Patient Safety Knowledge and Its Determinants in Medical Trainees

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BACKGROUND: Patient safety is a core educational topic for medical trainees.

OBJECTIVES: To determine the current level and determinants of patient safety knowledge in medical trainees.

DESIGN: Multi-institutional cross-sectional assessment of patient safety knowledge.

PARTICIPANTS: Residents and medical students from seven Harvard-affiliated residencies and two Harvard Medical School courses.

MEASUREMENTS: Participants were administered a 14-item validated test instrument developed based on the patient safety curriculum of the Risk Management Foundation (Cambridge, MA). The primary outcome measure was the amount of patient safety knowledge demonstrated by trainees on the validated test instrument. The secondary outcome measure was their subjective perceptions as to their baseline knowledge level in this domain.

RESULTS: Ninety-two percent (640/693) of residents and medical students completed the patient safety test. Participants correctly answered a mean 58.4% of test items (SD 15.5%). Univariate analyses show that patient safety knowledge levels varied significantly by year of training ($p=0.001$), degree program ($p<0.001$), specialty ($p<0.001$), country of medical school ($p=0.006$), age ($p<0.001$), and gender ($p=0.050$); all but the latter two determinants remained statistically significant in multivariate models. In addition, trainees were unable to assess their own knowledge deficiencies in this domain.

CONCLUSIONS: Patient safety knowledge is limited among medical trainees across a broad range of training levels, degrees, and specialties. Effective educational interventions that target deficiencies in patient safety knowledge are greatly needed.

KEY WORDS: safety; medical errors; medical education.

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INTRODUCTION

The Accreditation Council for Graduate Medical Education now requires that all U.S. residency programs teach and assess their residents in each of six general competencies: patient care, medical knowledge, practice-based learning and improvement, interpersonal and communication skills, professionalism, and systems-based practice.^{1,2} Many medical schools are now adopting similar competency frameworks.^{3–7} The competency of systems-based practice is defined as the awareness of and responsiveness to the larger context and system of health care and the ability to effectively call on system resources to provide care that is of optimal value.¹ Patient safety is one of the core topics that falls under this competency domain. The 1999 release of the Institute of Medicine report *To Err is Human* highlighted the patient safety challenges within the U.S. healthcare system and has dramatically elevated the importance of patient safety as a core educational topic for physician trainees.⁸

To properly design effective educational programs on patient safety for medical students and residents, it is critical to understand the current knowledge level of medical trainees in this topic area. To this end, we developed and administered a validated test instrument of patient safety knowledge to medical students and residents across a broad range of training levels, specialties, and hospitals and investigated the determinants of increased trainee knowledge in this domain. We also assessed the relationship of trainees' subjective perception of their knowledge level with their actual performance on the test instrument.

METHODS

Study Participants

Residents and students from seven Harvard-affiliated residencies and two Harvard Medical School courses were enrolled between August and October 2005 (Table 1). Each course director or residency program director agreed to have their students and residents complete the test. The institutional review board at Harvard Medical School approved the protocol. To protect the residents' and students' rights as potential research subjects, participants were free to withhold their test data from the research data set.

Development of a Validated Test Instrument

A content-validated curriculum on patient safety focusing on error prevention and systems theory was adopted from the

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Table 1. Univariate Analyses of Patient Safety Test Scores

Determinant	Number of trainees	Percentage of test items correct (mean (SD))	p values
All trainees	640	58.4 (15.5)	0.001*†
Year of training			
Medical school year 2	171	55.8 (15.2)	
Medical school year 3	97	55.1 (15.9)	
Postgraduate year 1	83	57.1 (15.6)	
Postgraduate year 2	109	63.0 (15.4)	
Postgraduate year 3	123	60.6 (14.5)	
Postgraduate year 4	38	58.8 (15.7)	0.050‡
Postgraduate year 5	19	62.0 (15.4)	
Gender			
Female	302	57.1 (15.6)	<0.001*†
Male	338	59.9 (15.4)	
Specialty			
Emergency medicine (1 residency program)	29	64.0 (11.5)	
Medicine (1 program)	106	64.7 (14.9)	
Obstetrics & Gynecology (2 programs)	47	57.1 (13.7)	
Surgery (3 programs)	190	58.4 (15.8)	
Undeclared/medical students (2 classes)	268	58.4 (15.5)	<0.001*†
Degree program*			
MD	528	58.4 (15.4)	
MD/PhD	33	63.4 (16.6)	
MD/MPH	32	65.4 (13.9)	
DMD	35	48.2 (14.0)	
Other	10	57.1 (9.5)	
No response	2	57.1 (20.2)	0.006*†
Country of medical school (residents only)			
United States	345	61.1 (15.2)	
International	21	50.7 (13.2)	
No response	6	54.7 (15.2)	

*Univariate statistical calculations performed by ANOVA

†Significant differences were retained in this variable under multivariate modeling, which controlled for covariates

‡Univariate statistical calculations performed by *t* test

Risk Management Foundation (RMF, Cambridge, MA) on the basis of its relevance to the systems-based practice competency and its perceived educational value for students and residents. A provisional set of 16 multiple-choice questions was developed by two investigators (BPK, GTM) based on this curricular content, and content validity of the items was established by two RMF content experts. To determine the psychometric properties of the validated test questions, the 16 items were pilot tested online with a group of 18 medical students (years 2–4) and 16 medical residents [postgraduate years (PGY) 1–3]. Point-biserial correlation and Kuder–Richardson 20 calculations were performed for each test item (Integrity, Edmonton, Alberta, Canada). Two poorly performing items were eliminated to optimize the reliability of the instrument. The resulting validated test of patient safety contained 14 items. At the beginning of the test, trainees were asked to provide demographic information and to rate their knowledge level on patient safety using a five-point Likert-type scale (1=poor, 5=excellent).

Administration of the Test Instrument

The patient safety test was administered to 693 residents and medical students (two medical school classes and seven

residency programs in three hospitals). Hyperlinks to the online test were distributed to the residents and students via email, and the test responses were collected online using the SurveyMonkey™ platform (Portland, OR, USA).

Outcome Measures and Statistical Methods

The primary outcome measure was the amount of patient safety knowledge demonstrated by trainees on the validated test instrument. The secondary outcome measure was their subjective perception as to their baseline knowledge level in this domain.

Reliability of the validated test instrument was measured utilizing Cronbach's alpha, a measure of internal consistency.⁹ In addition, test–retest reliability (stability of measurement over time) was calculated by Pearson correlation using the scores of a subset of 272 participants who repeated the test 4 weeks later in the absence of any education on patient safety.¹⁰

Two-tailed Student's *t* tests and ANOVA were employed to test the statistical significance (univariate) of differences in test scores between groups. Potential associations between test scores and subject characteristics were examined via graphical and tabular exploration and formally assessed using multiple linear regression analyses. Subjects were classified according to age, gender, year of training, degree (or degree program), specialty, and country of their medical school. Because some subject descriptors were related by definition (for instance, medical students' specialties were classified as “undecided,” and no students were attending international medical schools), multivariate models were restricted to combinations of covariates that yielded valid results. Because of the low number of participants who self-rated their patient safety knowledge as “excellent” (rating of 5), self-ratings of 4 and 5 were collapsed prior to statistical analysis. Results were considered statistically significant if null hypotheses could be rejected at the 0.05 level. Statistical calculations were performed with Stata 9.0 (College Station, TX, USA) and SPSS for Windows 13.0 (Chicago, IL, USA).

RESULTS

Ninety-two percent (640/693) of residents and medical students completed the patient safety test, excluding two residents who elected to have their test data removed from the research database. Cronbach alpha reliability for the 14-item online test instrument was 0.43; four-week test–retest reliability was 0.55.

Participants correctly answered a mean 58.4% of test items (SD 15.5%). Test scores were found to vary significantly with year of training ($p=0.001$), with medical students scoring significantly lower than residents [mean 55.5% (SD 15.3%) test items correct vs. 60.5% (SD 15.4%), respectively; $p<0.001$]. Test scores also varied significantly with degree ($p<0.001$), with MD/MPH recipients/candidates scoring the highest [mean 65.4% (SD 13.9)] and DMD candidates scoring the lowest [mean 48.2% (SD 14.0), Table 1]. Males performed slightly better than females [mean 59.9% (SD 15.4%) vs. 57.1% (SD 15.6%), respectively; $p=0.050$]. Age was significantly correlated with test scores (Pearson $r=0.143$, $p<0.001$), but accounted for only 2.0% of test score variance. Significant specialty-related differences were demonstrated ($p<0.001$, ANOVA), with Internal Medicine

residents scoring the highest [mean 64.7% (SD 14.9%)] and Obstetrics–Gynecology residents scoring the lowest [mean 57.1% (SD 13.7%)]. Residents from international medical schools performed significantly worse than residents from U.S. medical schools [mean 50.7% (SD 13.2%) vs. 61.1% (SD 15.2%), respectively; $p=0.006$].

In a multivariate regression model, year of training remained significantly associated with test scores [$p=0.014$ for those residents PGY-2 or higher in comparison to the referent (second-year medical students)]. Conversely, age and gender no longer showed any significant association with test scores when the effect of training year was controlled. When medical students (undeclared specialty) were excluded from the model, specialty remained significantly associated with test scores: Obstetrics–Gynecology residents scored significantly lower than emergency medicine residents (referent) ($p=0.025$). Residents from U.S. medical schools significantly outperformed graduates from international medical schools when controlling for covariates ($p=0.004$).

There was no significant association or linear trend between trainees' perception of their own knowledge level in patient safety and their subsequent scores on the test. ($p=0.37$, ANOVA; $p=0.09$, linear trend analysis).

DISCUSSION

This multi-institutional assessment of patient safety knowledge among medical trainees demonstrates that knowledge levels are limited across a broad range of training levels, degrees, and specialties. Even so, significant determinants of patient safety knowledge among trainees were identified. Patient safety knowledge levels vary significantly by year of training, degree, specialty, and country of medical school using both univariate and multivariate models. In addition, trainees were unable to assess their own knowledge deficiencies in this domain.

The results of our study argue strongly that effective educational interventions on patient safety are greatly needed given trainees' substantial knowledge deficits in this topic. To date, a wide variety of pedagogical approaches have been attempted to educate trainees in patient safety: independent study projects,¹¹ monthly workshops,¹² outcome cards,¹³ root cause analyses by interprofessional teams,¹⁴ web-based teaching,¹⁵ etc. Further research is needed to evaluate the relative effectiveness of these varied methodologies.¹⁶

While it appears that all groups of trainees can benefit substantially from patient safety education, our study identified specific determinants associated with different levels of patient safety knowledge. It is not unexpected that more-senior residents (PGY-2 or higher) would have greater patient safety knowledge than medical students. For these residents, patient safety is an active day-to-day concern with concrete consequences for the patients under their care. In contrast, medical schools traditionally have placed little emphasis on patient safety education, especially in the first 2 years of training.¹⁷ Previous research has documented specialty-level differences in attitudes regarding error disclosure and patient safety, with surgeons reporting the highest support for the disclosure of serious errors to patients.¹⁸ Of note, attitudes and knowledge may not necessarily align: in our study, residents in Surgery and Obstetrics–Gynecology had the lowest levels of patient

safety knowledge. While it is unclear why residents who completed medical school outside of the U.S. have significantly less patient safety knowledge, this subgroup of residents appears to have the most to gain from educational interventions targeting this domain.

The finding that trainees were unable to assess their own knowledge deficits on patient safety issues (and, by extension, their learning needs) is not unexpected given the large number of psychological studies documenting that humans have difficulty recognizing their own knowledge deficiencies.^{19,20} These results highlight the need to utilize validated assessment instruments to assist in distinguishing between self-perceived learning needs and trainees' true knowledge deficits.

Several factors should be considered when interpreting the results of the study. The test was designed for program improvement and is not appropriate for determining individual competency standards. Although the psychometric properties of the instrument were constrained by the homogeneity of knowledge across the sample, the test performed well when utilized for group-level comparisons. In addition, although the patient safety curriculum and test instrument were developed to address issues germane to all specialties, it is possible that the differences in test scores between specialties reflect some systematic biases regarding patient-safety practices in those specialties. Strengths of the study include the methodologic rigor of its test construction and the inclusion of large numbers of participants across a broad range of specialties and levels of training.

In conclusion, trainees' knowledge about patient safety issues is quite limited across a wide range of specialties, institutions, and training levels. In addition, trainees are unable to appreciate their knowledge deficits and learning needs in topics related to patient safety. Effective educational interventions that target deficiencies in patient safety knowledge are greatly needed.

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APPENDIX

Items on the Validated Test of Patient Safety Knowledge

Test items were developed based on the content-validated patient safety curriculum (error prevention and systems theory) from the RMF (Cambridge, MA). Difficulty refers to the percentage of participants who answered an item correctly.

1. What is the reported frequency of serious adverse events (injuries that results from medical care) among hospitalized patients in the United States?

- (A) <1 percent.
- (B) 1–5 percent.
- (C) 6–10 percent.
- (D) >10 percent.

Answer: B

Difficulty: 55%

2. Two different paralytic agents, one with a long half-life and the other with a short half-life, are packaged in similar glass vials with yellow caps. This is an example of

- (A) a forcing function.
- (B) a latent error.
- (C) a medication error.
- (D) description error.

Answer: B

Difficulty: 55%

3. If the process of ordering and administering a medication has 20 steps, each with 99% accuracy, what is the likelihood of a medication error occurring *each time* the medication is ordered and administered?

- (A) 0.2 percent.
- (B) 1 percent.
- (C) 2 percent.
- (D) 20 percent.

Answer: D

Difficulty: 61%

4. A 21 year-old college student with a documented penicillin allergy is given doxycycline for yet another episode of chlamydia. He develops a rash from the medication. This incident is best described as

- (A) a potential adverse drug event.
- (B) a preventable adverse drug event.

(C) a nonpreventable adverse drug event.

(D) a latent error.

Answer: C

Difficulty: 42%

5. A harried resident connects the oxygen tubing to the intravenous (IV) line of a pediatric patient who subsequently dies from a massive gas embolus. This tragedy is best described as

- (A) a latent error.
- (B) an active failure.
- (C) a forcing function.
- (D) a knowledge deficit.

Answer: B

Difficulty: 72%

6. In general, blaming the individual who makes an error does not help fix the problem or prevent it in the future. Even so, under the framework proposed by error theorist James Reason, two types of misconduct by practitioners should be punished. One is intentional injury to a patient (or anyone else, for that matter), and the other is...

- (A) injury from willful disobedience of practice guidelines.
- (B) injury from provider incompetence.
- (C) injury caused by substance abuse.
- (D) injury from violation of an unworkable rule.

Answer: C

Difficulty: 24%

7. Which one of the following is the best example of an active failure?

- (A) Different chemotherapy medications with similar bottles and labeling.
- (B) An infusion pump that requires complex dosage calculations.
- (C) Scheduling residents to work more than 60 hours in a row to cover a "power weekend."
- (D) Overlooking a pneumothorax on a postcentral line chest film.

Answer: D

Difficulty: 73%

8. Which one of the following is the best example of a latent error?

- (A) Ordering of a chest radiograph on the wrong patient.
- (B) Using bar codes as patient-identifiers.
- (C) Confirming a drug dose on a computerized directory.
- (D) Understaffing an intensive care unit.

Answer: D

Difficulty: 67%

9. Anesthesia machines are designed so that the tube carrying the anesthetic gas physically cannot be attached to the oxygen port. What Human Factors Principle does this best exemplify?

- (A) Constraint.
- (B) Forcing function.
- (C) Reduced reliance on memory.
- (D) Elimination of look-alikes.

Answer: B

Difficulty: 58%

10. A computerized medication order-entry system has been implemented which presents a limited range of doses to the ordering practitioner. What Human Factors Principle does this best exemplify?

- (A) Constraint.
- (B) Forcing function.
- (C) Simplification.

(D) Reduced reliance on vigilance.

Answer: A

Difficulty: 43%

11. Most preventable errors are caused by

(A) Factual deficiencies.

(B) Process deficiencies.

(C) Performance deficiencies.

(D) Defensive practices.

Answer: B

Difficulty: 83%

12. What are latent errors?

(A) The injuries caused by medical management rather than the underlying disease.

(B) The faulty interrelationships between humans, the tools they use, and the environment in which they live and work.

(C) The unsafe acts of front-line workers.

(D) The hidden properties of a system that permit individuals to make mistakes.

Answer: D

Difficulty: 81%

13. Which one of the following is the most frequent error of daily life?

(A) An arithmetic miscalculation.

(B) Misreading of a label.

(C) Forgetting to turn off a switch.

(D) Mixing drug dosages.

Answer: A

Difficulty: 24%

14. When describing how errors occur, the proximal cause refers to which one of the following?

(A) The unsafe acts of front-line workers

(B) The individual responsible for the error.

(C) The apparent reason the error was made.

(D) The pharmacophysiological interactions that occurred in the affected patient.

Answer: C

Difficulty: 79%

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