ORIGINAL ARTICLE

A Cross-Sectional Study of Medical Students' Knowledge of Patient Safety and Quality Improvement

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BACKGROUND The Association of American Medical Colleges and the World Health Organization have endorsed formal patient safety and quality improvement (QI) education for medical students. We surveyed medical students to assess their current level of patient safety and QI knowledge and to identify factors associated with increased knowledge.

METHODS A literature review, focus groups with medical students, and local expert interviews were used to develop an electronic survey, which was distributed to all medical students at a single medical school in the spring of 2012.

RESULTS Fifty-seven percent of the medical school student body (N = 790) participated in the survey. A greater proportion of students reported previous exposure to patient safety education than to QI education (79% vs 47%). Students scored an average of 56% and 58% on the patient safety and QI knowledge tests, respectively. Having or pursuing an advanced degree (P = .02) and previous exposure to patient safety education (P = .02) were associated with higher knowledge scores. After adjusting for confounding variables, only previous exposure to QI education (P = .02) was associated with higher QI knowledge scores.

LIMITATIONS There is a risk of measurement bias due to the use of an unvalidated instrument. Students who have greater knowledge of patient safety or QI might recall exposure at a greater frequency, inflating the association between exposure and knowledge. Also, this is a cross-sectional study, so we cannot draw conclusions about causality.

CONCLUSIONS Medical students' knowledge of patient safety and QI is low. Previous formal or informal education about these topics is associated with increased knowledge.

The need for education on patient safety and quality improvement (QI) was formally introduced in the landmark reports *To Err Is Human* [1, 2] and *Crossing the Quality Chasm* [3]. Using 1984 data, *To Err Is Human* estimated that medical errors lead to 98,000 deaths per year [1], and an updated estimate based on 4 recent studies found that at least 210,000 deaths per year are associated with preventable harm [4]. By the latter estimate, if medical errors were included among the leading causes of death in the United States, they would rank third [5]. QI research shows that education can improve patient outcomes, costs, and safety [3, 6, 7]. Previous efforts to reduce medical errors and improve health care quality have focused on education of residents and physicians [8].

Recent research has highlighted the need for patient safety and QI education starting during medical school, in order to help change the culture of medicine and to integrate medical students into the health care team [9-11]. The Association of American Medical Colleges (AAMC) and the World Health Organization (WHO) recently endorsed formal patient safety and QI education for medical students [10, 12, 13]. Despite consensus on the importance of patient safety and QI education during medical school, few schools have implemented formal integrated curricula, and the most effective strategy for teaching these principles to medical trainees is unknown [14, 15].

The literature on patient safety education for medical students is underdeveloped, and even less is available regarding QI education for medical students. The majority of the literature consists of pre- or post-survey studies of stand-alone piloted curricula [8]. In a systematic review of medical student patient safety education, 6 of 7 studies found that student knowledge improved with the piloted curriculum [8]. Included studies varied significantly with regard to hours of instruction, educational format, evaluation of change in knowledge, and the year during medical school when the curriculum was offered. Components of piloted curricula include lectures, readings, and interactive discussions, as well as exercises during which students could practice medication reconciliation or explain a medical error to a standardized patient [16-21]. A multi-institutional study of patient safety knowledge among residents and medical students [22] found that knowledge was affected by year of training, degree program, specialty, and country of medical school. The WHO has developed a comprehensive guide to help medical schools around the world design and implement a patient safety curriculum [10]. The curriculum is currently being piloted in 6 WHO regions, and the results of

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this study will help to improve future patient safety education and will further the development of a comprehensive, integrated, systems-based curriculum.

Research on QI education has mainly focused on residents and attending physicians [6, 14]. A systematic review of QI education for clinicians [6] found that a piloted curriculum improved physicians' knowledge of QI and their confidence in performing QI activities. Literature on QI education for medical students is in short supply. A study conducted at the University of Connecticut School of Medicine [7] demonstrated that student-led diabetes QI projects improved patient care and taught students QI principles. A longitudinal curriculum started at Mayo Medical School showed that active learning techniques (exercises, simulation games, storytelling, and practical experience) were superior to lectures in improving student knowledge [23].

We examined students' current patient safety and QI knowledge and factors associated with greater knowledge. In particular, we wondered whether students who report previous exposure to patient safety or QI education actually attain greater knowledge of these topics. We also wondered whether students who pursue additional education, such as a Master of Public Health (MPH) degree, have greater knowledge of these topics.

Methods

Survey development. We used a literature search, a series of 3 focus groups with medical students, and key informant interviews with local experts to develop a survey that was distributed electronically from April 20, 2012, to May 7, 2012 to all medical students enrolled at the University of North Carolina (UNC) School of Medicine. This survey collected information about demographic characteristics and previous exposure to patient safety and QI education, asked students to rate their level of knowledge about patient safety and QI, and assessed students' current patient safety and QI knowledge. (See Appendix 1; online version only). Students were also asked to rate their own knowledge of patient safety and QI compared with that of other students at their level of training. The 4 questions designed to assess students' knowledge of patient safety were adapted from the content-validated patient safety curriculum (error prevention and systems theory) of the Risk Management Foundation [22]. The 5 questions designed to assess students' knowledge of QI were adapted from the QI curriculum of the Institute for Healthcare Improvement's Open School [24]. Our study was exempted from review by UNC's Office of Human Research Ethics.

Survey administration. All students enrolled at the UNC School of Medicine were contacted by e-mail and asked to participate in the online survey. We also sent 2 follow-up e-mails encouraging students to participate; the e-mails were sent to the students by a medical student involved in the study. Students consented electronically to participate in this study. To incentivize student participation, we offered entry into a drawing for a free iPad (Apple).

Survey of course directors. As part of our initial research, we conducted a survey of all medical school clerkship directors to determine how UNC is currently teaching students about patient safety and QI. We found that diagnostic errors are discussed in the second-year clinical epidemiology class and in the transition-to-internship course that occurs at the end of the fourth year. A transition course taken by all UNC medical students between their second and third years addresses the role that third-year medical students play in patient safety. During the third-year surgical clerkship, students participate in time-outs in the operating room. During their fourth year, all students participate in a full-day program during which they attend a lecture on the National Committee for Quality Assurance and the Medicare Quality Improvement Organization Program, and they write an essay on a patient safety or QI topic of their choosing. Finally, a small number of students took elective courses during which they were exposed to QI projects on lung transplantation and reduction of central line–associated infections, and/or they participated in small-group discussions of QI policy topics. Students who had received or were working toward an MPH degree had significant exposure to patient safety and QI education through required and elective courses.

Data analysis. We report student characteristics, previous exposure to education about patient safety and QI, self-rated knowledge of patient safety and QI, and relative importance of patient safety and QI in the medical school curriculum using percentages and means, with a standard deviation (SD) when appropriate. For each student, we determined scores for patient safety knowledge and QI knowledge using the percentages of correct answers to patient safety questions and QI questions, respectively. A bivariate analysis was used to compare each factor of interest to the patient safety and QI knowledge scores, using a 2-sample t-test or 1-way analysis of variance for variables with more than 2 categories. Factors that were significant in bivariate analysis at a *P*-value less than or equal to .10 were placed in a multiple linear regression model to provide adjusted estimates. Initially we included race in our models; however, race was not associated with any of our exposures of interest and therefore was dropped from the models. For final reporting, we used a significance level of $P \leq .05$. All analyses were performed using Stata 12 (StataCorp).

Results

Participants. A total of 450 of 790 students participated in the survey, for a response rate of 57%. Overall, the demographic characteristics of students who participated in our survey were very similar to those of the medical student body as a whole. Seven percent of respondents were black, compared with 8% of all medical students, and 46% of respondents were male, compared with 49% of all medical students (Table 1). Thirty-nine percent of survey participants were in their preclinical years (first or second year); 47%

TABLE 1.
Demographic Characteristics of Medical Students Who Responded to a Survey About Patient Safety and Quality Improvement

Characteristic	No. (%)
Race (n = 352)	
White	250 (71%)
Black	26 (7 %)
Asian	48 (14%)
Hispanic	22 (6%)
Other	6 (2%)
Sex (n = 356)	
Male	164 (46%)
Female	192 (54%)
Year in medical school (n = 358)	
Preclinical (year 1 or 2)	140 (39%)
Clinical (year 3 or 4)	168 (47%)
Other[a]	50 (14%)
Holds or is pursuing an advanced degree (n = 356)	
Yes	118 (33%)
No	239 (67%)
Intended specialty (n = 355)	
Primary care[b]	131 (37%)
Medicine/pediatrics subspecialty	35 (10%)
Surgical specialty[c]	98 (28%)
Other specialty[d]	91 (26%)

Note. Due to rounding, not all percentages add up to 100%.
[a]Includes students doing research, pursuing an MPH or PhD degree, or taking a leave of absence.
[b]Primary care specialties include medicine, family medicine, medicine/pediatrics, and pediatrics.
[c]Surgical specialties include general surgery, orthopedics, ophthalmology, otolaryngology, plastic surgery, thoracic surgery, vascular surgery, urology, obstetrics and gynecology, and neurosurgery.
[d]Other specialties include anesthesia, dermatology, emergency medicine, medicine/psychiatry, neurology, nuclear medicine, pathology, physical medicine and rehabilitation, preventive medicine, psychiatry, radiation oncology, and radiology.

of participants were in their clinical years (third or fourth year); and 14% of participants were classified as "other" because they were doing research, studying for an MPH or a PhD degree, or taking a leave of absence; corresponding percentages for the medical student body as a whole were 42%, 44%, and 13%, respectively. Among survey participants, 33% of students were currently working on or had already received an advanced degree, such as an MPH, PhD, master of business administration (MBA), or master of science (MS) degree. The most commonly pursued advanced degree was an MPH, which was sought or held by 42% of advanced-degree students. Thirty-seven percent of respondents planned to go into primary care; 10% intended to enter a medical or pediatric subspecialty; 28% planned to go into general surgery or a surgical subspecialty; and 26% intended to enter other specialties.

Patient safety and QI education and self-rated knowledge. More than three-quarters (79%) of students reported previous formal or informal education about patient safety, whereas only 47% of students reported previous formal or informal education about QI (Table 2). Almost half of students (45%) rated their knowledge of patient safety as better than average, whereas only 30% of students rated their knowledge of QI as better than average.

Knowledge scores. The average knowledge score (percentage of answers that were correct) on the 4-item test of patient safety knowledge was 56% (SD = 25%), with a range of 0% to 100%. The most frequently missed item asked about the number of deaths in the United States each year that are attributable to medical errors.

The average score on the 5-item QI knowledge test was 58% (SD = 20%), with a range of 0% to 100%. The question that was most frequently answered incorrectly asked about the effect of systems on improvement of outcomes. Students who did not provide answers to the QI and patient safety items were similar to other respondents in terms of race, sex, year in medical school, and proportion with an advanced degree.

Factors associated with greater knowledge of patient safety. On the patient safety knowledge items, the average score for those holding or currently pursuing an advanced degree was 60%, versus 54% for those without an advanced degree (P = .048; Table 3). Students who reported previous formal or informal education on patient safety performed significantly better than those who did not (57% vs 47%; P = .023). Sex, year in medical school, self-rated patient safety knowledge, and intended specialty were not significantly associated with students' performance on the patient safety knowledge items.

TABLE 2.
Medical Students' Self-Rated Level of Knowledge, Previous Education, and Knowledge Scores for Patient Safety and Quality Improvement (QI)

Measure	No.	Percentage or Mean (SD)
Mean self-rating of knowledge of patient safety (on a scale of 1 to 5[a])	404	3.5 (0.69) 45% rated themselves better than average
Mean self-rating of knowledge of QI (on a scale of 1 to 5[a])	371	3.2 (0.81) 30% rated themselves better than average
Proportion of respondents claiming previous formal or informal education about patient safety	450	79%
Proportion of respondents claiming previous formal or informal education about QI	450	47%
Average percentage of correct answers to 4 questions about patient safety	374	56% (25%)
Average percentage of correct answers to 5 questions about QI	349	58% (20%)

Note. SD, standard deviation.
[a]On the 5-point scale for self-rating one's knowledge of patient safety or QI compared with the knowledge of one's peers, 1 is "poor," 3 is "average," and 5 is "excellent."

TABLE 3.
Demographic Characteristics Associated With Knowledge About Patient Safety

Characteristic	No.	Mean percentage of questions answered correctly	*P*-value[a]
Race (n = 351)			
White	249	59%	.009
Nonwhite	102	51%	
Sex (n = 355)			
Female	191	55%	.60
Male	164	57%	
Year in medical school (n = 358)			
Preclinical (year 1 or 2)	140	54%	.48
Clinical (year 3 or 4)	168	57%	
Other[b]	50	59%	
Holds or is pursuing an advanced degree (n = 356)			
Yes	117	60%	.048
No	239	54%	
Self-rated knowledge of patient safety (n = 373)			
At or below average	198	54%	.15
Above average	175	58%	
Intended specialty (n = 352)			
Primary care[c]	129	58%	.77
Medicine/pediatrics subspecialty	35	58%	
Surgical specialty[d]	98	57%	
Other specialty[e]	90	54%	
Previous formal or informal education about patient safety (n = 374)			
Yes	339	57%	.023
No	35	47%	

[a]Means and *P*-values are based on 2-sample t-tests or 1-way analysis of variance for variables with more than 2 categories; correlations and *P*-values are based on Pearson's correlation.
[b]Includes students doing research, pursuing an MPH or PhD degree, or taking a leave of absence.
[c]Primary care specialties include medicine, family medicine, medicine/pediatrics, and pediatrics.
[d]Surgical specialties include general surgery, orthopedics, ophthalmology, otolaryngology, plastic surgery, thoracic surgery, vascular surgery, urology, obstetrics and gynecology, and neurosurgery.
[e]Other specialties include anesthesia, dermatology, emergency medicine, medicine/psychiatry, neurology, nuclear medicine, pathology, physical medicine and rehabilitation, preventive medicine, psychiatry, radiation oncology, and radiology.

After adjustment, all included factors continued to be significantly associated with greater knowledge scores (Table 4). The adjusted average knowledge score for students holding or currently pursuing an advanced degree was 61%, compared with 54% for students without an advanced degree (*P* = .02). Students with previous exposure to patient safety education had an adjusted average knowledge score of 57%, versus 47% for students with no previous patient safety education (*P* = .02).

Factors associated with greater knowledge of QI. On the QI knowledge items, students in their clinical years performed the same as preclinical students, with an average score of 56% for both groups; however, students who were pursuing an MPH or PhD degree, doing research, or on a leave of absence performed significantly better than the other 2 groups, with an average score of 64% (*P* = .02; Table 5). Students who reported previous formal or informal education about QI performed significantly better than those who did not (60% vs 54%; *P* = .004). Students' intended specialty was also associated with their QI knowledge score; the average score for students entering primary care was 62%, compared with 55% for students entering surgery, 54% for students entering medical or pediatric subspecialties, and 57% for those entering other specialties. Sex, having or pursuing an advanced degree, and self-rated QI knowledge were not associated with students' QI knowledge scores.

After adjustment, previous exposure to QI continued to be significantly associated with higher QI knowledge scores (Table 6). Students who had previous exposure to QI had an adjusted average knowledge score of 60%, versus 55% for students with no previous patient safety education (*P* = .02).

Discussion

Our study found that, overall, students' knowledge of patient safety and QI is low. Exposure to formal or informal QI education during medical school is limited—only 47% of respondents to our survey reported previous exposure to such education. Patient safety education is more common, with 79% of students reporting previous exposure. Overall, we found that previous exposure to patient safety or QI is associated with improved knowledge of the topic, which suggests that patient safety and QI education is effective.

Previous studies have also found that education on patient safety or QI improves students' knowledge [7, 8]; our study helps to affirm this finding. A study of residents and medical students at Harvard Medical School [22], which used the same validated patient safety knowledge questions from which we adapted our patient safety questions, had results similar to those of our study. The Harvard study participants answered a mean of 58.4% (SD = 15.5%) of questions correctly, compared with 56% (SD = 25%) for our participants. Participants in the Harvard study who were in a

TABLE 4.
Adjusted Comparisons Between Student Characteristics and Patient Safety Knowledge Scores

Characteristic	No. (n = 356)	Adjusted mean percentage of questions answered correctly[a]	*P*-value
Holds or is pursuing an advanced degree			
Yes	117	61%	.02
No	239	54%	
Previous formal or informal education about patient safety			
Yes	321	57%	.02
No	35	47%	

[a]Based on beta estimates from a multiple linear regression model, adjusted for advanced degree and previous exposure to patient safety.

TABLE 5.
Demographic Characteristics Associated With Knowledge About Quality Improvement (QI)

Characteristic	No.	Mean percentage of questions answered correctly	*P*-value[a]
Race (n = 341)			
White	242	60%	<.001
Nonwhite	99	50%	
Sex (n = 345)			
Female	184	59%	.14
Male	161	56%	
Year in medical school (n = 347)			
Preclinical (year 1 or year 2)	136	56%	.02
Clinical (year 3 or year 4)	162	56%	
Other[b]	49	64%	
Holds or is pursuing an advanced degree (n = 346)			
Yes	115	60%	.07
No	231	56%	
Self-rated knowledge of QI (n = 349)			
At or below average	240	56%	.06
Above average	109	61%	
Intended specialty (n = 342)			
Primary care[c]	126	62%	.04
Medicine/pediatrics subspecialty	35	54%	
Surgical specialty[d]	93	55%	
Other specialty[e]	88	57%	
Previous formal or informal education about QI (n = 349)			
Yes	198	60%	.004
No	151	54%	

[a]Means and *P*-values are based on 2-sample t-tests or 1-way analysis of variance for variables with more than 2 categories; correlations and *P*-values are based on Pearson's correlation.
[b]Includes students doing research, pursuing an MPH or PhD degree, or taking a leave of absence.
[c]Primary care specialties include medicine, family medicine, medicine/pediatrics, and pediatrics.
[d]Surgical specialties include general surgery, orthopedics, ophthalmology, otolaryngology, plastic surgery, thoracic surgery, vascular surgery, urology, obstetrics and gynecology, and neurosurgery.
[e]Other specialties include anesthesia, dermatology, emergency medicine, medicine/psychiatry, neurology, nuclear medicine, pathology, physical medicine and rehabilitation, preventive medicine, psychiatry, radiation oncology, and radiology.

combined MD/MPH or MD/PhD program had higher knowledge scores; similarly, our study found that students holding or pursuing an advanced degree performed better. We are unsure whether the better performance is due to increased education, increased interest in these topics, or both.

In our study, students' intended specialty was not associated with their patient safety knowledge scores. In the Harvard study, however, medical specialty was associated with participants' patient safety knowledge scores; students and residents intending to specialize in emergency medicine or medicine performed better than those entering other specialties [22]. This difference could be explained by differences in residency education, since the Harvard study included residents as well as medical students; in contrast, our study only included medical students, all of whom receive similar education regardless of their intended specialty.

The literature on QI education for medical students is sparse, but studies have found that previous exposure is associated with improved knowledge. Two single-center studies of implemented QI curricula found that students' knowledge improved [7, 23]. The results of our study are consistent with this finding, which adds to this growing body of evidence.

Our study has several possible limitations. There is a risk of measurement bias due to the use of an unvalidated instrument to generate a QI knowledge score. Items in the patient safety knowledge test were adapted from a validated test, but our version was shortened, possibly limiting the applicability of the previous validation. There is also a risk for recall bias, as students who have greater knowledge of patient safety or QI might recall exposure to patient safety or QI education at a greater frequency, inflating the association between exposure and knowledge. There are many factors that influence changes in students' knowledge and attitudes; given that this is a cross-sectional study, we cannot draw conclusions about causality. There is minimal risk of nonresponse bias, as we have shown that the demographic characteristics of survey participants were similar to those of the entire medical school student body. We did not require that the students respond to every question on the survey, which resulted in a variable number of participants for each question. Our study may have limited generalizability because it was conducted at only one medical school. The UNC School of Medicine is a large public institution

TABLE 6.
Adjusted Comparisons Between Student Characteristics and Quality Improvement (QI) Knowledge Scores

Characteristic	No. (n = 342)	Adjusted mean percentage of questions answered correctly[a]	*P*-value[a]
Intended specialty			
Primary care[b]	126	61%	.07
Surgical specialty[c]	93	55%	
Medicine/pediatrics subspecialty	35	54%	
Other specialty[d]	88	57%	
Previous formal or informal education about QI			
Yes	196	60%	.02
No	146	55%	

[a]Based on beta estimates from a multiple linear regression model, adjusted for previous QI exposure and specialty choice.
[b]Primary care specialties include medicine, family medicine, medicine/pediatrics, and pediatrics.
[c]Surgical specialties include general surgery, orthopedics, ophthalmology, otolaryngology, plastic surgery, thoracic surgery, vascular surgery, urology, obstetrics and gynecology, and neurosurgery.
[d]Other specialties include anesthesia, dermatology, emergency medicine, medicine/psychiatry, neurology, nuclear medicine, pathology, physical medicine and rehabilitation, preventive medicine, psychiatry, radiation oncology, and radiology.

with a focus on primary care and research. Therefore, UNC students might have more exposure to patient safety and QI education than students at other institutions. Finally, a large number of students attending the UNC School of Medicine also participate in the university's MPH program, which significantly increases their exposure to patient safety and QI topics.

Conclusion

Our study found that previous exposure to patient safety and QI education is associated with improved knowledge about these topics, which helps to support the argument for increased education on patient safety and QI during medical school. Further multicenter research is needed both to determine the most effective methods for teaching these topics and to determine whether teaching medical students about patient safety and QI actually helps to improve patient care and to decrease morbidity and mortality [25]. Given the AAMC endorsement of patient safety and QI education for medical students, curriculum development and assessment are currently at the forefront of medical education. NCMJ

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