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Impact of online education on intern behaviour around Joint Commission National Patient Safety Goals: A randomised trial

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Abstract

Purpose—To compare the effectiveness of 2 types of online learning methodologies for improving the patient-safety behaviours mandated in the Joint Commission National Patient Safety Goals (NPSG).

Methods—This randomized controlled trial was conducted in 2010 at Massachusetts General Hospital (MGH) and Brigham & Women's Hospital (BWH) in Boston USA. Incoming interns were randomised to either receive an online Spaced Education program (SE) consisting of cases and questions that reinforce over time, or a program consisting of an online slide show followed by a quiz (SQ). The outcome measures included NPSG-knowledge improvement, NPSG-compliant behaviors in a simulation scenario, self reported confidence in safety and quality, program acceptability and program relevance.

Results—Both online learning programs improved knowledge retention. On four out of seven survey items measuring satisfaction and self reported confidence, the proportion of SE interns responding positively was significantly higher ($p < 0.05$) than the fraction of SQ interns. SE interns demonstrated a mean 4.79 (36.6%) NPSG-compliant behaviors (out of 13 total), while SQ interns completed a mean 4.17 (32.0%) ($p = 0.09$). Among those in surgical fields, SE interns demonstrated a mean 5.67 (43.6%) NPSG-compliant behaviors, while SQ interns completed a mean 2.33 (17.9%) ($p = 0.015$). Focus group data indicates that SE was more contextually relevant than SQ and significantly more engaging.

Conclusion—While both online methodologies improved knowledge surrounding the NPSG, SE was more contextually relevant to trainees and engaging. SE impacted more significantly on both self reported confidence and the behaviour of surgical residents in a simulated scenario.

Keywords

Education; Education, graduate; Safety; Quality of healthcare

INTRODUCTION

The need to educate health professionals in patient safety is now well recognised and is starting to be addressed through a variety of mechanisms.¹ This includes the mandating of education in patient safety for all hospital staff by the Joint Commission and the requirement by the Accreditation Council for Graduate Medical Education (ACGME) that residency programs provide education for interns in safety and quality.²

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Interns represent a particularly vulnerable population of health professionals due to their

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No additional data available

COMPETING INTERESTS

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lack of experience and knowledge around patient safety.³ Their lack of knowledge, combined with their workload and competing learning priorities, potentially places these young doctors and their patients at an increased risk of being involved in adverse events. Otherwise known as the 'July Effect', some studies suggest that there is an increase in errors and adverse events in certain hospital settings at the beginning of the academic year, which coincides with an influx of new junior doctors.⁴⁻⁶

Online learning clearly represents new opportunities to reach interns and other health professionals with education. However, while there are a growing number of programs being developed that focus on patient safety,^{7,8} there is little evidence in the literature regarding which educational methodologies are effective in actually changing the behaviour of health professionals.⁹

Online Spaced Education (SE) is a novel, evidence-based form of online education that has been demonstrated in randomized trials to improve knowledge acquisition,¹⁰ boost retention^{11,12} and change behavior.¹³⁻¹⁵ SE involves participants receiving short, case-based multiple choice questions and feedback via email in a reinforcing pattern over a number of weeks. The methodology is based on two core psychological research findings: the spacing and testing effects. The *spacing effect* refers to the finding that educational encounters that are repeated over time increase the acquisition and retention of knowledge.¹⁶ The *testing effect* refers to the finding that the process of testing does not merely measure knowledge, but actually alters the learning process itself to significantly improve knowledge retention.^{17,18}

Each SE item consists of an evaluative component (a clinically-relevant multiple-choice question) and an educational component (the correct answer and a detailed explanation of the answer). Participants submit an answer, receive immediate feedback, and compare their performance with peers. To harness the educational benefits of the spacing effect, the spaced education item is then repeated over intervals of time ranging from 1-12 weeks. An adaptive algorithm tailors the length of the spacing intervals and number of repetitions of the content for each learner based on his or her performance. In order to be retired, each question must be answered correctly twice in a row. In a randomized trial, this adaptive SE algorithm was found to increase learning efficiency by over 35% over a non SE program with identical content.¹⁹

This study aimed to compare a SE program developed for interns at Brigham and Women's Hospital (BWH) and Massachusetts General Hospital (MGH) with a more traditional online program that uses an online slide show followed by a multiple choice quiz format. Both programs were designed to improve knowledge and compliance with the NPSG. The study aimed to look impact on behaviour, knowledge retention and user satisfaction.

METHODS

Education Programs

Setting—This study was conducted in 2010 at Brigham and Women's Hospital (BWH) and Massachusetts General (MGH) Hospital. Both hospitals are primary teaching hospitals of Harvard Medical School located in Boston, Massachusetts.

Intervention—The Spaced Education program consisted of 16 case-based multiple choice questions. The cases were developed by a multidisciplinary curriculum committee consisting of physicians, nurses and educators in collaboration with current MGH and BWH residents in surgery and medicine. Cases were largely based on real life scenarios encountered previously by the residents. Cases were selected to illustrate teaching points from the NPSGs covered in the program. After answering each multiple choice question, interns received feedback consisting of the key take-home message and a brief description of what actually happened. The cases and associated multiple choice questions were emailed to the interns in the following manner: every two days, each intern was sent an email containing two cases. An intern who answered the question incorrectly was sent the same case 8 days later. An intern who answered the question correctly was sent the same question 15 days later. Any question answered correctly twice in a row was 'retired' for that intern. An intern's course was completed once 80% of the questions had been retired. The emailing of initial questions and repeating of questions was fully automated once an intern logged onto the SE platform.

The slideshow-based online program (SQ) was developed at BWH by safety and quality experts and contained 15 slides that discussed key aspects of the NPSGs. Upon reviewing the slides, interns completed a 14 question multiple choice quiz.

The content of the SE program was matched to cover the same content as covered in the SQ program. The same nine of the 2009 NPSGs were covered in both programs.

Study design—Incoming interns were randomized at each hospital into two groups (using the Research Randomizer Software - www.randomizer.org). Subjects were drawn from surgical specialties (Surgery and OB-GYN) and medical specialties (Medicine, Anesthesiology, Emergency Medicine and Psychiatry Programs) at both hospitals. Participants were stratified by speciality. All incoming 2010 interns were eligible to participate. Randomisation was performed by a single research officer. All researchers involved in evaluation of performance were blinded to randomisation.

At MGH one group received SE and the other group received no intervention. At BWH one group received SE and the other received the SQ program. There was a difference in approach at the 2 hospitals in that MGH was not planning on delivering online training in safety and quality to interns in the year of the study in contrast to BWH where SQ was planned to be rolled out to all residents. At the conclusion of the project MGH interns were provided access to the SE program so no group was disadvantaged.

Outcome Measures

A randomly selected sub-group of SE and SQ interns at BWH completed a central line simulation. Interns were blinded to the purpose of the simulation and the simulation was included in an existing orientation program for interns. Each intern individually participated in the simulation station and interns did not observe each other's performance. The simulation sessions were timed and also digitally recorded for later review. Two reviewers used the recordings to score performance. For each intern, each examiner recorded whether the intern did or did not properly perform each of 13 key procedural tasks tested in the simulation station. Table 1 details the procedural tasks assessed and their relationship to the National Patient Safety Goals.

Interns from all groups completed a 15 item multiple choice question pre-intervention and post-intervention test that tested knowledge around the NSPG. The questions on both tests were identical. The test was written by the project's multidisciplinary curriculum committee. The pre/post test was then piloted amongst a sample of interns at BWH and MGH from the year preceding the study and members of the curriculum committee not involved in its development. The pre and post-tests were presented to the participants in an online format.

Interns who received either SQ or SE intervention completed an online exit survey consisting of 7 questions, which asked them to rate their confidence around the NPSG's and acceptability of the interventions on a 1-5 Likert scale ranging from strongly agree to strongly disagree (Table 2).

BWH surgical interns from both SQ and SE groups participated in a 45-minute semi-structured focus group to provide qualitative feedback on their experience of the interventions. The group discussion was analysed by three investigators. Grounded theory was used in the analysis of the data and emergent themes were identified for consideration.

Statistical Analyses

Using video replay, 2 independent observers recorded whether each intern did or did not perform each of 13 mandatory tasks in the simulated environment. A log-transformed t-test was used to analyze the interns' time to complete the simulation and the number of NPSG-compliant behaviours they performed.

Analyses of simulation performance by specialty did not include interns from Anesthesiology (n=10), Emergency Medicine (n=12), or Psychiatry (n=6) due to their limited numbers. Bonferroni correction was performed to adjust for multiple comparisons.

Scores on the knowledge tests were analysed with paired t-tests. Survey results were analysed using a two-sample test of proportions, comparing the fraction within each group whose score was 1 ("Strongly agree") or 2 ("Agree").

The study was approved by Partners Institutional Review Board.

RESULTS

Three hundred and seventy one trainees participated in the study (196 at BWH and 175 at MGH). Randomisation was effective with an even distribution of trainees across interventions and between specialities.

Knowledge test and completion rates

At BWH, 88 of the 98 interns randomized to SE completed the pre-test and 91 of the 97 interns randomized to SQ completed the pre-test. At MGH, 81 of the 85 interns randomized to SE completed the pre-test and 79 of the 89 interns randomized to no intervention completed the pre-test. Among all 169 SE interns who completed the pre-test 120 (71%) completed the post-test; among 91 SQ interns who completed the pre-test, 85 (93%) completed the post-test ($p<0.001$).

SE participants took 4-6 weeks to complete the SE course and SQ participants completed the online quiz within this same 4-6 week period.

The post-test score was significantly higher than the pre-test score for the SQ group (average difference 1.0) and each of the two SE groups (1.2 at BWH and 1.4 at MGH- $p<0.001$ for all 3 differences; Table 3). For the control group at MGH, there was no significant difference between pre-test and post-test scores. While the score increases of the pooled SE groups were greater than those of SQ interns, this difference did not reach statistical significance ($p=0.18$).

Simulation

Inter-rater reliability between observers was high with a kappa-coefficient of 0.9.

Among the BWH interns, 53 in the SE group and 48 in the SQ group participated the simulation. Among randomly-selected participants who underwent simulation testing, SE interns demonstrated a mean 4.79 (36.6%) NPSG-compliant behaviors (out of 13 total), while SQ interns completed a mean 4.17 (32.0%) ($p=0.09$). Among those in surgical fields, SE interns demonstrated a mean 5.67 (43.6%) NPSG-compliant behaviors, while SQ interns completed a mean 2.33 (17.9%) ($p=0.015$) (Table 4).

Survey

On four out of the seven survey items, the fraction of SE interns responding “Strongly Agree” or “Agree” was significantly higher ($p<0.05$) than the fraction of SQ interns. These corresponded to the items for “Improved confidence in hand off”, “Improved confidence re: infection control”, “Effective as a method to learn or reinforce key aspects of S&Q”, and “Engaging and enjoyable”. For the remaining three survey items, there was no statistically significant difference between the SE and SQ respondents. These results are displayed in Table 2.

Focus Group

Analysis of the focus group data with 30 Brigham and Women's surgical interns identified a number of themes. The interns found the SE online cases authentic and engaging - *'they made me feel interny'* or, 'I was looking for a program that was geared to my anxiety not to kill anyone this year and this program met my need!' In contrast, participants did not find the SQ format as engaging or memorable *'you just click through to the end..'*

A number of interns indicated that receiving either program just prior to commencing residency training raised the profile of patient safety - 'Patient safety must be a priority at Partners Healthcare as this was the first real interaction I had with the organisation'.

A number of the interns in the SE program found that the content was memorable and could reflect on the outcomes of the patients - '...the fact that that patient died due to that adverse event really stuck in my mind'.

The repeating nature of the SE methodology was also considered positively - 'I knew the cases were going to repeat so I made sure I concentrated on getting them right the first time'. However, not all interns felt SEs intensive nature would be suitable for delivery of all types of education - '...sometimes I just want a resource I can go to and look up things on a particular area'.

DISCUSSION

The results of this randomized control study demonstrate that both Spaced Education and the more traditional slide-based program can be used to improve knowledge around the NPSGs. Although drawing on a relatively small number of participants, SE was superior to the traditional program in changing behaviors amongst interns in the surgical specialities in a simulated environment. This finding was reinforced by the self-reported increased confidence scores when SE was compared to SQ. Qualitative data from the survey and focus group with surgical interns demonstrated that they found the delivery methodology of SE preferable to SQ. This study is one of a limited number of studies to evaluate the impact of educational interventions on the behavior of interns.⁷²⁰²¹ Why SE may have had a greater impact on behaviour than the more traditional online program is likely to be due to multiple factors. The literature indicates that CME that is case-based and interactive has a greater impact on knowledge and behaviour²². There is a growing body of literature supporting that Spaced Education, by repeatedly presenting content and testing knowledge, itself has a significant impact on knowledge retention and behavior in medical practitioners¹³⁻¹⁵. Findings from the focus group held with surgical interns at BWH who had participated in the study indicated that the SE content was more memorable than the traditional format. The cases, exploring incidents that were largely based on events that had in fact happened, were felt to be realistic and directly applicable to the context of the intern. There was a strong consensus from the group around a statement from an intern who saw that the program was aligned to his 'anxieties' on entering practice.

The study found relatively poor performance for all the interns in the central line simulation station. This indicates that there are perhaps significant gaps in medical school education in

this area and underlines the importance of delivering orientation programs in safety and quality to young doctors as they assume independent patient care responsibilities

The fact that interns found the SE program significantly more engaging than the SQ program and that it was a more effective method to learn or reinforce key aspects of safety and quality is significant as engaging young doctors in safety and quality during their early years represents a significant challenge for program directors worldwide.

The findings of this study raise a number of questions that warrant further research. First, why did the SE program have a greater impact on interns in surgical fields, i.e. surgery and OB-GYN, than on other interns, specifically those who enter non-procedural specialties? This difference is potentially due to the way the cases were written. A number of cases emphasized peri-surgical care, thus potentially capturing the imagination of the surgical speciality interns more readily. This may indicate that care in design of future spaced education courses is needed in order to tailor questions to the specialties of participants. This notion is supported by research that indicates that CME which is contextually relevant to participants is more likely to be effectual.²³

Second, will the behavior change detected in the simulation station translate to a change in practice on the ward? Presumably, if good safety and quality habits are developed, they will be practiced in the clinical environment. These practices should be, and in many hospitals are, supported by standardization of pre-procedure preparation, readily available hand sanitizer, nursing or senior resident supervision etc. Additional studies, however, are necessary to really determine what behaviors are displayed on the wards and how these effect patient safety outcomes.

More studies are also needed to answer the final question raised by this study; how long does the impact of either methodology last? Previous studies have indicated that Spaced Education increases the long-term knowledge retention around a variety of clinical conditions¹⁰¹⁴ but it is unknown how long knowledge surrounding safety and quality will be retained.

Strengths of the study include the randomisation of participants, the large number of participants and the multiple evaluation methods used, including a measure of behaviour change in a simulated environment.

Limitations of the study include the fact that there was no control group that received no intervention in the simulation study. This prevents analysis of the impact of either methodology compared to no intervention and may have prevented the study revealing a significant impact on behaviour by the slideshow-based program or a more significant impact on behaviour by Spaced Education. This limitation was unavoidable due to the requirements of intern training and the different sites. The authors believe this limitation is offset by the randomisation of participants. Other limitations include the small number of surgical interns, that the power of the study was limited by the set number of incoming interns and the simulation test was only available to BWH residents.

In conclusion, this study is one of a very limited number that describe the impact of online learning programs in safety and quality on the behaviour and knowledge of interns. This has importance given the substantial clinical role that interns play in health systems around the world. In addition, this study is particularly relevant as many organisations are in the process of introducing mandated online education around safety and quality and the evidence is still not clear as to which types of online learning have the greatest impact. Results from this study indicate that Spaced Education has the potential as a delivery methodology to impact more on intern behaviour than a slideshow based methodology. It also shows that SE was more engaging for interns than the traditional format and that both methodologies have a similar resource requirement for implementation. The authors are currently conducting further studies around the impact of spaced education on reporting of adverse events by junior doctors and in the education of more senior interns and specialists.

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Table 1

Matching the 2009 NPSGs to expected behaviors at the central line simulation station

NPSG	Preparation at the Station	Tested Procedural Tasks/ Interns Expected Behaviors Showing Compliance with NPSGs
Goal 2: Improve the effectiveness of communication among caregivers 02.05.01 Hand-off	Provide the intern with an incomplete sign-out, instructing them to proceed with central line placement Written sign-out available	Asks for additional information/ proper hand-off or consults the sign-out sheet, or both Selects correct site for procedure based on hand-off information
Goal 1: Improve Accuracy of Patient Identification 01.01.01 Use at least two patient identifiers	Simulated patient wears wristband	Uses wristband to verify patient identity
		Matches wristband against other source of identifiers
Goal 7: Reduce the Risk of Healthcare Associated Infection 07.01.01 Comply with hand hygiene guidelines	Hand sanitizer and gloves available	Uses hand sanitizer before touching patient
Goal 7: Reduce the Risk of Healthcare Associated Infection 07.04.01 Evidence-based practices to prevent central line-associated bloodstream infections	Hand sanitizer, hat, mask, and sterile gown and gloves available Central line kit does not contain skin prep	Uses hand sanitizer before sterile technique
		Wears hat, mask, gown, and sterile gloves to place central line
		Requests chlorhexidine to disinfect patient's skin
Universal Protocol UP 01.01.01 Conduct a pre-procedure verification process		Asks for safety pause that includes:
		Patient name
		Other identifiers
		Procedure
		Site
Goal 3: Improve the Safety of Using Medications 03.04.01 Label all medications	Central line kit contains unlabeled medication vial instead of labelled local anesthetic	Identifies unlabelled medication vial as inappropriate to use

Table 2

Survey questions

Participants in SE and SQ interventions were asked survey questions scored on a Likert scale, ranging from 1 (strongly agree) to 5 (strongly disagree).	% SE responding 1-2 (n=118)	% SQ responding 1-2 (n=84)	p-value
Intervention improved confidence in hand off	65	42	0.0026
Intervention improved confidence re: infection control	70	55	0.046
Intervention improved confidence in Patient ID	70	63	0.42
Intervention will improve how I practice as a intern with regard to S&Q	67	58	0.27
Intervention was effective as a method to learn or reinforce key aspects of S&Q	78	63	0.031
Intervention was engaging and enjoyable	65	48	0.018
Happy to undertake other health related programs if in the same format	68	64	0.81

Table 3

Pre/post written knowledge test scores

Institution	Intervention	Number completing post-test	Mean pre-test score	Mean post-test score	Pre-test vs. post-test score: p-value
BWH	SE	62	12.3	13.5	<0.001
BWH	SQ	85	11.7	12.7	<0.001
MGH	SE	58	12.2	13.6	<0.001
MGH	None	70	12.3	12.2	0.62

Table 4

Comparison of average simulation score within medical and surgically orientated residency programs

Residency program	Mean # items correct among SE interns	Mean # items correct among SQ interns	p-value (two-sample t-test using log-transformation)
All Specialties	4.79 (n=53)	4.17 (n=48)	0.09
Medicine	5.07 (n=28)	4.92 (n=27)	0.52
Surgery +OB-GYN	5.67 (n=9)	2.33 (n=9)	0.0025