Discovering Innovation at the Intersection of Undergraduate Medical Education, Human Factors, and Collaboration: The Development of a Nasogastric Tube Safety Pack
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Abstract

Problem
Significant deficiencies exist in the knowledge and skills of medical students and residents around health care quality and safety. The theory and practice of quality and safety should be embedded into undergraduate medical practice so that health care professionals are capable of developing interventions and innovations to effectively anticipate and mitigate errors.

Approach
Since 2011, Leeds Medical School in the United Kingdom has used case study examples of nasogastric (NG) tube patient safety incidents within the undergraduate patient safety curriculum. In 2012, a medical undergraduate student approached a clinician with an innovative idea after undertaking an NG tubes root cause analysis case study. Simultaneously, a separate local project demonstrated low compliance (11.6%) with the United Kingdom’s National Patient Safety Agency NG tubes guideline for use of the correct method to check tube position. These separate endeavors led to interdisciplinary collaboration between a medical student, health care professionals, researchers, and industry to develop the Initial Placement Nasogastric Tube Safety Pack.

Outcomes
Human factors engineering was used to inform pack design to allow guideline recommendations to be accessible and easy to follow. A timeline of product development, mapped against key human factors and medical device design principles used throughout the process, is presented. The safety pack has since been introduced into health care professional staff training for NG tubes.

Next Steps
A mixed-methods evaluation is currently under way in five NHS organizations.

Problem
Education and innovation continue to be driving forces in the quest to maintain and improve quality and safety in health care. Despite the crucial role of clinicians in quality and safety improvement efforts, significant deficiencies exist in the knowledge and skills of medical students and residents in this vital area.1 Reforming medical education to build a culture of safety into undergraduate medical education is an important first step toward improving future physicians’ knowledge and skills related to quality and safety. To achieve this, the theory and practice of patient safety should be embedded throughout training, so that health care professionals appreciate the nature and scale of medical errors that cause patient harm and are able to apply evidence-based methods to develop effective interventions and innovations to accurately anticipate and mitigate errors.2 Using strategies to communicate these innovations through key channels over time amongst key stakeholders can increase both the diffusion of ideas across the system and the likelihood of sustained improvement.3

One particular medical error attracting increasing attention is feeding through misplaced nasogastric (NG) tubes,4,5 which are frequently used in the clinical setting. Feeding through tubes unintentionally placed in the respiratory tract is not uncommon and can have serious consequences; in the United Kingdom between 2005 and 2011 there were 21 deaths and 79 harms as a result of feeding into the lungs.4 Consequently, the United Kingdom’s National Patient Safety Agency (NPSA) issued guidance to National Health Service (NHS) organizations, classifying feeding through misplaced tubes as a “never event,” its term for largely preventable patient safety incidents that should not occur if the available preventive measures have been implemented.4 This particular example has been used as the basis of an applied root cause analysis (RCA) activity in the Leeds Medical School (LMS) undergraduate medicine patient safety curriculum since 2011 (Figure 1).

During 2011 and 2012, three hospitals in the north of the United Kingdom were involved in a project to enhance the implementation of the NG tubes NPSA guideline.6,7 Simultaneously, undergraduate medical students from LMS performed RCA on the case of a misplaced NG tube as part of their curriculum requirements. Here we demonstrate how these separate endeavors collaborated to develop a generalizable innovation to improve the safety of NG feeding tubes practice.

Approach
The innovation process consisted of three key phases: (1) a local project focusing...
on the implementation of an NG tubes guideline in a teaching hospital, (2) introduction of an NG tubes case study through the undergraduate medicine curriculum, and (3) development of an NG tubes safety innovation based on an undergraduate medical student proposal.

Local project
Between September 2011 and November 2012, one author (N.T.) led the aforementioned implementation project to improve compliance with the NG tubes guideline at three UK hospitals. As part of this project, one author (A.C.) led a hospital audit of 43 notes for patients who had received an NG tube in 2011 in a participating teaching hospital. The guideline indicates that misinterpretation of X-rays was the biggest cause of harm in NG tubes patients between 2005 and 2014 and recommends that pH should be used as the first-line method for checking tube position; however, the audit revealed high use of X-ray (72.7% of cases) and low use of pH (11.6%) as the first-line method—a level of compliance that is representative of a number of organizations.

Next, the validated Influences on Patient Safety Behaviours questionnaire and four focus groups were used to identify and understand the key barriers staff faced to using pH as the first-line method for checking tube position. Barriers included skills (e.g., no provision of necessary training), social influences (e.g., others discouraging checking pH), and environmental context and resources (e.g., necessary equipment unobtainable). Junior doctors, registrars, dieticians, nurses, radiologists, physiotherapists, and consultants participated in focus groups conducted by N.T. in December 2011 and January 2012. During these focus groups, participating nurses, junior doctors, and allied health and consultant clinicians generated ideas to overcome key barriers to guideline implementation and suggested that one way to address the “environmental context and resources” barrier would be through an NG tubes information and equipment pack, for example:

Can you get it in the packs? Like the IV catheter packs? You’ve got all the stuff for your aseptic technique … maybe you need a similar NG pack so people don’t forget that here’s your 20-mL syringe that you aspirate with; here’s your pH paper.”

These hospital staff suggestions indicated the need for an innovative approach to make NG tubes practice safer; simultaneously, the LMS undergraduate medicine curriculum was providing a forum for students to develop evidence-based ideas to tackle pertinent patient safety problems.

Undergraduate medicine curriculum
The five-year patient safety curriculum (Figure 1) is delivered as part of the LMS undergraduate medicine degree. In February 2012, second-year students investigated a real misplaced NG tube event using RCA methods. Specifically, through a “serious incident” patient safety workshop, students used a range of theoretical models (e.g., Swiss Cheese Model, organizational accident model) to construct a Fishbone Diagram to attempt to identify the contributing factors to the serious incident. Students identified why each factor occurred and which might be classified as a root cause. Next, students highlighted areas of good practice, developed a list of recommendations to address each root cause, and presented their action points.

Undergraduate medical student proposal
An undergraduate medical student generated an idea to reduce the risk of feeding through misplaced tubes after conducting the NG tubes case study RCA. In April 2012, the student proposed an innovation—using an NG tube safety pack—that had the potential to help clinicians perform the correct checks in the appropriate order (e.g., using pH as the first-line check), and having necessary equipment available for insertion and
Collaboration between the student, health care organization, and industry
Following initial discussions, the implementation lead (N.T.) invited T.B. to attend the next meeting, held in April 2012, where he presented his idea. T.B. worked with team members, who held expertise in human factors and the NG tubes process, to develop the idea, and following the identification of an appropriate manufacturing partner, submitted a proposal in June 2012 to establish a partnership for taking the idea through to production.

Outcomes
The innovation
The main idea behind the Initial Placement Nasogastric Tube Safety Pack is a green–amber–red traffic light prompt card system that makes guideline recommendations accessible, concise, and easy to follow (Figure 2). A green traffic light instructs the user to use pH aspirate check as a first-line method for checking NG tube position. The amber traffic light demonstrates what to do if unable to obtain an aspirate. The red traffic light shows that the tube is not safe to feed if no aspirate is obtained or if the pH value is greater than that agreed by local policy, prompting a request for X-ray. The pack also contains a process documentation sticker for patient records, a summary of the insertion process, and basic equipment, all of which can be used across different hospitals. A detailed timeline of product development, mapped against the key human factors and medical device design principles used throughout the process, is presented in Supplemental Digital Appendix 1, http://links.lww.com/ACADMED/A315, and summarized below.

Throughout the development of the innovation, we took steps to critically examine each aspect of the process to ensure that the main objective of producing an innovation capable of making NG tubes practice safer was being...
met. Furthermore, in line with strategy recommendations about the diffusion of innovations, communication channels were established to ensure that the development of the safety pack was being informed by intelligence gathered as part of the initial body of work (i.e., the local project), and vice versa. Specifically, the NG tubes implementation project team members’ knowledge of the NG tubes process and current practice through recent hospital-wide audits (i.e., local health care professionals’ knowledge) was combined with human factors expertise (e.g., a health psychologist, N.T.) to inform the contents of the pack and the format of the sticker for patient records.

The design and development of the pack occurred in June 2012. The team worked with Enteral UK to develop the pack, using key human factors and medical device design principles (e.g., anticipate device failures and procedures, facilitate workflow, review and simplify work processes, standardize common processes, design to prevent user confusion, follow industry conventions and consensus standards). An initial prototype was developed in October 2012, and discussions were held with the implementation team and Enteral UK to consider amendments, taking into account both human factors and medical device design evidence. For example, input was required on (1) whether or not to include pH paper in the pack considering the use of a range of pH paper types within different organizations, (2) whether to place a prompt card in the pack or a sticker on the NG tube considering potential hazards that had been identified, and (3) whether to tailor the pack to this particular hospital guideline, or to make the wording more applicable to hospitals nationwide (i.e., consider the potential for the innovation to be used in other environments).

When the pack was being developed in October–December 2012, we made several amendments to improve the presentation of the sticker for patient records so that the order of completion aligned with the order of the process, accounting for a range of potentially required actions by health care professionals. The revised prototype was reviewed at a national nutritional nurse advisory board in December 2012, and recommended changes were incorporated between January and April 2013. One hospital ward piloted the pack in May 2013, and T.B. consulted with ward staff about user experience, informing further refinements. Feedback was gathered from a second UK nutritional nurse advisory board (June 2013), which, along with information from new NG tubes safety adverse incidents relating to latent failures, was used to further refine the pack (July 2013). The final version of the Initial Placement Nasogastric Tube Safety Pack (Supplemental Digital Appendix 2, http://links.lww.com/ACADMED/A315) was launched in the developing hospital, which purchased 1,000 packs in August 2013. Steps were taken to introduce the pack into staff training about NG tubes, including the production of an educational video in September 2013.

Implications
We have demonstrated how a medical student, a hospital, a university, and a commercial organization from industry have collaborated to develop a patient safety innovation. Previous research has indicated that, with the provision of a structured forum for discussion in a trusted and collegial environment, medical students are capable not only of identifying reportable patient safety issues within the care system but also of proposing robust safety interventions. In this case, the medical undergraduate curriculum, and the invitation to join an approachable group of like-minded health care professionals to reduce the risks of NG tubes practice, provided a safe setting for a motivated student to voice and develop his idea. Therefore, in addition to mastering underlying basic science, institutions should encourage students to learn to apply this knowledge in day-to-day situations, using skills and attitudes appropriate for the context, in “psychologically safe” environments—this may be one area for policy development.

Involving different stakeholders in each innovation phase—from the initial concept, through the design and development process, to the official launch of the product—is also recommended because of the blend of theoretical, design, and contextual expertise.

Next Steps
We have introduced the Initial Placement Nasogastric Tube Safety Pack in five NHS hospitals, and the first phase of a mixed-methods evaluation is currently under way. This consists of a pre–post intervention implementation audit on several wards across five hospitals, the main outcome measure being the use of pH aspirate as the first-line method of checking NG tube placement. Staff interviews are under way to deduce the usability of the innovation and scope for improvements.

Since its initial launch, additional feedback has led to further refinements of the pack and to the use of the materials with other packaged equipment (e.g., NG tubes). Further educational materials have been released to enhance training provided on the use of the pack in practice. Our journey thus far, however, has demonstrated how integrating a philosophy of safety culture in undergraduate medical education and health care settings, linking education to real-world incidents from a health care organization and encouraging partnership with industry, can generate practical innovations that aim to improve safety for patients. This preliminary work provides a solid platform for a large-scale rigorous implementation project evaluation.

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