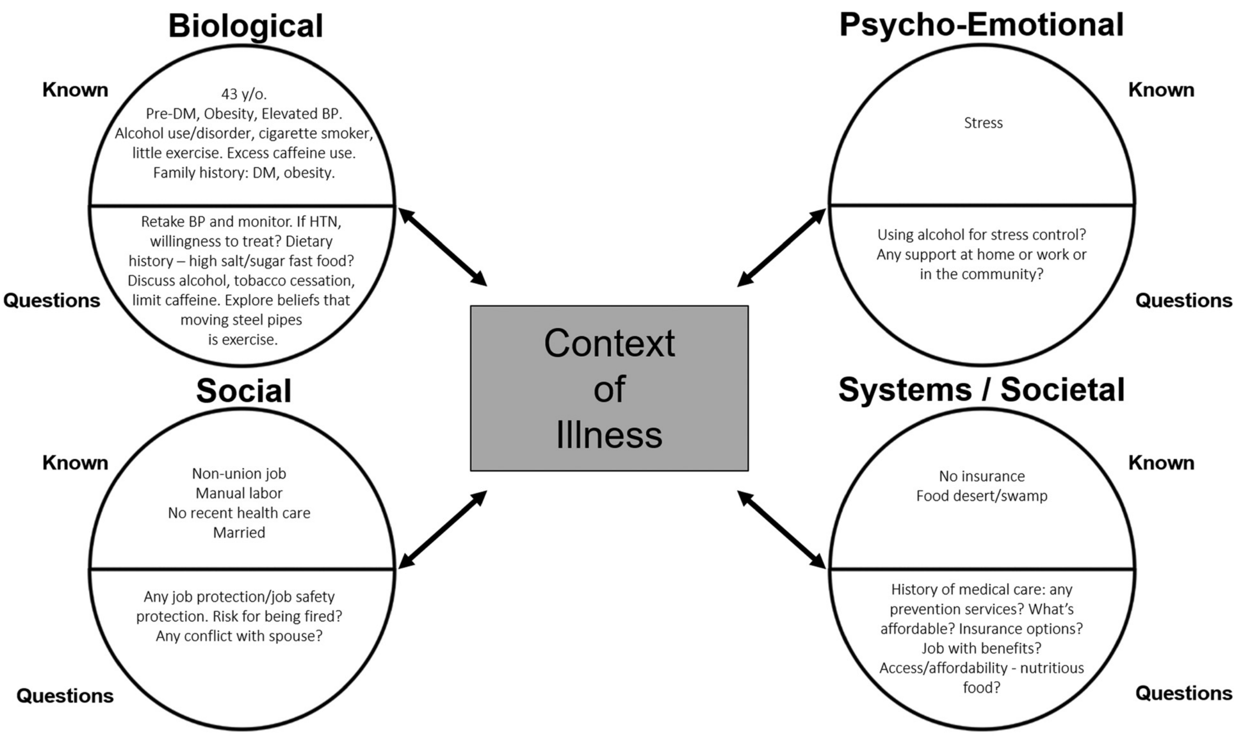

Figure 1. Context of illness tool for obstructive sleep apnea.

Basic science integration. The Integrated Illness Script and Mechanism of Disease Map pedagogical framework created by Aquifer, Inc. (www.aquifer.org) were chosen to integrate basic science and clinical medicine.[17] An Integrated Illness Script defines the condition, the epidemiology, the underlying pathophysiologic insult, and the causal and conceptual explanations of the key clinical features of the prototypical presentation of a disease.[17] The Mechanism of Disease Map illustrates the holistic interrelationships of the underlying core concepts and causal explanations for each key clinical feature, starting with the underlying insult.

Having defined the top three conditions on their differential diagnosis, students divide into teams of three. Each team creates an Integrated Illness Script and Mechanism of Disease Map for one of the diseases. A sample Mechanism of Disease Map for obstructive sleep apnea is shown in Figure 2. Once each subgroup has completed their work, they engage in peer teaching.

Justifying clinical decisions. Referring to their completed Mechanism of Disease Maps, students next answer the question, "What is the most likely diagnosis?" The Mechanism of Disease Map that best describes the patient presentation is likely to be the correct diagnosis. The facilitator reveals the diagnosis and guides the group in revisiting their clinical reasoning if they were incorrect. Groups are provided with a worked example of the correct Mechanism of Disease Map in case they did not construct their own (if they had the incorrect diagnosis). Groups are then asked to identify and justify the work-up and treatment of the prototypical disease. Students justify their decisions by physically placing the work-up and treatment on the map to show how each intersects with the basic science causal explanations. A sample of a Mechanism of Disease Map that includes work-up and treatment of obstructive sleep apnea is shown in Figure 3.

Integrating health systems science. Having defined the work-up and treatment for a prototypical disease presentation, groups return their focus to their specific patient. Groups are given a completed Context of Illness Tool for the patient. This version contains more information about the patient. Providing the students additional information simulates the reality that there is more to know about a patient than can be learned in an initial 15-min patient encounter. Students use this Context of Illness Tool to outline the specific ways in which they will help the patient succeed in one aspect of their treatment. For example, in a patient with obstructive sleep apnea, students explore ways to help the patient successfully lose weight. Students start by identifying which patient details represent supportive resources that may help the patient succeed in weight loss. They also identify which details are potential barriers. The group chooses one resource and outlines how they can help the patient leverage it to lose weight. They then plan how to help the patient overcome one of the identified barriers to weight loss. This

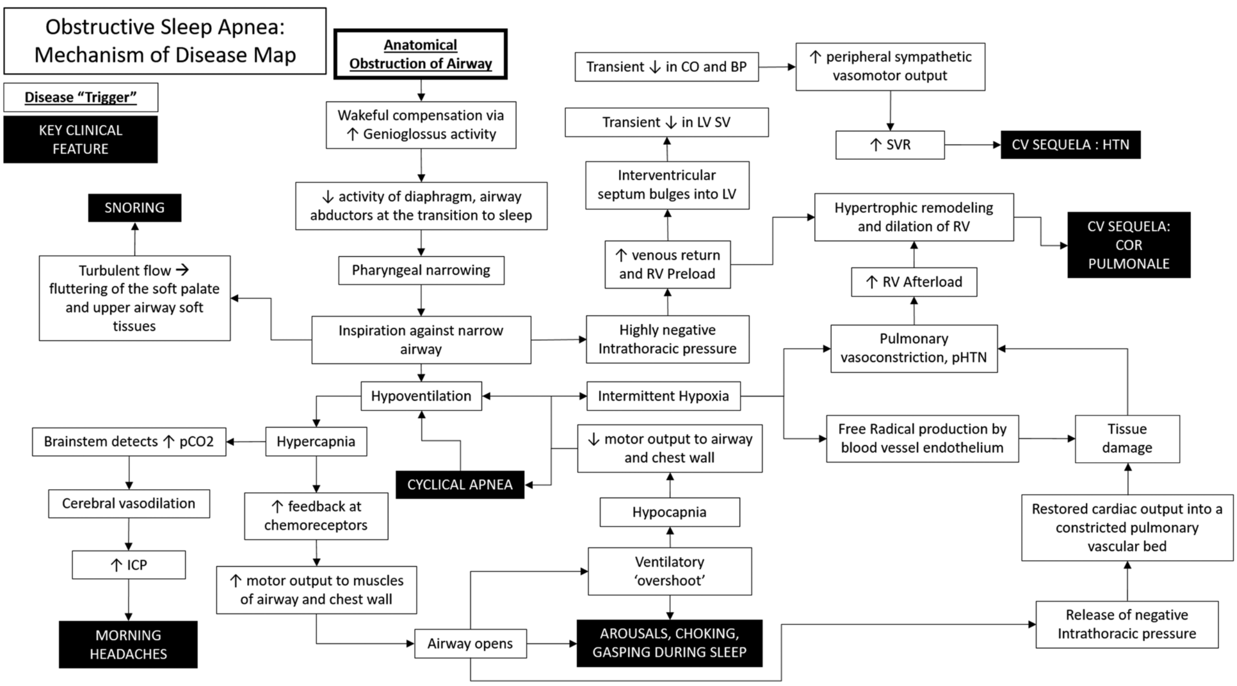

Figure 2. Mechanism of disease map for obstructive sleep apnea.

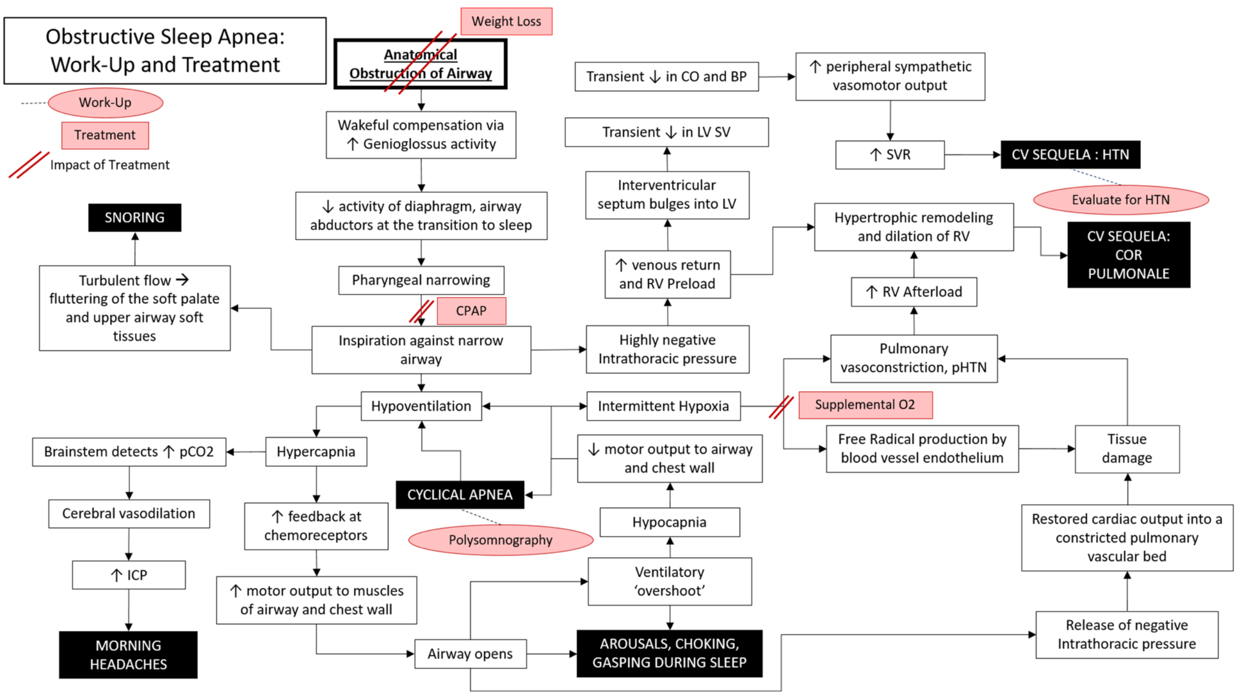

Figure 3. Work-up and treatment for obstructive sleep apnea.

final tool is referred to as a Care Delivery Tool as it helps students conceptualize moving from identifying what the treatment is to how to successfully deliver that treatment. A sample of a Care Delivery Tool for our obstructive sleep apnea patient is seen in Figure 4.

Art of medicine case conclusion. Each session concludes with an activity informed by each respective session. For example, in the obstructive sleep apnea case, students review and build on their motivational interviewing skills to promote successful weight loss.

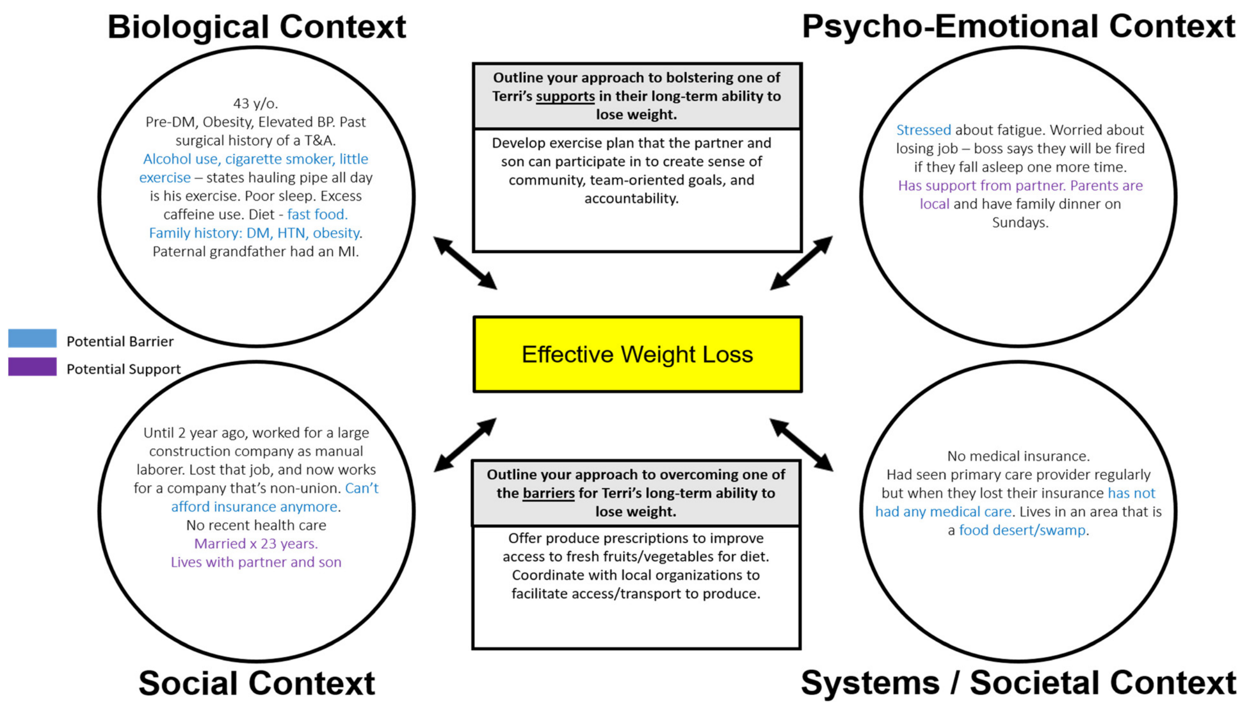

Figure 4. Care delivery tool for obstructive sleep apnea.

Check-out. Each SAMI session closes with a semi-structured check-out. Facilitators are provided probing questions that prompt students to reflect on their individual contributions and the group's teamwork. Students are encouraged to comment on strengths and areas for improvement with respect to group dynamics to engage in group-based quality improvement.

Take-home materials. At the end of each SAMI session, students are provided with the learning objectives and a list of case resources. Each case author provides students a one-page "quick guide to diagnosis and management" as a clerkship resource and summary of the work-up and treatment discussed during the session. Students receive worked examples of all session materials (eg, Figures 2–4).

Results

Student assessment

SAMI is a discrete, required course that runs in tandem with the core clerkships. Students are graded pass/fail. Facilitators assess student performance by observing their teamwork and professionalism skills during all aspects of the SAMI session. Students are also assessed by timely submission of all SAMI work (eg, Context of Illness Tools and Mechanism of Disease Maps).

Program evaluation

One approach to program evaluation focuses on student reactions to facilitation and the SAMI curriculum. For the most recent offering of the course, over half of the students stated that SAMI was "good" or "excellent" in supporting their education. Over three-fourths "agreed" or "strongly agreed" that having time to practice justifying a differential diagnosis, work-up, and treatment supported the clinical reasoning they do in their clerkships. A second approach to program evaluation utilizes facilitators who provide weekly programmatic feedback.

Discussion

SAMI answers the call for medical schools to integrate HSS with basic science and clinical medicine.[6] The integration of basic science and clinical medicine helps bolster the ability to arrive at the correct diagnosis and identify ideal management. These skills are necessary but not sufficient to delivering optimal patient care. The most effective clinicians incorporate the entire environment in which they practice medicine, from the individual patient context to the entire healthcare delivery system.

SAMI supports an environment in which students may safely practice the behaviors and skills of Master Adaptive Learners[18] and promotes students' preparation for future learning.[19] During the core clerkships, students immerse themselves in learning about diseases from presentation through work-up and treatment. The temptation to memorize "the right answers" runs the risk of students limiting their learning to pattern recognition. SAMI augments clerkship experiences through sessions that allow students to practice fully partnering with patients to devise and realize management plans.

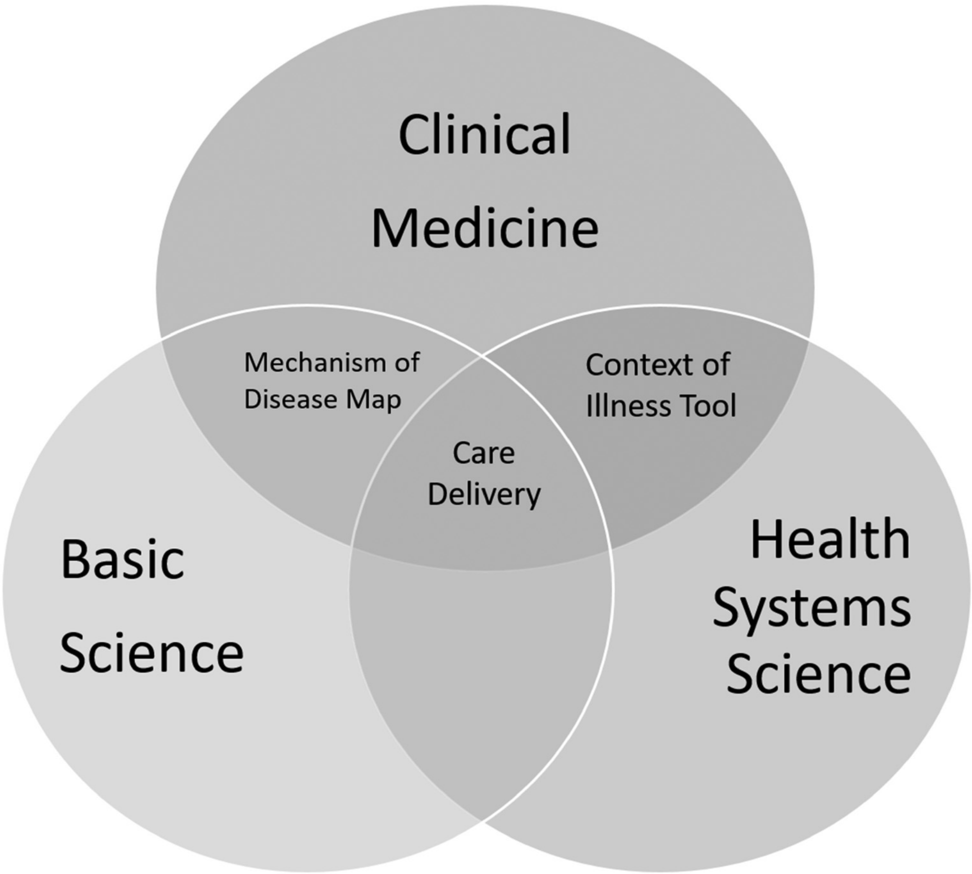

Figure 5. Structure and tools of the integrated SAMI session.

Following examples from previous research, we know that explicit elaboration on the relationship between key clinical features and basic science mechanisms promotes a learner's knowledge of a disease.[20] The structure and tools of the SAMI session were designed to promote cognitive integration[12] and move the learner beyond simple pattern recognition (Figure 5). Further, students who are content to learn the "what" of a treatment plan will miss the value of the "why" and the "how." By elaborating on how the basic science and HSS justify their clinical decision-making, students are exposed to all three: "what," "why," and "how."

Potential limitations for schools considering a program like SAMI include recruiting sufficient numbers of clinician educators, simulation center resources for conducting patient encounters, and dedicated time for weekly, three-hour sessions. The successful launch of SAMI at CWRU involved anticipating and overcoming a number of these challenges. Administrative support was required to create and implement a weekly program. We succeeded in recruiting sufficient clinician facilitators by utilizing residents, fellows, physician assistants, and retired and active faculty. Success also requires the open attitude of students to engage in a curriculum that pushes them beyond what they traditionally view as the goals of the clerkship phase of learning. The results of our most recent offering of the course suggest that students are both positively engaged and find value in participating in SAMI. Lastly, we did not include an estimate of statistical power nor validate the student feedback tool as this was not a formal survey research study. Future iterations of this work may consider a more formal survey research approach that considers these issues.

The SAMI course is currently limited in its ability to measure the impact course participation has on clinical reasoning. We are developing an integrative, standardized patient-based assessment as part of an Objective Structured Clinical Examination. We hypothesize that students who have engaged in a year-long course such as SAMI will think in a more cognitively integrated fashion about basic science, HSS, and clinical medicine demonstrated by enhanced justification of clinical reasoning and a more holistic approach to planning patient care.

Conclusion

We have successfully created a program that integrates basic science, HSS, and clinical medicine. Clinicians with the ability to switch from pattern recognition to truly integrated thinking are likely to make better decisions by aligning the sciences of medicine with patient-specific needs and goals.

These clinicians will be the ones who will transform the health-care system through true delivery of high-value care.

Author's Note

Mamta K. Singh is also affiliated with Department of Medicine, VA Northeast Ohio Healthcare System, Cleveland, OH, USA.

Author Contributions

Kathryn E. Miller substantial contributions to conception or design, drafting the work, final approval of published content, accountable for all aspects of the work. Kelli Qua contributed to drafting the work, final approval of published content, accountable for all aspects of the work. Colleen M. Croniger substantial contributions to conception or design, final approval of published content, accountable for all aspects of the work. Donald Mann substantial contributions to conception or design, final approval of published content, accountable for all aspects of the work. Karen B. Mulloy substantial contributions to conception or design, final approval of published content, accountable for all aspects of the work. Elizabeth Painter substantial contributions to conception or design, final approval of published content, accountable for all aspects of the work. Anastasia Rowland-Seymour substantial contributions to conception or design, final approval of published content, accountable for all aspects of the work. Oliver Schirokauer substantial contributions to conception or design, final approval of published content, accountable for all aspects of the work. Mamta K. Singh substantial contributions to conception or design, final approval of published content, accountable for all aspects of the work. Amy L. Wilson-Delfosse substantial contributions to conception or design, drafting the work, final approval of published content, accountable for all aspects of the work.

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