

Identifying and Analyzing Systems Failures: An Interactive, Experiential Learning Approach to Quality Improvement for Clerkship-Level Medical Students

Galina Gheihman, MD*, Brent P. Forester, MD, MSc, Niraj Sharma, MD, MPH, Cynthia So-Armah, MD, MPH, Kathleen A. Wittels, MD, Tracey A. Milligan, MD

*Corresponding author: ggheihman@partners.org

Abstract

Introduction: Medical students are positioned to observe, document, and explore opportunities to improve patient safety and quality in their institutions. Medical schools are introducing quality improvement (QI) knowledge and skills in the preclinical classrooms, yet few provide opportunities to apply these tools in the clinical setting. **Methods:** Clerkship students participated in two 1-hour sessions, organized in groups of 12-15 students, led by faculty with QI expertise. The sessions in the module introduced core concepts in QI and patient safety, while drawing on students' own clinical experiences. Students identified a system failure they encountered in their own clinical setting/practice and analyzed contributing factors using the 5 Whys Tool. We evaluated the efficacy of the two-session module with a pre- and postsurvey of students' self-reported change in knowledge, skills, and attitudes. Surveys also assessed students' satisfaction with module content and format. Faculty perspectives were solicited by email. **Results:** In April-May 2019, 59 students at a large US medical school participated. Of students, 73% and 53% completed pre- and postsurveys, respectively. All students submitted a report of an identified systems failure and their analysis of contributing factors. Students' self-rated knowledge and skills increased significantly. Students preferred active engagement compared to passive learning. Students and faculty identified areas for future module improvement. **Discussion:** The educational program was well received and increased students' knowledge and confidence in core concepts of QI and safety. The module addressed the requirement for graduating students to identify safety incidents and contribute to a culture of QI.

Keywords

Quality Improvement, Patient Safety, Systems-Based Practice, Experiential Learning

Educational Objectives

By the end of this activity, learners will be able to:

1. Define adverse events versus near misses, and describe elements of a culture of safety.
2. Identify a systems failure in their own setting/experience and practice analyzing contributing factors by applying the 5 Whys Tool.

3. Propose an intervention to address an identified system failure and discuss potential challenges and barriers to doing so.

Introduction

Medical schools, graduate medical education programs, and health care systems all acknowledge the importance of building students' and trainees' skills in quality improvement (QI), health systems thinking, and delivery science. The ACGME requires residents to be able to identify patient safety incidents and offer solutions to address them.¹ Likewise, the AAMC has listed, "Identify[ing] systems failures and contribut[ing] to a culture of safety and improvement," among its 13 core Entrustable Professional Activities (EPAs) in which graduating medical students must demonstrate competency prior to entering residency.² Accordingly, medical school curricula are increasingly emphasizing these topics.³ While medical schools are introducing

Citation:

Gheihman G, Forester BP, Sharma N, So-Armah C, Wittels KA, Milligan TA. Identifying and analyzing systems failures: an interactive, experiential learning approach to quality improvement for clerkship-level medical students. *MedEdPORTAL*. 2021;17:11151. https://doi.org/10.15766/mep_2374-8265.11151

QI concepts in the classroom, few provide opportunities to apply these tools in the clinical setting⁴ and only 29% of students feel they have received adequate training by graduation.⁵

Core clinical clerkships may offer an opportunity to engage medical students and build QI knowledge and capacity in a way that is student-centered, integrated with clinical learning, and sustainable over time. Medical students are positioned to identify, document, and explore opportunities to improve patient safety and quality in their institutions.⁶ Students witness examples of both poor quality care and excellent care during their day-to-day work, yet many do not have the opportunity or skills to contextualize or address what they are observing.

In accordance with EPA 13—“Identify systems failures and contribute to a culture of safety and improvement”²—we designed a two-session module that introduced clinical clerkship students to basic concepts in QI and patient safety. We aimed to develop students’ foundational knowledge in QI and health systems sciences, equip students with a new vocabulary of QI and patient safety terms, and build preliminary skills in QI. Since identifying systems failures and analyzing contributing factors is a foundational skill, we focused our attention on equipping students to systematically analyze contributing factors to safety incidents and propose interventions based on this causative analysis.⁷ Specifically, the module asked students to identify a systems failure, investigate contributing factors using the 5 Whys Tool,⁸ and propose interventions in response to this incident. The module was bookended by two 1-hour discussion sessions 1 month apart facilitated by faculty with QI expertise.

We know medical students witness systems failures in their daily clinical work.^{6,9} We wanted to equip them with introductory skills to begin to understand what contributes to errors as well as prepare them to report safety errors and contribute to hospital-wide QI measures in the future.¹⁰⁻¹² We also hoped to influence students’ attitudes towards QI and patient safety by introducing the concept of just culture and a culture of safety, and helping students shift from blaming individuals for safety incidents to understanding the system factors that may contribute to health care errors and near misses.¹³ We report our evaluation of this pilot and next steps for our curriculum development in this publication.

To the best of our knowledge, there are few mandatory QI modules teaching medical students to identify and analyze systems failures using the 5 Whys Tool in the clerkship year. In preparation, we reviewed *MedEdPORTAL* and other publications

available on this topic. A number of curricula focused on providing QI and patient safety education to trainees have been published, but the majority focus on training for residents.¹⁴⁻²⁰ Medical student modules have been limited and have been primarily offered to students at other stages of training or as an optional activity,²¹⁻²⁴ although one effective QI simulator in a psychiatric context was mandatory for all students.²⁵ We believe that providing this training to medical students during their clerkship year is critical for successful integration of QI and systems based-practice with developing clinical skills, and overall professional development. Curricula targeting preclerkship students,²⁶ offered in specific clerkships but not the entire clinical year,¹² or focusing on other topics within QI/patient safety other than identifying and analyzing root causes—such as disclosing errors to patients⁷—have been reported previously. At the time of writing, we found no QI curricula focusing on a systematic approach to root-cause analysis for medical students in the clerkship year that was published and immediately available for use.

Methods

Module Development

A two-session module was developed following a literature review and the authors’ prior experience in educational design. The session was reviewed by two educators with expertise in health systems sciences and QI education, and medical education curriculum design, respectively. The module was pilot tested with two fourth-year medical students who provided valuable feedback about simplifying pre-session work requirements, spacing the sessions out over a 1-month time frame, and clarifying instructions and key concepts in the session guide.

The module introduced students to basic concepts in patient safety and QI, and guided students in applying these skills in their own practice. A detailed session guide (Appendix A) and accompanying key concepts sheet (Appendix B) were created to guide student preparation and assist faculty facilitating the sessions. Session 1 focused on event identification and analysis, with students working through the Institute for Healthcare Improvement’s (IHI) 5 Whys Tool worksheet⁸ (included as Appendix C with permission for reprinting and use from the IHI). Between sessions, students investigated contributing factors and brainstormed interventions to address a specific systems failure. They were guided in this work by completing a structured reflection assignment prior to returning to Session 2 (Appendix A). Session 2 offered an opportunity to debrief as a group about the experience of investigating root causes and

completing the reflection (guiding questions in Appendix A, Session 2).

Prerequisite Knowledge

Prior knowledge required for students included reviewing the session guide (Appendix A), key concepts sheet (Appendix B), and the first two pages of the 5 Whys Tool worksheet (Appendix C) to learn new vocabulary prior to the session. Students were also asked to think about a quality or safety incident they may have witnessed during their clinical training or experienced as a patient or family member. No further prerequisite knowledge was required. In our initial session, we asked students to complete two online modules from the IHI Open School²⁷—however in feedback we were told by students they did not review these modules as they did not feel they had time for them. As such, we have included this as an optional resource but removed it as a required prerequisite for the session.

Faculty leading discussions had some prior experience in teaching QI and/or leading quality initiatives within the hospital, and thus had a working knowledge of foundational concepts in QI and patient safety, as well as comfort with conducting contributing factors analysis, considering unintended consequences, and discussing basic QI methods (e.g., the Model for Improvement, plan-do-study-act cycles, run charts, etc.). While this QI expertise was an asset for answering student questions, faculty did not require any specific prerequisite knowledge to facilitate the sessions as suggested guiding principles and questions were provided in the detailed session guide (Appendix A), which supported students and faculty to move together from event identification, to contributing factors analysis, and then to suggesting solutions for implementation over the course of two sessions.

Setting and Participants

The pilot ran in April-May 2019, during the students' core clerkship year at a large urban US medical school. Students were completing rotations at a large tertiary care medical center. Students were in the second year of a four-year MD program—it was their core clerkship year during which they rotated among several specialties for 1-3 months at a time. At our medical school, clerkship students are randomized to rotate at one of four hospitals. The pilot ran at one of our four hospitals only; all students rotating at that hospital participated.

Students enter the core clerkship year at two entry points. Thus, students were either one or three quarters into their clerkship year. We included both groups of students as we felt this session would be valuable for all students regardless of their timing in the

clinical year. For students further in the clinical year, they would have more clinical exposure but would gain the vocabulary to describe what they had observed. For students earlier in the year, we anticipated they would be equipped with a new lens through which to observe systems failures in the coming months. All students did not have any prior formal curricula related to QI or patient safety topics prior to this session, although students may have been exposed to these concepts informally.

Students were already scheduled to meet in four groups of 12-15 students twice monthly for a yearlong humanistic curriculum at our institution. Students at various time points in the clinical year were mixed amongst all groups. The QI module was offered over two 1-hour sessions, spaced 1 month apart, during this dedicated time. The sessions were facilitated by four guest faculty members with expertise in QI and patient safety.

Module Implementation

Details of module implementation were outlined in the session guide (Appendix A) which provides students and faculty with step-by-step guidance to work through the two sessions.

Briefly, before the session, students were prompted to review the key concepts sheet (Appendix B) and the 5 Whys Tool worksheet⁸ (Appendix C) ahead of time. Students were asked to reflect on a systems failure, error, or near miss they had observed during their clinical experiences and come prepared to discuss one case that they would like to investigate further. Students completed the pre-session survey online prior to session 1 (Appendix D).

Students and faculty met in groups of 10-12 students in a small meeting room. Meeting rooms had tables and chairs for all students and faculty as well as whiteboards available to make note of discussion topics. In session 1, faculty began by reviewing the modules, summarizing key concepts and asking for students to raise any preliminary questions. Students then worked in pairs to complete the 5 Whys Tool worksheet⁸ (Appendix C) for each of their respective cases, which were printed ahead of time and provided to students in hard copy. This worksheet guided students through identifying and describing a system failure they had encountered in their own practice as well as analyzing possible categories of contributing factors that led to the error. The faculty led students through an example of discovering the contributing factors to a QI or patient safety incident and encouraged each of them to undergo a similar investigative process for their QI or patient safety incident in the coming month (e.g., by speaking with other stakeholders involved, reviewing the literature on the topic, proposing

categories of contributing factors, etc.). Students then pursued their own investigation of their case and completed the reflection assignment (Appendix A, page 4) prior to the second session. The assignment prompted students to submit a one- to two-page reflection in which they identified a system error in their clinical practice, analyzed contributing factors, and reflected on the experience.

One month later, students returned together in the same group with the same QI facilitator to debrief their experiences investigating and reflecting upon their QI incidents. Semistructured guiding questions for discussion were provided in the session guide (Appendix A, page 5), however QI faculty were also free to respond to the needs of the students. Many students wanted to hear about current QI initiatives taking place in the hospital and what next steps occur when a QI incident is identified and reported. Our QI faculty were able to answer these questions from their own knowledge and experience working within the QI and patient safety infrastructure of the institution. Finally, students completed a postmodule survey by email (Appendix E). We also surveyed faculty by email after the modules were completed (Appendix F) to gather their perspectives on module value and ease of facilitation.

Evaluation Approach

Survey instrument: Students completed a pre- and postmodule survey (Appendices D and E, respectively) to assess their self-reported change in knowledge and understanding of basic concepts in patient safety and QI. Our surveys were designed de novo for this pilot project following the Kirkpatrick Model²⁸ for educational program evaluation to evaluate students' knowledge, skills, and attitudes. We pilot tested our survey with two medical students and the survey was also reviewed by two faculty with experience in QI and medical education research.

Students were asked to self-report their level of understanding or level of confidence with fundamental concepts and skills related to QI and safety on a 10-point scale (1 = *low understanding/confidence*, 10 *high understanding/confidence*) as well as their level of agreement with statements assessing their attitudes towards QI. The same questions were asked in the pre- and postsurvey to assess changes in self-reported understanding and confidence following the module. The postsession survey evaluated the overall quality of the module and students' satisfaction with content and format on a 5-point scale (1 = *strongly disagree*, 5 = *strongly agree*).

All student reflective assignments were collected and marked for participation. Students emailed a copy of their assignment in a

Word or PDF file to the clinical coordinator who deidentified these and sent them to the faculty.

Data collection and analysis: Surveys were distributed via Qualtrics to students' emails, with two weekly reminders following the session. We also surveyed faculty facilitators (Appendix F) via email after the completion of both sessions on the module's overall value, ease of facilitation, and suggestions for improvement.

For data analysis, descriptive statistics were completed in Excel (Microsoft Office). We used nonpaired *t* tests to compare student responses pre- and postmodule. We used a significance level of $\alpha = .05$.

Student reflections were reviewed and marked for participation only. They were reviewed for evidence that the students followed the assignment guidelines including event identification, contributing factor analysis (following the format of the 5 Whys Tool worksheet, and a brief self-reflection on this experience and their learning).

Ethical approval: Ethical approval was obtained from the Harvard Medical School Academy. The study protocol was reviewed and deemed QI by the academy so it was waived from formal Institutional Review Board review.

Results

A portion of these results were reported by the authors previously as a Concise Research Report in the *Journal of General Internal Medicine*.²⁹ We summarize these findings and present new data below.

Participant Demographics

All students who participated ($N = 59$) were in their core clinical clerkship year and represented all of the students randomized to rotate at one of four hospitals affiliated with our medical school. Some students had started the clerkship year 8 months before (43 of 59; 73%) and the remaining students started 2 months before (16 of 59; 27%). Of students who participated, 43 completed the premodule survey in its entirety (response rate 43 of 59; 73%) and 31 completed the entire postmodule survey (response rate 31 of 59; 53%).

Four QI faculty were involved in delivering content. All were early-to-mid career doctors in different subspecialties (one in general surgery, two in internal medicine, one in psychiatry) who were involved in either leading QI/patient safety projects within their department and/or at the hospital level, or teaching QI and patient safety to trainees.

Student Reflective Narratives

All students submitted one- to two-page narrative reflections that included a summary of a systems failure identified from their clinical experience, an analysis of contributing factors following the 5 Whys Tool worksheet format, and a brief reflection on their experience. All students demonstrated an ability to identify a system failure which they encountered during a clinical rotation and to identify diverse contributing factors to this error. We did not assess the quality or comprehensiveness of student analysis beyond noting compliance with the assignment, including whether students identified a critical incident or error, completed the 5 Whys Tool analysis of contributing factors in their write-up, and included a self-reflection. All students demonstrated each of these elements, in alignment with our second Educational Objective for students to, "Identify a systems failure in their own setting/experience and practice analyzing contributing factors by applying the 5 Whys Tool." We intend to conduct a qualitative analysis of students' narrative reflections and as such do not report these results here.

Students' Self-Rated Knowledge and Skills

As previously reported, following the module we found a significant increase in students' self-rating of their level of understanding of basic concepts within patient safety and QI ($M = 6.1, SD = 2.0$ vs. $M = 8.2, SD = 1.6, p < .001$), basic steps for improving systems ($M = 4.4, SD = 1.9$ vs. $M = 7.9, SD = 1.5, p < .001$), and the role they could play as students ($M = 5.3, SD = 2.0$ vs. $M = 7.2, SD = 1.8, p < .001$). Similar significant improvements were seen in students' self-ratings of their skills following the module, including identifying a systems failure in their clinical work ($M = 6.5, SD = 2.0$ vs. $M = 8.3, SD = 1.6, p = .001$), using the 5 Whys Tool to understand contributing factors ($M = 3.7, SD = 2.5$ vs. $M = 8.1, SD = 1.4, p < .001$), proposing possible interventions to address systems failures ($M = 5.6, SD = 2.0$ vs. $M = 7.9, SD = 1.5, p < .001$), and reflecting on unintended consequences of interventions implemented to address systems failures ($M = 6.3, SD = 1.8$ vs. $M = 8.2, SD = 1.5, p < .001$).

Students came into the session with a wider variance in their skills and abilities; the standard deviation among students decreased after the module.

Student Attitudes

Student attitudes were assessed by their level of agreement with two statements. After the session, all students (31 of 31; 100%) agreed or strongly agreed with the statement, "It is important for medical students and physicians to be able to identify errors and contribute to a system of patient safety and QI." In keeping with this strong interest, all but three students agreed or strongly

agreed (28 of 31; 90%) with the statement, "I am interested in learning more about patient safety and QI in health care," following the session.

We solicited students' overall impression of the quality and value of the module. We found a majority (25 of 31; 81%) agreed or strongly agreed with the statement, "These two sessions have increased my interest in patient safety and QI." Likewise, 74% (23 of 31) agreed or strongly agreed the sessions should continue during the clerkship year in the future.

Evaluation of Module Quality and Value

We asked students to rate which components of the session and materials contributed most to their learning. Students preferred active, participatory components (e.g., completing the 5 Whys Tool worksheet in Appendix C, reflecting with classmates in real time) versus passive didactic teaching or individual assignments (e.g., completing online preparation work, written reflection). Students most valued the dedicated time during the session, finding it difficult to allocate time outside the session to complete prerequisite prep work or the reflection assignment. Of students who completed the postsession survey, 90% (28 of 31) agreed or strongly agreed that having a QI-trained faculty facilitator contributed significantly to their learning.

Suggestions for Module Improvement

Through open-ended responses, we solicited students' ideas for how to improve the module. Thematic analysis revealed key elements to keep in future iterations and areas for improvement (Figure 1 includes a summary of student suggestions, with additional student quotations available in a previous publication²⁹). Students appreciated the two-session structure (which provided an opportunity to return as a group and debrief their investigation experiences), faculty facilitators with QI expertise, and dedicated time to process cases with fellow students in a supportive setting. Novel ideas for how to improve the session for the future include: (1) providing information about ongoing QI initiatives in our hospital, and (2) finding opportunities to feed forward student cases and ideas for improvement into the formal QI and safety infrastructure at the institution (Figure 1).

Very few students were able to complete the suggested online preparatory modules from the IHI Open School²⁷ that were recommended in the original curriculum. Students felt they did not have enough time amidst clinical duties to review these before the session. Given that few students completed these modules, and yet our results still showed a significant improvement in students' self-rated knowledge, skills, and attitudes as a result of this session, we feel confident that the

Students	
Elements to Keep	Suggestions for Improvement
<ul style="list-style-type: none"> Utilize facilitator with background in QI. Offer case-based discussion of real scenarios. Require structured, guided reflection (e.g., using the 5 Whys Tool worksheet). Dedicate time for discussion with fellow students and sharing of experiences. Schedule processing time between sessions (focus first session on introduction, second on debriefing). Identify the role medical students can play in QI within the institution. 	<ul style="list-style-type: none"> Require less prep work and clarify instructions. Sign-post the session earlier in the year (introduce basic concepts early so students are on the lookout for cases ahead of this module). Schedule dedicated time to complete reflection assignment. Offer more time for the session discussions. Provide information about current QI/safety initiatives at the local institution. Feed forward student cases into the formal QI infrastructure at the institution; if possible, provide feedback on actions taken. Demonstrate filing a safety report and discuss what happens next at the institution level to address reported systems failures.

Figure 1. Summary of students' suggestions for module improvement. Abbreviation: QI, quality improvement.

benefits of the curriculum would still hold if we removed this as a required prerequisite. As such, the updated session guide for this curriculum (Appendix A) reflects this change. We still listed the modules as an optional resource for students interested in learning more. Finally, students noted that it was challenging to find time to write their reflections and requested protected time for completing the assignment.

Faculty Perspectives and Experiences

Faculty feedback mirrored student perspectives. Faculty also valued having a facilitator with QI expertise. Faculty emphasized the need for students to reflect on their individual clinical experiences, supported and guided by a systematic and structured methodology. Challenges identified by faculty included limited time and balancing input from all students versus in-depth discussion of a few cases. Faculty also raised the idea of introducing students to more formal processes for QI and safety within the hospital (e.g., demonstrating safety dashboards and adverse event reporting systems) in order to expose students to QI and safety practices at our institution. For example, one

faculty member suggested the following: "I might expand the discussion/case analysis to think more broadly about system and individual contributors to the error or event. Might have some more structured conversation around safety reporting on the wards and in the hospital and clinics."

Figure 2 lists a summary of faculty perspectives on elements to keep or change for module improvement.

Discussion

Our pilot was well received by medical students in the clerkship year and led to a statistically significant increase in students' self-rated knowledge and skills related to core concepts in QI and patient safety. We also showed that our program involving two 1-hour sessions can be successfully integrated into an established clinical clerkship environment. The module was designed to target EPA 13 for students to, "Identify systems failures and contribute to a culture of safety and improvement,"² and we feel confident the module reached its objective. Students demonstrated an ability to apply new QI skills, including

Faculty	
Elements to Keep	Suggestions for Improvement
<ul style="list-style-type: none"> Utilize facilitator with background in QI. Structured and systematic analysis of problems (e.g., using the 5 Whys Tool worksheet). Student reflections of their own medical errors and/or safety incidents that one was involved in or witnessed on a clinical rotation. Discussion of fair and just culture and how it does or does not play out during clinical rotations. 	<ul style="list-style-type: none"> Clarify instructions and role of QI faculty. Offer more time for the session discussions. Provide a structured conversation around safety reporting in the hospital and clinics (e.g., introducing students to the formal safety reporting system or showing QI dashboards).

Figure 2. Summary of faculty suggestions for module improvement. Abbreviation: QI, quality improvement.

identifying and analyzing systems failures in the clinical setting through group work during the in-person sessions as well as in their submitted assignments. Additionally, students gained an understanding of the role they can play if they observe or participate in a future adverse event or systems failure in the hospital.¹⁰

Principles of adult learning theory³⁰ and Kolb's experiential learning cycle³¹ informed our design of the module. Our intention was to support students in learning from their own experiences, actively reflect, and integrate new knowledge and skills into future practice. We chose to emphasize active, real-time, participatory learning, and evaluations of the session confirmed an experiential, interactive approach contributed most to students' learning. Specifically, students preferred completing the 5 Whys Tool worksheet⁸ (Appendix C) and reflecting with classmates in real time with the support of a trained QI facilitator, as compared to completing prework assigned ahead of the session or the individual reflective assignment on their own time. Key elements suggested by students to keep in the module or change to improve it reflected this pattern (Figure 1). Involving faculty with QI expertise was an essential success factor in our intervention. QI faculty helped answer student questions, discussed institutional QI policies, and facilitated in-depth discussions including noting the strengths and limitations of systematic analysis such as that facilitated by the 5 Whys Tool. Limited availability of faculty with QI expertise to guide these sessions may be a barrier to implementing this module in other institutions.

We intend to deliver this module to clinical students at our institution again next year. The sessions will be improved upon in response to student and faculty feedback. First, as mentioned above, we will be removing the requirement to complete the online IHI modules ahead of the session as there was minimal uptake of this resource among students; however, it will remain as an optional resource in the student guide. We have kept the reflection assignment as it is, but we will begin sign-posting this session earlier during orientation at the start of the year. In this way, we hope to encourage students to begin noting adverse events or critical incidents in their early clerkship rotations so they are able to come better prepared for the group discussions during the sessions. We are also allocating 1 hour of dedicated writing time in students' calendars following the first session to complete the reflection assignment, in recognition of the many competing demands on students' time during the clinical year. We will continue to engage QI-trained faculty facilitators in these sessions and update our faculty guide.

Limitations

Limitations of our evaluation included a small sample size in a single institution in an academic medical setting; our results may not generalize to students in other years, institutions, or clinical settings. There may be nonresponse bias given the lower number of students completing the postmodule survey. While we could not link individual student responses and thus reported them in aggregate, we had robust response rates and a sufficient sample to detect nonpaired statistical differences in pre- and postmodule results. There may be response bias among students interested in QI and patient safety, however we suspect this was minimal given the mandatory nature of the session. In terms of the evaluation approach, we assessed students' self-reports and did not observe behaviors. We felt this was appropriate to evaluate students' self-perceptions of their knowledge and skills.

One limitation was that we utilized a survey developed de novo for this pilot study, rather than a previously validated one. Future longitudinal research is needed to validate our survey against other available self-reported measures, to formally evaluate changes in student knowledge beyond students' self-report (e.g., through a standardized case or through faculty assessment of students), and to investigate whether students change their behavior as a result of these modules. We did not conduct a detailed analysis of students' reflective narratives beyond noting their compliance with the assignment instructions. Future research, including qualitative analysis of the student reflections, can help assess the quality and comprehensiveness of students' written analysis and their ability to apply new skills of identifying and analyzing systems failures in their own clinical setting. We did not design a longitudinal component to this pilot evaluation; it would be interesting to assess whether this module affects students' future involvement in QI to determine if early exposure affects later engagement.

Another important limitation of this educational intervention was that students did not have an opportunity to participate in a practicum component, such as initiating a QI project or joining existing projects within our institution. We hope that by exposing students to the fundamentals of QI and patient safety knowledge and skills, we can encourage those interested in learning more to seek additional elective opportunities available within students' medical school curricula or at their associated hospitals. Within our institution, senior students who have completed their clerkship year may participate in a month-long QI and patient safety elective, lead their own QI project as part of the graduation scholarly requirement, enroll in the health systems sciences Advanced Integrated Science Course (inaugural offering

Spring 2020), or join QI initiatives at the institution where they completed their clerkship training or another Harvard Medical School-affiliated hospital. Moreover, as a result of growing student interest in QI and patient safety, the medical school now offers a student-run QI and health system interest group where students can continue to grow their knowledge and skills. Other opportunities for medical student involvement described in the literature include preclerkship and longitudinal curricula,^{13,26,32} simulation-based learning of QI,¹¹ dedicated clerkships to QI,²⁴ and involvement in safety event reporting, analysis, and QI project implementation.¹¹⁻¹³ Each medical school and institution may vary in the opportunities available to students in their specific setting. We believe instruction in QI and systems-based practice should be introduced early in the medical school curriculum. Our pilot module in the clerkship year could be complemented by foundational curricula in the preclerkship years^{26,32} as well as opportunities for QI involvement integrated across the full 4 years of medical school.³³

Important considerations for implementing this module within the formal structure of the clerkship year are time constraints and competing interests for students' education. These limitations apply for any newly proposed curricular change that may conflict with established clerkship organization and educational priorities.

At our institution, no prior formal curriculum in QI existed for medical students in the clerkship year. Some students may have been exposed to these concepts through the graduate medical education environment, but this was not consistent. We were fortunate that we were able to substitute our module for two sessions within an existing twice-monthly longitudinal humanistic curriculum. Students were already scheduled to be off clinical duties during this time, and thus we did not require buy-in from clerkships. Other institutions may need to negotiate for student time with clerkship leaders when implementing this module. We believe a small pilot like ours is an opportunity to plant the seed for future QI training and offers a means for educators to introduce and ultimately grow such an educational program, either integrated with or as a compliment to other undergraduate and graduate medical education QI initiatives at their institutions. In future work, we hope to engage clerkship directors to investigate opportunities for collaboration with specific clerkships, and to gather feedback on whether the module impacts students' behavior. Buy-in from clerkship directors may be important to ensure the longitudinal sustainability of clerkship-year curricula.

Future Directions

There are many ways for medical students to contribute to and get involved with QI and patient safety efforts within medical

schools and in clinical settings. Medical students are well positioned to observe, document, and explore opportunities to improve patient safety and quality.⁶ One of our major objectives, therefore, was to help students understand the role they could play in QI and to begin to encourage engagement with this role. Our module emphasized specific foundational skills, knowledge, and attitudes related to event identification and analysis such as searching for multiple underlying root causes, considering systems issues, and practicing a culture of safety. Students explored this theoretically, drawing upon their experiences in the clinical setting.

We recognize that students may not feel comfortable bringing up systems failures or issues within their clinical teams, especially if there is a perceived hierarchy of power or concerns about evaluation. Our module created a safe space in which students had a chance to practice voicing their observations, processing their emotions, and practicing foundational skills in QI that may equip them with the vocabulary and confidence to explore future issues that arise. We wanted students to know there exist alternative safe avenues to raise concerns if they did not feel comfortable doing so within their clinical teams.

As a next step, we are exploring opportunities for connecting students' observations and ideas into the formal QI and safety infrastructure at our hospital.^{9,11} Ideas include showcasing hospital quality dashboards during the session, training students to use the formal safety reporting system, and having students submit cases they have witnessed to the safety reporting system at our institution. A missed opportunity in the pilot iteration of this module was feeding forward students' observations of critical incidents into the hospital's formal patient safety event reporting system, such that the institution has an opportunity to become aware of students' observations and ideas to pursue health system improvements. We hope to incorporate this in later versions of this module as a means to promote deeper engagement among students with the institutional infrastructure for QI and patient safety. Students may also be contacted to share their experiences by investigators and may be invited to join the hospital team assigned to tackle the issue they raised. Future opportunities for student engagement include students shadowing with or speaking to QI professionals within the hospital. We hypothesize that these changes could increase students' likelihood of reporting future safety events and contributing to institutional QI efforts, while also addressing students' desire to have "[our suggestions] taken seriously" as described in session evaluations.^{7,12} While we did not assess students' behavior over time, future research should evaluate the

longitudinal impact of such modules on students' involvement in QI and patient safety during medical training and throughout their career.^{13,26,32}

Conclusion

Medical schools are introducing QI and patient safety concepts in preclinical classrooms, yet few provide opportunities to apply these tools in the clinical setting.³³ Our module can be feasibly implemented during the core clerkship year and engaged students in active, reflective, and experiential learning while addressing the graduation requirements of EPA 13.² This session introduced students to fundamental concepts in QI and patient safety early in their clinical training and prepared students to contribute to QI initiatives and a culture of safety throughout their career as a student, resident, and future physician.

Appendices

- A. Session Guide (Faculty and Students).docx
- B. Key Concepts Sheet.docx
- C. 5 Whys Tool Worksheet.pdf
- D. Premodule Student Survey.docx
- E. Postmodule Student Survey.docx
- F. Postmodule Faculty Survey.docx

All appendices are peer reviewed as integral parts of the Original Publication.

Galina Gheihman, MD: Resident Physician, Department of Neurology, Brigham and Women's Hospital and Massachusetts General Hospital; ORCID: <https://orcid.org/0000-0003-1599-3271>

Brent P. Forester, MD, MSc: Chief, Division of Geriatric Psychiatry, McLean Hospital; Associate Professor of Psychiatry, Harvard Medical School

Niraj Sharma, MD, MPH: Director of the Internal Medicine-Pediatrics Residency Program, Brigham and Women's Hospital and Boston Children's Hospital; Assistant Professor of Internal Medicine and Pediatrics, Harvard Medical School

Cynthia So-Armah, MD, MPH: Assistant Program Director of Quality Improvement, Internal Medicine Program, Brigham and Women's Hospital

Kathleen A. Wittels, MD: Director of Student Programs, Department of Emergency Medicine, Brigham and Women's Hospital; Assistant Professor of Emergency Medicine, Harvard Medical School

Tracey A. Milligan, MD: Vice-Chair for Education, Department of Neurology, Brigham and Women's Hospital; Assistant Professor of Neurology, Harvard Medical School

Acknowledgments

The authors wish to acknowledge Anjala V. Tess, MD, and Holly Gooding, MD, MSc, for their review of the original session materials. Thank you to all of the Developing Physician faculty who supported this session: Kathryn Britton, MD, Joaquim M. Havens, MD, John Roseman, MD, Kristen Schaefer, MD, and Erik K. Alexander, MD, all of Brigham and Women's Hospital. We also wish to specifically recognize and thank the Brigham and Women's Hospital faculty with quality improvement and patient safety expertise who facilitated the pilot sessions: Sonali Desai, MD, David Kroll, MD, and Peter Najjar, MD.

Disclosures

None to report.

Funding/Support

None to report.

Ethical Approval

The Harvard Medical School Academy Institutional Review Board approved this study.

References

1. Lane-Fall MB, Davis JJ, Clapp JT, Myers JS, Riesenber LA. What every graduating resident needs to know about quality improvement and patient safety: a content analysis of 26 sets of ACGME milestones. *Acad Med*. 2018;93(6):904-910. <https://doi.org/10.1097/ACM.0000000000002039>
2. Crowe R, Hyderi A, Rosenfeld M, Uthman M, Yingling S. EPA 13: Identify system failures and contribute to a culture of safety and improvement. In: Obeso V, Brown D, Phillipi C, eds. *Core Entrustable Professional Activities for Entering Residency: Toolkits for the 13 Core EPAs—Abridged*. Association of American Medical Colleges; 2017:17. Accessed July 24, 2019. <https://www.aamc.org/system/files/c/2/484778-epa13toolkit.pdf>
3. Skochelak SE, Stack SJ. Creating the medical schools of the future. *Acad Med*. 2017;92(1):16-19. <https://doi.org/10.1097/ACM.0000000000001160>
4. Wong BM, Etchells EE, Kuper A, Levinson W, Shojania KG. Teaching quality improvement and patient safety to trainees: a systematic review. *Acad Med*. 2010;85(9):1425-1439. <https://doi.org/10.1097/ACM.0b013e3181e2d0c6>
5. Levitt DS, Hauer KE, Poncelet A, Mookherjee S. An innovative quality improvement curriculum for third-year medical students. *Med Educ Online*. 2012;17(1):18391. <https://doi.org/10.3402/meo.v17i0.18391>
6. Gonzalo JD, Dekhtyar M, Hawkins RE, Wolpaw DR. How can medical students add value? Identifying roles, barriers, and strategies to advance the value of undergraduate medical education to patient care and the health system. *Acad Med*. 2017;92(9):1294-1301. <https://doi.org/10.1097/ACM.0000000000001662>
7. Halbach JL, Sullivan LL. Teaching medical students about medical errors and patient safety: evaluation of a required curriculum.

- Acad Med.* 2005;80(6):600-606.
<https://doi.org/10.1097/00001888-200506000-00016>
8. 5 Whys: finding the root cause. Institute for Healthcare Improvement. Accessed March 9, 2021. <http://www.ihl.org/resources/Pages/Tools/5-Whys-Finding-the-Root-Cause.aspx>
 9. Martinez W, Lo B. Medical students' experiences with medical errors: an analysis of medical student essays. *Med Educ.* 2008;42(7):733-741.
<https://doi.org/10.1111/j.1365-2923.2008.03109.x>
 10. Ryder HF, Huntington JT, West A, Ogrinc G. What do I do when something goes wrong? Teaching medical students to identify, understand, and engage in reporting medical errors. *Acad Med.* 2019;94(12):1910-1915.
<https://doi.org/10.1097/ACM.0000000000002872>
 11. Hall LW, Scott SD, Cox KR, et al. Effectiveness of patient safety training in equipping medical students to recognise safety hazards and propose robust interventions. *BMJ Qual Saf.* 2010;19(1):3-8. <https://doi.org/10.1136/qshc.2008.031781>
 12. Mohsin SU, Ibrahim Y, Levine D. Teaching medical students to recognise and report errors. *BMJ Open Qual.* 2019;8(2):e000558. <https://doi.org/10.1136/bmjoc-2018-000558>
 13. Dudas RA, Bundy DG, Miller MR, Barone M. Can teaching medical students to investigate medication errors change their attitudes towards patient safety? *BMJ Qual Saf.* 2011;20(4):319-325.
<https://doi.org/10.1136/bmjqs.2010.041376>
 14. Djurichich A. A continuous quality improvement (CQI) curriculum for residents. *MedEdPORTAL.* 2007;3:468.
https://doi.org/10.15766/mep_2374-8265.468
 15. Keefer P, Orringer K, Vredevelde J, Warriar K, Burrows H. Developing a quality improvement and patient safety toolbox: the curriculum. *MedEdPORTAL.* 2016;12:10385.
https://doi.org/10.15766/mep_2374-8265.10385
 16. Stewart D, Lye C, Lopez M, Mothner B, Camp E, Vachani J. Engaging learners through modules in quality improvement and patient safety. *MedEdPORTAL.* 2016;12:10482.
https://doi.org/10.15766/mep_2374-8265.10482
 17. Tad-y D, Price L, Cumbler E, Levin D, Wald H, Glasheen J. An experiential quality improvement curriculum for the inpatient setting—part 1: design phase of a QI project. *MedEdPORTAL.* 2014;10:9841. https://doi.org/10.15766/mep_2374-8265.9841
 18. Tapper E, Sullivan A, Tess A. Teaching quality improvement on the wards: how we do it. *MedEdPORTAL.* 2015;11:10211.
https://doi.org/10.15766/mep_2374-8265.10211
 19. Vinas EK, White AB, Rogers RG, Ridgeway JJ, Young AE. Developing best clinical practices through outcomes improvement: an ongoing quality improvement curriculum for faculty and residents. *MedEdPORTAL.* 2018;14:10676.
https://doi.org/10.15766/mep_2374-8265.10676
 20. Werner JA. An integrated, multimodal resident curriculum in patient safety and quality improvement. *MedEdPORTAL.* 2017;13:10641. https://doi.org/10.15766/mep_2374-8265.10641
 21. Bartlett CS, Huerta SA. Creating change: an experiential quality improvement and patient safety curriculum for medical students. *MedEdPORTAL.* 2018;14:10660.
https://doi.org/10.15766/mep_2374-8265.10660
 22. Dumenco L, Monteiro K, George P, McNicoll L, Warriar S, Dollase R. An interactive quality improvement and patient safety workshop for first-year medical students. *MedEdPORTAL.* 2018;14:10734.
https://doi.org/10.15766/mep_2374-8265.10734
 23. Haidet P, Cherry R, Clark MB, O'Sullivan S, Yang C. An interprofessional team-based learning module in quality improvement concepts. *MedEdPORTAL.* 2012;8:9074.
https://doi.org/10.15766/mep_2374-8265.9074
 24. Lohr K, Peppler R, Duhig J, Schlappy D. Patient safety/quality improvement clerkship. *MedEdPORTAL.* 2009;5:388.
https://doi.org/10.15766/mep_2374-8265.388
 25. Worsham C, Swamy L, Gilad A, Abbott J. Quality improvement virtual practicum: the QI simulator. *MedEdPORTAL.* 2018;14:10670. https://doi.org/10.15766/mep_2374-8265.10670
 26. Madigosky WS, Headrick LA, Nelson K, Cox KR, Anderson T. Changing and sustaining medical students' knowledge, skills, and attitudes about patient safety and medical fallibility. *Acad Med.* 2006;81(1):94-101.
<https://doi.org/10.1097/00001888-200601000-00022>
 27. Institute for Healthcare Improvement Open School. Institute for Healthcare Improvement. Accessed March 9, 2021. <http://www.ihl.org/education/Ihiopenschool/Pages/default.aspx>
 28. Kirkpatrick DL. *Evaluating Training Programs: The Four Levels.* 2nd ed. Berrett-Koehler Publishers; 1998.
 29. Gheihman G, Forester BP, Sharma N, So-Armah C, Wittels KA, Milligan TA. Introduction to quality improvement and systems-based practice: a two-part module for clinical clerkship students. *J Gen Intern Med.* 2020;35(12):3742-3744.
<https://doi.org/10.1007/s11606-020-05788-0>
 30. Taylor DC, Hamdy H. Adult learning theories: implications for learning and teaching in medical education: AMEE guide no. 83. *Med Teach.* 2013;35(11):e1561-e1572.
<https://doi.org/10.3109/0142159X.2013.828153>
 31. Kolb DA, Fry RE. *Toward an Applied Theory of Experiential Learning.* MIT Alfred P. Sloan School of Management; 1974.
 32. Dumenco L, Monteiro K, George P, Rougas S, Dollase R. Outcomes of a longitudinal quality improvement and patient safety preclerkship curriculum. *Acad Med.* 2019;94(12):1980-1987. <https://doi.org/10.1097/ACM.0000000000002898>
 33. Nie Y, Li L, Duan Y, et al. Patient safety education for undergraduate medical students: a systematic review. *BMC Med Educ.* 2011;11:33. <https://doi.org/10.1186/1472-6920-11-33>

Received: August 7, 2020

Accepted: March 3, 2021

Published: April 30, 2021