Ward round simulation in final year medical students

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Ward round simulation in final year medical students: Does it promote students learning?

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ABSTRACT

Introduction: Ward round skills are essential for doctors in hospital settings. Literature shows medical students' deficiencies in these skills. Simulation has been used to train these skills. However, exposing learners to simulation at an early stage may be associated with a high cognitive load and limited learning. This study aims to determine how students experience this load and its interplay with performance and which factors promote and impair learning.

Methods: Fifty-six final year medical students participated in a simulated ward round training exercise. Both students' performance and cognitive load were measured to determine if there was any correlation and interviews were carried out to understand which factors support and impair learning.

Results: Performance scores revealed deficiencies in ward round skills. Students experienced a cognitive load that weakly correlated with performance. Qualitative findings provided important insights into simulated ward-based learning. It is clear that well-designed clinical scenarios, prioritization tasks, teamwork and feedback support students' learning process whereas distractions impair learning.

Conclusions: WRS proved to be a good teaching method to improve clinical skills at this stage as the cognitive load is not too high to impair learning. Hence, including tasks in the simulation design can enhance the learning process.

Introduction

Doctors face many challenges working in the complex arena of modern clinical practice. Hospital ward rounds represent a key activity that brings a structured process to interact with patients in order to best guide their clinical care. Ward rounds integrate a wide range of skills including teamwork, interpersonal communication, clinical reasoning, patient management, and decision-making skills (Nikendei et al. 2007). However, the evidence base would suggest that both medical students and junior doctors have deficiencies in ward round skills, which could be defined as a range of technical and non-technical skills that healthcare professionals need to apply to work effectively in a clinical ward based environment, such as decision making, initiating appropriate prescriptions and documentation (Norgaad et al. 2004; Nikendei et al. 2007).

Practice points

- The existence of well-designed clinical scenarios, prioritization tasks and teamwork in the simulation design on WRS are factors that enhance the learning process.
- Feedback is the most valuable element for students and there is an imperative to include this form of simulation into the curriculum.
- Distractions and noise interfere with performance. However, they add realism to the situation in order to reflect real clinical practice.
- WRS can offer meaningful learning opportunities for final-year medical students to improve their clinical ward skills without compromising patients' safety.

Ward round simulation

We are aware that simulation-based education (SBE) has the potential to be an effective and important learning tool for healthcare professionals (Issenberg et al. 2005; Cook et al. 2011; McGaghie et al. 2011; Haji, Khan, et al. 2015). Recently, a specific SBE has been developed called ward round simulation (WRS). Simulation-based ward round learning activities have emerged, aiming to best prepare students for ward round based activates. Overall, characteristics of WRS consist of complex clinical scenarios situated in a simulated clinical ward that involves multiple elements such as managing more than one patient, interacting with relatives and other healthcare professionals, and dealing with multiple competing tasks activities where interruptions and distractions happen (Ker et al. 2006; Nikendei et al. 2007; Pucher et al. 2014). Thus, WRS provides a realistic environment that has the potential to help students develop their clinical ward skills such as diagnostic and management skills, decision-making, communication, and teamwork skills. By developing these skills in a safe controlled simulated environment, students can prepare for actual clinical practice (Pucher et al. 2013).

However, immersive simulations such as WRS are complex and challenging learning environments that can place a high demand on learners' cognitive resources. Hence, it is

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necessary to have an adequate instructional design in order to achieve desired learning outcomes without overburdening learners and inhibiting their development. Cognitive load theory (CLT) can bring value insights into such learning contexts and challenges (Fraser et al. 2015).

Cognitive load theory

Cognitive load theory builds on classical working memory research that demonstrates the narrow limits of working memory (Miller 1956). Instructional design must operate within the narrow limits of working memory, otherwise learning and performance are likely to be impaired (Young et al. 2014). CLT defines learning as the development of cognitive schemas of a topic, skill, or problem-solving procedure (Leppink et al. 2015) and currently distinguishes between two types of cognitive load: *intrinsic cognitive load* and *extraneous cognitive load* (Leppink and Van den Heuvel 2015). Intrinsic cognitive load arises from new information, elements that are not yet part of learners' cognitive schemas, whereas extraneous cognitive load results from cognitive processes that as such do not contribute to learning. Some examples of the latter include ineffective problem-solving search (Leppink et al. 2015), having split attention between sources that could be integrated into a single source (Van Merriënboer and Sweller 2010) and distracting ambient noise from clinical monitor alarms while a student is evaluating a patient. Education and training should be designed so that extraneous cognitive load is minimized and students are stimulated to optimally allocate their resources to deal with intrinsic cognitive load (Lafleur et al. 2015; Leppink et al. 2015).

A recent educational design model inspired by CLT has potential implications for SBE (Leppink and Van den Heuvel 2015). In this model, three dimensions are to be considered: task fidelity, task complexity, and instructional support. This model implies that the process of reducing instructional support (i.e. from worked examples to autonomous task performance) should be repeated for each subsequent complexity level and level of fidelity. Providing early stage learners with a very complex task (e.g. a case with many possible diagnoses and a high degree of comorbidity) (Leppink and Duvivier 2016) with too little instructional support is not likely to result in learning for two reasons. First, the many interacting information elements about the case that have to be processed, constitute a high intrinsic cognitive load. Second, the lack of instructional support will likely trigger ineffective search processes that contribute to an extraneous cognitive load (Leppink et al. 2015).

Tremblay et al. (2017) recently demonstrated how a high level of fidelity may hinder learning in novice pharmacy students. In line with CLT and the aforementioned three-dimensional model, the simulated workplace environment resulted in higher levels of intrinsic and extraneous cognitive load and somewhat higher levels of stress. Moreover, focus groups revealed that participants were more capable of engaging in clinical reasoning in a low fidelity environment, because – again in line with CLT and the three-dimensional model – the simulated working environment triggered participants to pay attention to other potential stimuli that take away from the main learning focus for the learner, for example, locating and collecting information from the patients computer record rather than engaging in deep problem solving.

New medical graduates have to face complex clinical scenarios with autonomous task performance during ward rounds. The use of WRS as training method during the last year of medical program could best prepare students for this duty. However, there is a paucity in the literature as to whether a high level of fidelity of simulation fidelity may actually impair learning for novices being trained to develop their clinical ward based skills. This study aims to determine (1) to what extent students experience intrinsic and extraneous cognitive load and what their performance scores during WRSs are, (2) how cognitive load scores and performance scores correlate, (3) factors that enhance learning, and (4) factors that hinder learning.

Methods

This study was conducted using an explanatory sequential mixed method design (Creswell 2012). We studied these questions with the help of a cognitive load questionnaire, the Postgraduate Ward Round Simulation (PgWRS) assessment tool and individual interviews with students who participated in a final-year WRS.

Setting

This study took place from April to July 2016 at the Clinical Simulation Center of Universidad Católica del Norte (UCN), Chile in the simulated emergency room, which replicated an emergency workplace fully equipped with medical equipment, (simulated) medicines, electronic records, and other artifacts commonly found in ward environments such as a nurse station, telephones and pagers. The UCN has a traditional medical curriculum. The degree program lasts 7 years. The last 2 years correspond to internships where students are enrolled in emergency ward rounds as part of their medical training. They join the medical team and act as observer during the emergency management. The exercise was part of their final year medical curriculum.

Emergency ward round: the "hand over" exercise

Each participant participated in a simulated emergency ward round experience. During the teaching exercise, each participant was involved on an "hand over" exercise for 30 minutes followed by a 45 minute debriefing using a "Debriefing with good judgment" approach (Rudolph et al. 2006). This approach utilizes a self-reflection process that helps students recognize and resolve clinical and behavioral dilemmas raised by the simulation itself and instructor. This supports the participant to critically reflect on their actions and how they could modify their future performance.

In this emergency simulated ward, participants had to interact with three patients in a ward round that included medical and surgical scenarios. A qualified nurse also took part in the scenarios as well as a doctor, who received the patients at the *change of shift,* after they were taken care by participants. Each role player had to adhere to scenario scripts which guided their performance and roles in the scenarios. Three sources of distractions were part of the exercise: (1) a patient's daughter asking for information,

(2) a phone call from a nurse who was asking for interpretation of some laboratory tests, and (3) ambient noise from other patients and clinical monitor alarms.

Participants were given the role of junior doctors whose task was to gain an overview of the patients' cases. They had to define consultation goals, conduct the ward round, reevaluate the patients' therapy and prepare written notes regarding the proposed management plan. They also had to deal with distractions as detailed above. All final-year students were invited to participate in the study by filling out a cognitive load questionnaire and participating in an individual interview.

Quantitative data collection and analysis

Simulation scenario sessions were video recorded. All video recordings were viewed by two independent raters who were experienced medical doctors and educators. They applied the PgWRS assessment tool (Stirling et al. 2012) to rate participants' performances as formative assessment (Supplementary Appendix A). Each of the raters had received training in using PgWRS. This tool assesses nine domains: Task management, clinical skills, acutely ill patients, prescribing techniques, written documentation, response to interruptions, communication, health and safety and professionalism. For each domain, a five-point Likert scale was used to assess domain performance, ranging from "1" (very poor performance) to "5" (outstanding performance).

Immediately after completing the simulated exercise, students were asked to complete a cognitive load questionnaire (Leppink and van den Heuvel 2015) translated to Spanish with an 11-point (0–10) rating scale, in which "0" indicates if you do not agree at all and "10" indicates if you completely agree.

Four items were intended to measure intrinsic cognitive load, and four other items aimed to measure extraneous cognitive load (Supplementary Appendix B).

Quantitative analysis was conducted with SPSS version 23 (SPSS Inc., Chicago, IL). A principal components analysis resulted in two components with item-component loadings in line with previous versions of the instrument (e.g. Leppink et al. 2014). Hence, scores for the four intrinsic cognitive load items were averaged to obtain an intrinsic cognitive load score, and the same was done for the extraneous cognitive load items.

Qualitative data collection and analysis

After the debriefing session, individual interviews were carried out in order to explore the perceived factors that enhance or hinder learning.

An explanatory sequential mixed methods design was used in this study. For qualitative analysis, one author (CBP) carried out all 56 individual interviews to determine participants' perception of learning in WRS. Each interview lasted from 20 to 30 minutes. Open-ended questions were asked on the students' perceptions of factors that enhanced and impaired learning during WRS, and how it affected their learning process (Supplementary Appendix C). Interviews were audio-recorded and transcribed verbatim. CBP listened and coded half of the interviews and a research assistant also read all the interviews and validated the coding (topics, themes). The research team discussed and reviewed the emergent themes based on importance and relevance to the study. After this step, CBP and the research assistant analyzed the remaining interviews with this coding scheme. Finally, the research team reached consensus on the main themes of the data.

Ethical considerations

This study received approval from the Research Ethics Committee of UCN (F.M. N° 09-2016). Written informed consents were obtained prior to filling the questionnaire and participating in interviews. Investigators were not directly involved with students' training at the moment of conducting the research.

Results

Fifty-six out of 64 subjects (87.5%) were recruited by email, with an equal ratio of male to female trainees with a mean age of 24.3 years.

Quantitative results

Cognitive load perceived by students

There was considerable variation in intrinsic cognitive load ratings among participants reaching a mean of 4.42 (SD ± 1.73) on a scale from 0 to 10, whereas extraneous cognitive load scores had a mean of 0.50 (SD ±1.19). 62.5% of the participants had a score of "0", and more than 90.0% of the participants had a score of less than 1.5.

Students' performance

For the three patient scenarios, the overall score reached by participants had a mean of 3.43 out of 5 (SD ± 0.72). Its results per component are shown in Table 1. The best domain-specific learning goals that were attained were "communication with colleagues" with a mean of 4.48 ± 0.73, "communication with patients/relatives" with 3.93 ± 0.93 and "response to interruptions" with 3.70 ± 0.83; whereas the lowest domains were "health and safety" with 3.05 ± 1.24 "prescribing techniques" with 3.02 ± 1.05 and "written documentation" with 2.82 ± 1.16.

Twenty out of 56 participants (35.7%) were scored by a second observer. Ratings of the two observers correlated almost perfectly ($r = 0.976$, $p < 0.001$). Intrinsic ($r = -0.22$, $p = 0.879$) and extraneous cognitive load ($r = -0.217$,

Table 1. Ward round simulation score (PgWRE) results, with individual components ($N = 56$).

	Score (1–5)
Task management	3.29 ± 1.26
Clinical skills	3.29 ± 1.02
Acutely ill patients	3.16 ± 1.30
Prescribing techniques	3.02 ± 1.05
Written documentation	2.82 ± 1.16
Response to interruptions	3.70 ± 0.83
Communication with patients/relatives	3.93 ± 0.93
Communication with colleagues	4.48 ± 0.73
Health and safety	3.05 ± 1.24
Professionalism	3.57 ± 0.93
Overall PgWRE score	3.43 ± 0.72

Values expressed as mean ± SD.

Table 2. Summary of qualitative results.

	Results summary	Illustrative quotations from individual interviews
Factors that support students' learning		
1. Relevant clinical cases and tasks	Students rated that the simulated patients were realistic and reflected the kind of patients that they will face in emergency wards. Besides, the series of task, documentation, note taking and communication are seen as duties that they must to do in real clinical practice.	"The simulation was very realistic, this is that we will have to do in one more year when we become doctors" (S* 30) "The clinical cases were very well structured as well as the environment and represented a challenge. I felt that I was in the emergency room" (S* 55)
2. Prioritization	Having to make decisions on how to prioritize was completely new for students, and they had not received previous training on prioritization. They recognized that the exercise was the first time that they were forced to make these types of decisions. They found this stressful.	"I had to apply prioritization criteria and give specific orders to the nurse … I had never done it before. It was very hard!" (S* 1)
3. Team working	The students found the presence of the nurse a key realistic feature in the simulation scenario. The nurse helped them to manage the patients in a best way and gave them "clues" when they felt lost. They felt that teamwork developed very well.	"It was great to have a nurse who knows a lot! … she helped us in patients' management working as a team" (S* 5)
4. Feedback	Students highlighted feedback received during debriefing. This was not only related to technical skills but also non-technical skills. This exercise gave them the opportunity to discuss aspects such as patients' management, communication, team working, time management and prioritization and realize their weaknesses in these matters.	"I really appreciate this opportunity because no one had given me feedback of my communication and teamwork skills … . now, I can see that I have a lot to improve" (S* 45)
5. Decision-making	Students realized that were not fully prepared for making clinical decisions on how to manage patients with life-threatening conditions. This point represents the most important challenge for students and they demand more exercises in order to acquire this skill.	"It was complicated to realize that I was alone, those patients depended on me and my decisions were crucial for obtaining a good outcome … I don't feel prepared for that responsibility, there is always a doctor who does it instead of me" (S* 51)
Factors that could impair students' learning		
1. Distractions	Two sources of distractions were identified. A phone call from other nurse asking about a test lab result of in-patients and the visit of the daughter of patient with myocardial problems who asked them information about his evolution. Although they considered that both facts distracted them and did not know how to deal with these, they are necessary because it makes simulation close to real life.	"The phone call distracted me, I do not know whether to answer it or not. Now, I believe that it was not prudent, I should have continued with my patient" (S* 44) "The daughter of a patient with myocardial infarction distracted me so much. She interrupted me several times and I felt out of focus. However, these things happen in real life and we have to be trained to deal with it" (S* 20)
2. Noise	Students felt that the noise was disruptive because sometimes they lost the focus on critically ill patients because the patient with renal colic was screaming or monitoring alarms were ringing. However, they think that this kind of training is necessary as this occurs in real emergency wards.	"The monitoring alarms were upsetting, I got nervous, but I think we must get used to working with noise because that is the reality" (S* 30)

*S: student number.

$p = 0.108$) had small, negative but statistically non-significant correlations with performance.

Qualitative results

All participants perceived the exercise as a meaningful task and identified several factors that contributed to their learning process. Overall, 1130 minutes of data was obtained. Analysis yielded themes relating to factors that influenced learning. Table 2 summarizes each factor and provides quotes that illustrate the factor.

Factors that contribute to learning

Prioritization tasks and clinical decision-making into the exercise mobilized their major mental effort and participants stated that this was the first time that they had to make decisions in prioritization on critical ill patients without support of their tutors. Those factors gave realism to the exercise and participants perceived that they would be able to transfer their learning to real situations. Participants expressed that an important contribution of WRS to the curriculum, was the feedback received during the debriefing sessions. The feedback focused not only on technical skills but also on non-technical skills. This exercise gave participants the opportunity to discuss aspects that were less discussed during their internships, e.g. patients' management, communication, team working, time management, and prioritization.

Factors that impair learning

According to the participants' perspective; distractions (i.e. phone calls, patient relatives' inquiries, and ambient noise) negatively affected their management planning of patient care. However, they felt that those elements must be present into simulation because they provided realism, making the exercise close to the real clinical practice.

Clinical decision-making

At the same time, participants felt underprepared for making decisions in complex scenarios due to a lack of opportunities to practice this during previous internships. This lack of practice influenced their performance during the WRS. This is consistent with the variation in performance scores.

Discussion

We used CLT to determine the relationship of its effects on students' performance in WRS. We found moderate intrinsic cognitive load scores and low extraneous cognitive load scores. In other words, it appeared that cognitive resources were largely allocated to dealing with intrinsic cognitive load, which is desirable (Leppink and van den Heuvel 2015). However, there were other elements (e.g. distractions, ambient noise and even stress) that arise as potential sources of extraneous cognitive load and were not caught by the questionnaire. This is consistent with a systematic review on the validity of cognitive load measures in SBE which stated that, although CLT is a useful framework for instructional design in healthcare simulation, current tools to measure cognitive load seem to generate inconsistent correlations between cognitive load and learning outcomes in simulation (Naismith and Cavalcanti 2015). This shows the need for the development of adapted tools to measure cognitive loads in simulation (Haji, Childs, et al. 2015; Naismith and Cavalcanti 2015).

Our quantitative and qualitative data revealed sub-optimal ward round skills, mainly related to the management of acutely ill patients, prioritization, documentation and clinical decision-making skills. This is consistent with literature, in which other researchers in WRS have reported deficiencies in doctors' teamwork skills, decision-making skills and clinical skills; such as difficulties in reaching a diagnosis in critically ill patients and prioritizing effectively (Norgaad et al. 2004; Nikendei et al. 2007, 2008). Although the students have clinical placements on real emergency wards, their role during emergencies is often as passive observers. For example, observing a "cardiac arrest team" treating a patient. This could explain the deficiencies reported in this study. Clinical decision-making was perceived as a difficult task. We can infer that a lack of opportunities to practice decision-making skills during the medical curriculum could have influenced these perceived difficulties. McGregor et al. (2012) reported similar data using WRS in an undergraduate setting.

We did not find a clear correlation between cognitive load scores and students performances. These results do not confirm that the extraneous cognitive load scores associated to WRS are too high in an undergraduate setting. However, at least two factors call for caution here. First, there was a considerable variation in intrinsic cognitive loads as well as in performance scores, indicating that the perceived complexity of the task varied considerably across students. Second, the participants in the current study were final year medical students. Previous research indicates that having undergraduate students learn in an authentic simulated workplace environment can result in elevated stress and extraneous cognitive load.

Our results showed that ward training is a valuable and realistic tool, supporting important reflective processes and providing relevant feedback for final year students. Well-designed clinical scenarios, prioritization tasks, team work and feedback given during debriefing sessions were factors that supported students learning and its presence contributed to increase task fidelity. Qualitative data supports that, immersing final year medical students in a highly authentic clinical environment, can potentially improve their clinical skills on the management of critical patients.

Although distractions and ambient noise added complexity to the task and could impair learning, our qualitative data indicate that students felt that these elements should be included in the simulation. Those extraneous stimuli reflect what actually happens in real clinical practice.

Some limitations of our study include a limited number of participants in a single center, a single short intervention and no long-term to follow up. Therefore, we have to be cautious about generalizing the results of this study to other contexts. More research is needed to explore the long-term effects of WRS training on ward round skills, and also how emotions experienced by students on WRS could maximize or impair learning.

Conclusions

WRS can offer meaningful learning opportunities for final year medical students to improve their clinical ward craft skills. WRS seems to be a good teaching method to strengthen those skills, as the extraneous cognitive load associated to the exercises is not too high to impair learning. Based on the findings of this study, we would recommend the incorporation of Ward Based Simulation learning activities into medical curricula. WRS not only provides the opportunity to develop technical and non-technical skills, but also clinical decision making skills that are more contextual particularly in emergency situations. As for WRS, well-designed clinical scenarios and the inclusion of relevant tasks, have the potential to enhance students' learning, whereas distractions make simulation close to the real clinical practice although it is not clear if those could hinder students' learning.

Disclosure statement

The authors report no conflicts of interest. The authors alone are responsible for the content and writing of this article.

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Glossary

Ward round simulation: A specific type of simulation that involves complex clinical scenarios situated in a simulated clinical ward where a health care students visit patients for the purpose of making decisions concerning patient care. This involves multiple elements such as managing more than one patient, interacting with relatives and other healthcare professionals, and dealing with multiple competing tasks activities where interruptions and distractions happen.

Ker JS, Hesketh EA, Anderson F, Johnston DA. 2006. Can a ward simulation exercise achieve the realism that reflects the complexity of everyday practice junior doctors encounter? Med Teach. 28(4):330–334. doi: 10.1080/01421590600627623

Pucher P, Darzi A, Aggarwal R. 2013. Simulation for ward processes of surgical care. Am J Surg. 206(1):96–102. doi: 10.1016/j.amjsurg.2012.08.013

References

Cook DA, Hatala R, Brydges R, Zendejas B, Szostek J, Wang A. 2011. Technology-enhanced simulation for health professions education: a systematic review and meta-analysis. JAMA. 306:978–988.

Creswell JW. 2012. Mixed methods design. In: Smith P, Robb C, editors. Educational research. Boston (MA): Pearson Education Inc.; p. 534–575.

Fraser KL, Ayres P, Sweller J. 2015. Cognitive load theory for the design of medical simulations. Simul Healthc. 10:295–307.

Haji FA, Childs R, Ribaupierre S, Dubrowski A. 2015. Measuring cognitive load: performance, mental effort and simulation task complexity. Adv Health Sci Educ. 49:815–827.

Haji FA, Khan R, Regehr G, Drake J, de Ribaupierre S, Dubrowski A. 2015. Measuring cognitive load during simulation-based psychomotor skills training: sensitivity of secondary-task performance and subjective ratings. Adv Health Sci Educ. 20:1237–1253.

Issenberg B, McGaghie WC, Petrusa ER, Lee Gordon D, Scalese RJ. 2005. Features and uses of high-fidelity medical simulations that lead to effective learning: a BEME systematic review. Med Teach. 27:10–28.

Ker JS, Hesketh EA, Anderson F, Johnston DA. 2006. Can a ward simulation exercise achieve the realism that reflects the complexity of everyday practice junior doctors encounter? Med Teach. 28:330–334.

Lafleur A, Cote L, Leppink J. 2015. Influences of OSCE design on students' diagnostic reasoning. Med Educ. 49:203–214.

Leppink J, Duvivier R. 2016. Twelve tips for medical curriculum design from a cognitive load theory perspective. Med Educ. 38: 669–674.

Leppink J, Paas F, Van Gog T, Van der Vleuten CPM, Van Merriënboer JJG. 2014. Effects of pairs of problems and examples on task performance and different types of cognitive load. Learn Instruct. 30:32–42.

Leppink J, Van den Heuvel A. 2015. The evolution of cognitive load theory and its application to medical education. Perspect Med Educ. 4:119–127.

Leppink J, Van Gog T, Paas F, Sweller J. 2015. Cognitive load theory: researching and planning teaching to maximise learning. Chapter 18. In: Cleland J, Durning SJ, editors. Researching medical education. Hoboken (NJ): John Wiley; p. 207–218.

McGaghie W, Issenberg S, Cohen E, Barkuk J, Wayne D. 2011. 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. 86:706–711.

McGregor CA, Paton C, Thomson C, Chandratilake M, Scott H. 2012. Preparing medical students for clinical decision making: a pilot study exploring how students make decisions and the perceived impact of a clinical decision making teaching intervention. Med Teach. 34:508–517.

Miller G. 1956. The magical number seven, plus or minus two: some limits on our capacity for processing information. Psychol Rev. 63:81–97.

Naismith LM, Cavalcanti RB. 2015. Validity of cognitive load measures in simulation-based training: a systematic review. Acad Med. 90:S24–S35.

Nikendei C, Kraus B, Lauber H, Schrauth M, Weyrich P, Zipfel S, Jünger J, Briem S. 2007. An innovative model for teaching complex clinical procedures: integration of standardised patients into ward round training for final year students. Med Teach. 29:246–252.

Nikendei C, Kraus B, Schrauth M, Briem S, Jünger J. 2008. Ward rounds: how prepared are future doctors? Med Teach. 30:88–91.

Norgaad K, Ringsted C, Dolmans D. 2004. Validation of a checklist to assess ward round performance in internal medicine. Med Educ. 38:700–707.

Pucher P, Darzi A, Aggarwal R. 2013. Simulation for ward processes of surgical care. Am J Surg. 206:96–102.

Pucher PH, Aggarwal R, Srisatkunam T, Darzi A. 2014. Validation of the simulated ward environment for assessment of ward-based surgical care. Ann Surg. 259:215–221.

Rudolph J, Simon R, Dufresne R, Raemer D. 2006. There's no such thing as "nonjudgmental" debriefing: a theory and method for debriefing with good judgment. Simul Healthc. 1:49–55.

Stirling K, Hogg G, Ker J, Anderson F, Hanslip J, Byrne D. 2012. Using simulation to support doctors in difficulty. Clin Teach. 9:285–289.

Tremblay M-L, Lafleur A, Leppink J, Dolmans DHJM. 2017. The simulated clinical environment: cognitive and emotional impact among undergraduates. Med Teach. 39:181–187.

van Merriënboer JJ, Sweller J. 2010. Cognitive load theory in health professional education: design principles and strategies. Med Educ. 44:85–93.

Young JQ, Van Merrienboer J, Durning S, Ten Cate O. 2014. Cognitive load theory: implications for medical education: AMEE Guide No. 86. Med Teach. 36:371–384.