MedEdPORTAL® The AAMC Journal of Teaching and Learning Resources

Original Publication

Open Access

The Mystery Dinner RCA: Using Gamification and Simulation to Teach Root Cause Analysis

Andrea Smeraglio, MD*, Matthew DiVeronica, MD, Christopher Terndrup, MD, Jacob Luty, MD, Garrett Waagmeester, MD, Shona Hunsaker, MD

*Corresponding author: smeragli@ohsu.edu

Abstract

Introduction: Root cause analysis (RCA) is a widely utilized tool for investigating systems issues that lead to patient safety events and near misses, yet only 38% of learners participate in an interdisciplinary patient safety investigation during training. Common barriers to RCA education and participation include faculty time and materials, trainee time constraints, and learner engagement. **Methods:** We developed a simulated RCA workshop to be taught to a mix of medical and surgical specialties from over 11 GME programs and to third-year medical students. The workshop was a single 90-minute session formatted as a gamified mystery dinner including characters and sequentially revealed clues to promote engagement. Participant satisfaction and subjective knowledge, skills, and attitudes were assessed with a pre/post survey. **Results:** The workshop was completed by 134 learners between October 2018 and October 2019. The short workshop duration and premade simulation allowed a small number of faculty to train a wide variety of learners in various educational settings. Participants' presurvey (124 out of 134, 92%) versus postsurvey (113 out of 134, 84%) responses showed that attitudes about RCA were statistically improved across all domains queried, with an average effect size of 0.6 (moderate effect); 91% of participants would recommend this course to a colleague. **Discussion:** A 90-minute, gamified, simulated RCA workshop was taught to medical students and multiple GME specialties with subjective improvements in patient safety attitudes and knowledge while alleviating faculty time constraints in case development.

Keywords

Root Cause Analysis, Quality Improvement/Patient Safety, Simulation, Gamification, Games, Health Systems, Interdisciplinary Medicine, Interprofessional Education

Educational Objectives

By the end of this simulation, participants will be able to:

1. Describe the components of a root cause analysis.
2. Demonstrate root causes of an error using a fishbone (cause-and-effect) diagram.
3. Analyze an error as a result of a system design and not individual culpability.
4. Create high-fidelity corrective actions to fix systems issues.
5. Identify how root cause analysis can make health care systems safer.

Citation:
Smeraglio A, DiVeronica M, Terndrup C, Luty J, Waagmeester G, Hunsaker S. The Mystery Dinner RCA: using gamification and simulation to teach root cause analysis. *MedEdPORTAL*. 2021;17:11165. https://doi.org/10.15766/mep_2374-8265.11165

Introduction

Root cause analysis (RCA) is a structured, interprofessional team approach to studying health care–related adverse events[1] that has been broadly adopted by health care systems around the world to improve patient safety. Despite RCA's widespread use in clinical settings, experiential education in RCA for medical learners has lagged. The ACGME's 2016 and 2018 Clinical Learning Environment Review national reports showed that only 38% of learners participate in interdisciplinary patient safety incident investigations like RCA,[2,3] leading to an ACGME mandate for this as a common core requirement since 2017.[4]

Barriers to creating effective infrastructure to teach RCA include lack of faculty funding, time, and expertise to create curriculum or lead patient safety investigations.[5-8] Similarly, learners also have minimal time, limited schedule flexibility, and competing educational demands. The lack of infrastructure for quality and patient safety education is further complicated by many

learners and educators having mixed attitudes and beliefs about quality and patient safety.[9-11] A novel attempt to overcome educational barriers has been the creation of freely available mock RCA workshops.[12-15] While such workshops are useful training tools, they typically provide skeleton frameworks with local error investigation that still requires significant faculty time. Furthermore, most workshops target a specific training population[13,14] and have not been studied across a variety of GME and UME learners. Given this backdrop, it is not surprising programs may struggle to provide RCA education.

Our goal was to create a simulated RCA that would engage physician learners from any level of training and overcome many common barriers to RCA education, including both faculty and learner time constraints and learner engagement. Simulation offers the benefit of scheduling flexibility and shortened time windows, thus overcoming aspects of performance that often prohibit learner participation in real-life RCA. Furthermore, simulation is known to be an effective way to achieve procedural skill acquisition,[16,17] and early studies have indicated simulation can also be used to teach patient safety concepts.[18-20] To address faculty expertise and time constraints in creating RCA materials, we formatted our simulated RCA into an interactive PowerPoint presentation that could be delivered without modification to any physician learner group. This removed the burden of developing a local case from faculty educators.

From a learner perspective, our simulated RCA runs in a single 90-minute session as opposed to a traditional RCA that can take multiple meetings over weeks to months.[21] To add further flexibility for learners' schedules, we built simulated interprofessional roles to allow physician-only groups to run the RCA without coscheduling interdisciplinary teams. Finally, to ensure learner engagement with the material, we modified the RCA into the format of a mystery dinner to gamify the experience. Gamification is an instructional method that utilizes various game interfaces, mechanics, or models (e.g., narration, storytelling) to enhance a learning activity.[22] We incorporated gamification into our design through the format of a mystery dinner, which is a style of theater where audience members become players, creating an immersive atmosphere. The Mystery Dinner RCA guides learners to assume character roles using carefully crafted scripts and documents that slowly reveal information about the error and solve the mystery of why it occurred. Here, we outline the creation of this gamified, simulated RCA and the results of its use at a single institution as proof of concept and training outcomes.

Methods

The RCA Simulation

We began each simulation by introducing the concept of RCA, based on a modified version of the VHA National Center for Patient Safety's RCA tools.[1] We presented a brief medical event report depicting an inappropriate route of administration of epinephrine to treat anaphylaxis in the emergency department (ED). This led to cardiac arrhythmia, seizure, and ICU admission. The case was based on real adverse events reported by the Institute for Safe Medication Practices Canada[23] in combination with local provider experiences. All content was deidentified and modified as required for educational purposes. We taught nine basic steps to complete an RCA (Figure 1), with eight of the nine steps having active learning elements following the prebrief, scenario, and debrief structure.[24,25]

1. Charter a team: Based on the medical event report, the group identified appropriate RCA team members (ED, ICU, nursing, pharmacy, patient safety). Trainees were encouraged to generate a list of any team members they felt would add to the RCA, but only the five members listed above became characters in the game.
2. Chart review: Participants were given a packet of medical documentation (Appendix A) to review (ED resident note, ED nursing note, ICU code note). Notes were designed to be deliberately vague in order to generate questions. Following this, trainees created a list of pertinent information gathered and questions that still needed answering.
3. Draft sequence of events: Based on the chart review, trainees drafted a sequence of events outlining how the error had happened. This was a broad overview to help teams develop a shared mental model of what had occurred. The sequence was typically four to seven steps showing what the team believed had occurred leading up to the error.
4. Identify knowledge gaps: To answer questions identified from chart review, trainees performed mock interviews in group settings. Each department listed in the first step (charter a team) became a character within the gamified RCA. Learners became players within the game by reading the scripts to each other as characters (Appendix B) to help uncover system issues that had contributed to the error. The scripts provided descriptions of medical procedures that some learners might not have been familiar with, such as appropriate routes and dosages of epinephrine, to create a level playing field for all participants. This also allowed for hints at system fixes that

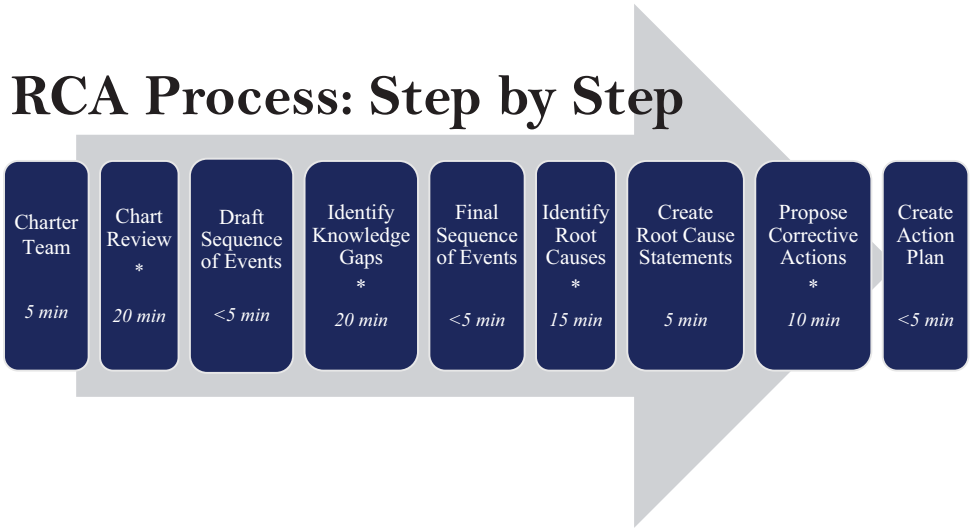

Figure. Overview of the nine steps for completing the Mystery Dinner RCA and the time needed for each step. If group size is larger than 10 participants, activities with an asterisk (*) can be divided into small groups. If the group is 10 participants or smaller, all activities can be done as a large group. Abbreviations: min, minutes; RCA, root cause analysis.

appeared later in the RCA. All characters were designed to have contributed equally to the system error by the end of the RCA except for the patient safety officer, who interviewed other characters and role-modeled nonjudgmental questioning to understand systems issues (for the patient safety officer's scripts, see Appendix C). Each role demonstrated a different systems error, perspective, and teaching point to spur discussion and better understanding of the interdisciplinary nature of health care. Discussion points, including second victim, culture of safety, cognitive bias, and the flaw of blaming individuals for systems issues, were highlighted for each character. After each interview, a debrief was held to clarify what had been learned and how this had contributed to the error.

5. Final sequence of events: The group created a final sequence of events that included the details of what had occurred based on the interview information and that thoroughly outlined how the error had happened. This sequence was typically seven to 10 steps detailing exactly how the error had occurred.
6. Identify root causes: A fishbone (cause-and-effect) diagram was used to identify at least one root cause per department that had contributed to the error. Basic training on how to perform a fishbone was done first via a didactic within the PowerPoint (Appendix D). This included an explanation that many roots could contribute to a problem and that not all lists would be the same. After discussion of the merits of each team-generated answer, a prepopulated set of roots was displayed. Teams chose to use their own root causes or the prepopulated version.
7. Create root cause statements: Based on the root causes previously identified, root cause statements were created by participants using a basic "Because of x, y error occurred" structure. It was explained that this offered a common language with which to eventually share the RCA findings with executives and other members of the hospital.
8. Propose corrective actions: To help create high-fidelity corrective actions, a basic introduction to human factors engineering was reviewed to highlight the effect of the user-system interface on error rates. Trainees were then tasked with proposing high-fidelity corrective actions to prevent the error from reoccurring in the future. This included a discussion of potential pitfalls of the proposed changes and how interdisciplinary stakeholders could make a change more successful.
9. Create an action plan: This was the only step that did not have an active learning component. Instead, learners reviewed the assignment of action items and created a time line to ensure that proposed changes, including monitoring for error relapse and any unintended consequences of the corrective actions, would be carried out.

Equipment

The simulation was run in a standard conference room with access to a projector. The version described here was based

solely on in-person education; however, since the advent of COVID-19, modifications for online training have been developed. Specific instructions on running the simulation virtually can be found in the facilitators guide (Appendix E) in the Virtual Learning Environment section.

Personnel

Five faculty members and a VA chief resident in quality and safety (CRQS) from internal medicine developed the RCA simulation as part the internal medicine residency's quality improvement and patient safety curriculum. The same six individuals volunteered to teach the RCA to third-year medical students on their core internal medicine rotation and as part of a GME quality improvement and patient safety boot camp. All five faculty teachers were experts in quality improvement and patient safety and did not require any additional training to teach the simulated RCA. The CRQS (Garrett Waagmeester) taught in combination with a faculty lead.

Implementation

Based on venue of attendance, learner group size varied from four to 30 participants. All groups with more than 10 participants had an additional facilitator per every additional 10 participants. This allowed the interactive RCA steps (Figure 1) to be done in groups of no more than 10 people. No additional personnel or support staff were needed. All participants were required by their respective departments to take the course. Third-year clinical medical students took the course independent of GME learners during a noon conference session. Interns, residents, and fellows took the RCA together in mixed groups from various departments as part of a 1-day quality improvement boot camp, except for those from internal medicine, who were required to take the RCA embedded in their longitudinal quality improvement curriculum during intern year. Each simulated RCA session took roughly 90 minutes to complete. No learners repeated sessions or took the RCA more than once. Throughout the RCA, trainees were encouraged to generate their own ideas and plans at each step. This allowed them to actualize their own experiences within health care and to generate ways the system could be improved. However, an example answer key was animated into the presentation after each activity to ensure that all key content had been covered. We stressed that there were many ways to improve a health care system, and for the sake of clarity, we provided examples, but discussion of all ideas was encouraged. Nonetheless, given the way the case was presented, we found that most learners' answers mirrored the example key provided. This model ensured that a variety of instructors would cover the same depth of content.

Survey

Survey questions about the attitudes of health care professionals regarding the conduct and benefits of RCA were adapted, with permission, from Braithwaite, Westbrook, Mallock, Travaglia, and Iedema.[26] These questions had originally been given to a multidisciplinary group of health care professionals. We used a slightly modified version of the survey (Appendix F) and included a different population; thus, we performed a series of validation steps. The survey was reviewed by a small group of internal medicine faculty familiar with patient safety to ensure content accuracy. We then had the survey reviewed by several local experts familiar with survey design. We trialed the survey on a test group of residents and incorporated changes based on their feedback. Finally, we grouped the survey questions into Kirkpatrick training evaluation model levels 1 and 2 to captures learners' reactions, as well as subjective knowledge, skills, and attitudes.[27]

Analysis

Microsoft Excel was used for all analysis. Descriptive statistics were used to report demographics, pre/post comparisons, and all satisfaction questions. In addition, unpaired two-tailed *t* tests were used to compare pre/post survey results as not all participants who completed the pretest survey also completed the posttest survey. Effect size as defined by Cohen was calculated for attitude-based pre/post questions.[28] The study and use of the survey received institutional IRB approval (OHSU 5/2018 STUDY00018058).

Results

The course was completed by 134 respondents between June 2018 and October 2019. Of the 134 participants who took the course, 124 (92%) completed the initial presurvey. A total of 113 participants (84%) completed the postsurvey. Various levels of trainees participated, including third-year clinical medical students (32), interns/residents (41), and fellows (51). A variety of medical specialties were represented, with general surgery, internal medicine, and other (we did not list fellowship specialties) being the most common (Table 1). Baseline rates of error reporting were collected to demonstrate our learners' underlying engagement with patient safety. Our results showed that 73% of learners (80) self-attested reporting zero patient safety events in the previous 6 months, 24% (21) reporting one to two errors, 4% (four) reporting three to six errors, and 0% reporting more than seven errors. When asked to estimate "how many times you probably could have reported an error in the past 6 months," 18% of learners (20) said zero times, 50% (55) said one to two times, 26% (29)

Table 1. Demographics

Category	Count
Level of training	
Fellow	51
Resident	14
Intern	27
Medical student	32
Program type (for fellows, residents, and interns)	
General surgery	13
Internal medicine	12
Orthopedics	8
Anesthesia	5
Radiology	4
OB/GYN	3
Pediatrics	3
Radiation oncology	2
Family medicine	2
Neurology	1
Preliminary	1
Other	35

said three to six times, and 5% (six) said more than seven times.

In reaction to the course (Kirkpatrick level 1), 95% agreed or strongly agreed that the mystery dinner was an effective format to teach an RCA. Ninety-one percent agreed or strongly agreed that they would recommend this course to a colleague. Learners' subjective knowledge, skills, and attitudes (Kirkpatrick level 2) showed that 96% of learners agreed or strongly agreed they were better trained in the methods of patient safety in health care. Ninety-five percent agreed or strongly agreed they had sufficient understanding of what was required to conduct an RCA (Table 2). Ninety-nine percent of learners agreed or strongly agreed they had the skills to be involved in an RCA after completing the simulation (Table 2). In our pre/post analysis, we found universal statistically significant improvement in learner attitude about the benefits of conducting an RCA after completing the Mystery Dinner RCA course. In all domains queried we found a 3%-17% change in attitude towards a more positive view of RCA, with an average effect size of 0.6 (medium effect; see Table 3).

Discussion

We developed a gamified RCA simulation that was taught to learners from medical school through fellowship from both medical and surgical specialties in a single 90-minute session with good learner satisfaction. This allowed a small group of internal medicine facilitators to teach a large number of learners from varying specialties about RCA without having to modify the content. By providing scripts that gave universal background information and hints at system fixes, our method of delivery allowed a mix of specialties and training levels to engage. This recipe for broad inclusion let us insert the RCA into a myriad of settings, including medical student noon conference,

Table 2. Postcourse Responses on Course Effectiveness and Participant Satisfaction

Kirkpatrick Level	Question and Training Levels	% (No.)	
		Strongly Disagree/ Disagree/Neutral	Agree/Strongly Agree
Level 1: Reaction	After completion of the mock RCA course, I am better trained in methods of patient safety in health care.		
	GME	1 (1)	99 (79)
	UME	10 (3)	90 (28)
	Total	4 (4)	96 (107)
Level 1: Reaction	After completion of the mock RCA course, I have sufficient understanding of what is required to conduct an RCA.		
	GME	6 (5)	94 (75)
	UME	0 (0)	100 (31)
	Total	5 (5)	95 (106)
Level 2: Knowledge	Overall, the mock RCA course provided me with skills to be involved in an RCA.		
	GME	1 (1)	99 (79)
	UME	0 (0)	100 (31)
	Total	1 (1)	99 (110)
Level 2: Knowledge	The mystery dinner was an effective format to teach an RCA.		
	GME	4 (3)	96 (77)
	UME	6 (2)	94 (29)
	Total	5 (5)	95 (106)
Level 2: Skills	I would recommend this course to a colleague.		
	GME	9 (7)	91 (73)
	UME	10 (3)	90 (28)
	Total	9 (10)	91 (101)

Abbreviation: RCA, root cause analysis.

Table 3. Pre- Versus Postcourse Responses

Question[a] and Training Levels	*M* (% Agreement)		% Change	Effect Size Cohen's *d*	*p*[b]
	Precourse	Postcourse			
Undertaking an RCA is a time-consuming business. Is it a good use of staff time and resources?					
GME	4.1 (85)	4.5 (95)	10		
UME	4.3 (97)	4.5 (100)	3		
Total	4.2 (88)	4.5 (96)	9	0.6	<.001
The achievements and benefits of conducting RCAs are that they:					
Improve work processes					
GME	4.3 (91)	4.6 (98)	7		
UME	4.3 (97)	4.5 (100)	3		
Total	4.3 (94)	4.6 (98)	4	0.5	<.001
Improve patient safety					
GME	4.5 (93)	4.6 (98)	5		
UME	4.5 (100)	4.6 (100)	0		
Total	4.5 (95)	4.6 (98)	3	0.3	.02
Help people work together in teams					
GME	4.0 (77)	4.4 (93)	16		
UME	3.8 (75)	4.3 (87)	12		
Total	3.9 (77)	4.4 (90)	13	0.7	<.001
Improve communication about patient care					
GME	4.1 (83)	4.5 (94)	11		
UME	4.0 (88)	4.4 (94)	6		
Total	4.1 (84)	4.4 (94)	10	0.6	<.001
Improve patient outcomes					
GME	4.2 (86)	4.5 (96)	10		
UME	4.4 (97)	4.5 (100)	3		
Total	4.3 (89)	4.5 (97)	8	0.4	.001
Improve the standing of my profession					
GME	3.9 (73)	4.4 (94)	21		
UME	3.9 (77)	4.2 (81)	4		
Total	3.9 (73)	4.4 (90)	17	0.6	<.001

Abbreviation: RCA, root cause analysis.
[a]Rated on a 5-point Likert scale (1 = *Strongly Disagree*, 5 = *Strongly Agree*).
[b]Based on nonparametric two-tailed *t* test of combined UME and GME scores.

a longitudinal internal medicine quality improvement and patient safety curriculum, an intern onboarding session, and an integrated GME quality improvement boot camp for residents and fellows from various programs.

Through use of gamification, we created a novel way to foster engagement with what many might perceive as a dull topic. By solving the mystery through chart note review and character interviews, we created intrigue in the RCA process. By making trainees characters within the script outside their own professional training, we helped them see the error from a novel interdisciplinary or interprofessional viewpoint depending on their character role. This resulted in a moderate effect size of 0.6 on attitude change about the perceived benefits of conducting an RCA. We saw a greater percentage change in attitudes for GME learners across the board when compared with UME learners, which may relate to personal experience with errors and should be further investigated. Attitude changes are believed to precede behavioral changes[29,30] and therefore are the first step toward achieving the culture of safety we seek to create among our trainees. Our moderate effect on attitude change is especially notable given the large cross section of both surgical and medical specialties, the fact that the training was mandatory, and the low baseline levels of engagement with systems error reporting.

Our study mirrors the improved subjective comfort with RCA seen in prior simulated RCAs[19,31] and adds additional educational outcomes of course reaction and self-assessed knowledge, skills, and attitude change. We also reached a breadth of learners not previously described in the literature. This was possible due to our 90-minute, single-case design and to early positive reviews from both UME and GME trainees. These factors contributed to GME leadership approaching us to use the Mystery Dinner RCA for all GME quality improvement and patient safety training boot camps. Having a well built out facilitator guide also made the GME leadership comfortable that other faculty could lead our module should the core development faculty be unavailable. The ability to overcome these basic design factors allowed us to reach a broader audience than has previously been cited in the literature.

There are several limitations to this study. We do not have a concurrent control group comparing the same material delivered using a didactic delivery format instead of the simulated gamification. Furthermore, our assessment offers no objective measurement of knowledge or higher Kirkpatrick levels and does not explicitly measure progress towards the learning objectives. Finally, we have been unable to track change over time to see if our effects were sustained.

We are continuing to study the impact of our simulated RCA across multiple institutions and disciplines, as well as with a myriad of faculty presenters, to obtain input on usability of the materials. We hope to understand what is required to adequately prepare a wide range of faculty to lead this simulation. We will continue to track trainee outcomes on self-reported satisfaction, knowledge, skills, and attitudes with other facilitators and educational settings, including within a virtual learning environment. In addition, we plan to evaluate higher Kirkpatrick outcomes, including impact on error reporting, objective knowledge assessment, and patient safety participation. Finally, we hope to further assess how the gamified format of the mystery dinner affects learner engagement using the lens of self-determination theory. We believe interactive instructional methods such as these are important tools in preparing the next generation of physicians to provide optimal and high-quality health care.

Appendices

A. Chart Notes.docx

B. Character Scripts.docx

C. Interviewer Scripts.docx

D. Mystery of the Misdosed Medicine.pptx

E. Facilitators Guide.docx

F. Survey.docx

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

Andrea Smeraglio, MD: Assistant Professor Internal Medicine, Department of Medicine, Oregon Health & Science University School of Medicine; Hospitalist, Division of Hospital & Specialty Medicine, Portland VA Medical Center; ORCID: https://orcid.org/0000-0003-0775-7930

Matthew DiVeronica, MD: Assistant Professor Internal Medicine, Department of Medicine, Oregon Health & Science University School of Medicine; Hospitalist, Division of Hospital & Specialty Medicine, Portland VA Medical Center; ORCID: https://orcid.org/0000-0002-1959-2451

Christopher Terndrup, MD: Assistant Professor Internal Medicine, Department of Medicine, Oregon Health & Science University School of Medicine; ORCID: https://orcid.org/0000-0002-1196-8290

Jacob Luty, MD: Assistant Professor Internal Medicine, Department of Medicine, Oregon Health & Science University School of Medicine; ORCID: https://orcid.org/0000-0002-6040-3448

Garrett Waagmeester, MD: Fellow Pulmonary & Critical Care, Department of Medicine, Oregon Health & Science University School of Medicine; ORCID: https://orcid.org/0000-0001-5764-7663

Shona Hunsaker, MD: Associate Professor Internal Medicine, Department of Medicine, Oregon Health & Science University School of Medicine; Hospitalist, Division of Hospital & Specialty Medicine, Portland VA Medical Center; ORCID: https://orcid.org/0000-0003-4040-2541

Disclosures
None to report.

Funding/Support
None to report.

Prior Presentations
Smeraglio A. Guess who's coming to dinner? Using an interactive "mystery dinner" format to teach root cause analysis. Presented at: Eastern Virginia Medical School; January 2018; Norfolk, VA.

Smeraglio A, Terndrup C, DiVeronica M, Waagmeester G, Luty J, Hunsaker S. Guess who's coming to dinner? Using an interactive "mystery dinner" format to teach root cause analysis. Presented at: Integrating Quality Conference; June 7-8, 2018; Washington, DC.

Smeraglio A, Terndrup C, DiVeronica M, Waagmeester G, Luty J, Hunsaker S. Guess who's coming to dinner? Using an interactive "mystery dinner" format to teach root cause analysis. Presented at: APDIM Fall Meeting; October 25-27, 2018; Orlando, FL.

Ethical Approval
The Oregon Health & Science University Institutional Review Board approved this study.

Disclaimer
The views expressed in this publication are the authors' own and not an official position of the institution by which the authors are employed.

References

1. Root cause analysis. VHA National Center for Patient Safety. 2018. Accessed October 24, 2019. https://www.patientsafety.va.gov/professionals/onthejob/rca.asp
2. Koh NJ, Wagner R, Newton RC, Casey BR, Sun H, Weiss KB; Program CLER. Detailed findings from the CLER National Report of Findings 2018. *J Grad Med Educ*. 2018;10(4)(suppl):49-68. https://doi.org/10.4300/1949-8349.10.4s.49
3. Wagner R, Koh NJ, Patow C, Newton RC, Casey BR, Weiss KB; CLER Program. Detailed findings from the CLER National Report

of Findings 2016. *J Grad Med Educ*. 2016;8(2)(suppl 1):35-54. https://doi.org/10.4300/1949-8349.8.2s1.35

4. Accreditation Council for Graduate Medical Education. *ACGME Common Program Requirements (Residency)*. Accreditation Council for Graduate Medical Education; 2020.
5. Wong BM, Levinson W, Shojania KG. Quality improvement in medical education: current state and future directions. *Med Educ*. 2012;46(1):107-119. https://doi.org/10.1111/j.1365-2923.2011.04154.x
6. Gonzalo JD, Baxley E, Borkan J, et al. Priority areas and potential solutions for successful integration and sustainment of health systems science in undergraduate medical education. *Acad Med*. 2017;92(1):63-69. https://doi.org/10.1097/ACM.0000000000001249
7. Gonzalo JD, Caverzagie KJ, Hawkins RE, Lawson L, Wolpaw DR, Chang A. Concerns and responses for integrating health systems science into medical education. *Acad Med*. 2018;93(6):843-849. https://doi.org/10.1097/ACM.0000000000001960
8. Mann KJ, Craig MS, Moses JM. Quality improvement educational practices in pediatric residency programs: survey of pediatric program directors. *Acad Pediatr*. 2014;14(1):23-28. https://doi.org/10.1016/j.acap.2012.11.003
9. Sorokin R, Riggio JM, Hwang C. Attitudes about patient safety: a survey of physicians-in-training. *Am J Med Qual*. 2005;20(2):70-77. https://doi.org/10.1177/1062860604274383
10. Gonzalo JD, Ogrinc G. Health systems science: the "broccoli" of undergraduate medical education. *Acad Med*. 2019;94(10): 1425-1432. https://doi.org/10.1097/ACM.0000000000002815
11. Butler JM, Anderson KA, Supiano MA, Weir CR. "It feels like a lot of extra work": resident attitudes about quality improvement and implications for an effective learning health care system. *Acad Med*. 2017;92(7):984-990. https://doi.org/10.1097/ACM.0000000000001474
12. Garcia C, Goolsarran N. Learning from errors: curriculum guide for the morbidity and mortality conference with a focus on patient safety concepts. *MedEdPORTAL*. 2016;12:10462. https://doi.org/10.15766/mep_2374-8265.10462
13. Keefer P, Orringer K, Vredeveld J, Warrier 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
14. Swamy L, Worsham C, Bialas MJ, et al. The 60-minute root cause analysis: a workshop to engage interdisciplinary clinicians in quality improvement. *MedEdPORTAL*. 2018;14:10685. https://doi.org/10.15766/mep_2374-8265.10685
15. Szymusiak J, Fox MD, Polak C, et al. An inpatient patient safety curriculum for pediatric residents. *MedEdPORTAL*. 2018;14: 10705. https://doi.org/10.15766/mep_2374-8265.10705
16. McGaghie WC, Issenberg SB, Cohen ER, Barsuk JH, Wayne DB. Does simulation-based medical education with deliberate practice yield better results than traditional clinical education? A meta-analytic comparative review of the evidence. *Acad Med*. 2011;86(6):706-711. https://doi.org/10.1097/ACM.0b013e318217e119
17. McGaghie WC, Issenberg SB, Petrusa ER, Scalese RJ. A critical review of simulation-based medical education research: 2003–2009. *Med Educ*. 2010;44(1):50-63. https://doi.org/10.1111/j.1365-2923.2009.03547.x
18. Junious DL. Collaborative simulation training: strategies used to teach root cause analysis leadership competencies. *Nurs Educ Perspect*. 2020;41(1):57-58. https://doi.org/10.1097/01.NEP.0000000000000404
19. Murphy M, Duff J, Whitney J, Canales B, Markham MJ, Close J. Implementation of a mock root cause analysis to provide simulated patient safety training. *BMJ Open Qual*. 2017;6(2): e000096. https://doi.org/10.1136/bmjoq-2017-000096
20. Quraishi SA, Kimatian SJ, Murray WB, Sinz EH. High-fidelity simulation as an experiential model for teaching root cause analysis. *J Grad Med Educ*. 2011;3(4):529-534. https://doi.org/10.4300/JGME-D-11-00229.1
21. Charles R, Hood B, DeRosier JM, et al. Root cause analysis and actions for the prevention of medical errors: quality improvement and resident education. *Orthopedics*. 2017;40(4):e628-e635. https://doi.org/10.3928/01477447-20170418-04
22. Rutledge C, Walsh CM, Swinger N, et al; Quality Cardiopulmonary Resuscitation (QCPR) leaderboard investigators of the International Network for Simulation-Based Pediatric Innovation, Research, and Education (INSPIRE). Gamification in action: theoretical and practical considerations for medical educators. *Acad Med*. 2018;93(7):1014-1020. https://doi.org/10.1097/ACM.0000000000002183
23. Epinephrine use for anaphylaxis—a multi-incident analysis. *ISMP Can Safety Bull*. 2017;17(6):1-6.
24. Keskitalo T, Ruokamo H. A pedagogical model for simulation-based learning in healthcare. *Seminar.net*. 2015;11(2):74-86.
25. Issenberg SB, McGaghie WC, Petrusa ER, Gordon DL, Scalese RJ. Features and uses of high-fidelity medical simulations that lead to effective learning: a BEME systematic review. *Med Teach*. 2005; 27(1):10-28. https://doi.org/10.1080/01421590500046924
26. Braithwaite J, Westbrook MT, Mallock NA, Travaglia JF, Iedema RA. Experiences of health professionals who conducted root cause analyses after undergoing a safety improvement programme. *Qual Saf Health Care*. 2006;15(6):393-399. https://doi.org/10.1136/qshc.2005.017525
27. Yardley S, Dornan T. Kirkpatrick's levels and education "evidence." *Med Educ*. 2012;46(1):97-106. https://doi.org/10.1111/j.1365-2923.2011.04076.x

28. Sullivan GM, Feinn R. Using effect size—or why the *P* value is not enough. *J Grad Med Educ*. 2012;4(3):279-282. https://doi.org/10.4300/JGME-D-12-00156.1

29. Hagger MS, Chatzisarantis NLD. Integrating the theory of planned behaviour and self-determination theory in health behaviour: a meta-analysis. *Br J Health Psychol*. 2009;14(2):275-302. https://doi.org/10.1348/135910708X373959

30. Chatzisarantis NLD, Biddle SJH. Functional significance of psychological variables that are included in the theory of planned behaviour: a self-determination theory approach to the study of attitudes, subjective norms, perceptions of control and intentions. *Eur J Soc Psychol.* 1998;28(3):303-332.

31. Aboumrad M, Neily J, Watts BV. Teaching root cause analysis using simulation: curriculum and outcomes. *J Med Educ Curric Dev*. 2019;6:2382120519894270. https://doi.org/10.1177/2382120519894270

Received: September 1, 2020
Accepted: April 11, 2021
Published: June 21, 2021