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Assessing Physician Safety and Quality Knowledge

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Abstract

Objective

It is well known that, for physicians to practice safe, high quality medicine, they must have sufficient safety and quality knowledge. Although a great deal is known about the safety and quality perceptions, attitudes, and beliefs of physicians, little is known about their safety and quality knowledge. This study tested the safety and quality knowledge of practicing primary care physicians.

Design

Prospective test of safety and quality knowledge

Setting

Primary care physicians practicing in the United States.

Participants

Study consisted of 518 U.S. practicing primary care physicians who answered an email invitation. It included 54% Family Medicine and 46% Internal Medicine physicians, who accepted an email invitation. The response rate was 66%.

Intervention

The physicians took a 24-question multiple-choice test over the Internet.

Outcome

The outcome was the percent correct.

Results

The average number of correct answers was 11.4 (SD, 2.69), 48% correct. Three common clinical vignettes questions were answered correctly by 45% of the physicians. Five physicians' knowledge of common radiation exposures questions were answered correctly by 40% of the physicians. Seven common healthcare quality and safety questions were answered correctly by 43% of the physicians. Seven Donabedian's model of structure, process, and outcome measure questions were answered correctly by 67% of the physicians. Two Institute of Medicine's definitions of quality and safety questions were answered correctly by 19.5% of the physicians.

Conclusion

Forty-eight percent of the physicians' answers to the safety and quality questions were correct. To our knowledge, this is the first assessment of the safety and quality knowledge of practicing U.S. primary care physicians.

Strengths and limitations of this study

- A strength is that it consisted of practicing primary care physicians
- A strength is that it is representative of U.S. physicians
- A strength is its large sample size
- A limitation is that, although the questions were designed to assess enduring information, a few questions may be outdated and need to be discarded, at the times of the follow-up testing.

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Disclaimer

The findings and conclusions of this paper are those of the authors and do not necessarily represent the positions or views of the U.S. Department of Defense, the Military Health System, the Defense Health Agency, or the Uniformed Services University of the Health Sciences.

Disclosures

The Uniformed Services University of the Health Sciences institutional review board approved this study.

Conflicting and/or competing interests

The authors declare that they have no conflicts or competing interests.

Author contributions

Both authors contributed to the conception, creation, design, implementation, analysis, and presentation of the results.

Data sharing

The frequency counts for each question are shown in the Appendix.

Acknowledgments

None.

Introduction

The landmark Institute of Medicine (IOM) report, *To Err Is Human: Building a Safer Health System,* [1] described a medical system that had become a clinical colossus, but its safety and quality had not kept pace with its size and complexity. It presented a system that was committing more errors yet detecting and correcting only a small fraction of them. It described a system with significant safety and quality deficits, some of which resulted in patient injury and death, and it recommended sweeping healthcare reforms.

Since *To Err Is Human* was published more than 20 years ago, a great deal of work has been done on improving safety and quality, [2] yet a recent IOM report, *Best Care at Lower Cost: The Path to Continuously Learning Health Care in America*, [3] and a recent study, [4] suggest that many of the errors reported in *To Err Is Human* are continuing. The persistence and frequency of errors, and our reduced tolerance for errors, has heightened the importance[3] in medical safety and quality.

Although a great deal is known about the safety and quality perceptions, attitudes, and beliefs of physicians, [5-9] little is known about their safety and quality knowledge. We designed a cross-sectional test of the safety and quality knowledge of practicing physicians. We believe this to be the first test of the safety and quality knowledge of practicing U.S. primary care physicians.

Methods

This is a cross-sectional test of the safety and quality knowledge of practicing United States (U.S.) General Internal Medicine and Family Medicine physicians. Its participants were drawn from a national panel of physicians registered in Medscape. Physicians who completed the test received a $30.00 Amazon gift card. The test was budgeted for 518 physicians completing

the test. Seven hundred and eighty-eight practicing primary care physicians were randomly selected and solicited, which resulted in a 66% response rate. The test instrument was web-based and consisted of 24 multiple-choice questions. The questions were taken from widely available safety and quality textbooks and clinical literature, it did not assume expert safety and quality knowledge and, for the most part, represented enduring information. The questions, and their references, are shown in the Appendix. The questions were presented in a random order and no changes were made to the questions during testing. The only instruction the physicians received was that they had to answer all the questions. The deidentified results were sent to the investigators. The questions were not weighted. For each question, the percent correct is calculated and, for each topic, the average percent correct was calculated. The Chi-square test was used to assess demographic differences and whether the categorial answer frequencies differed from chance, and the Student's t-test was used to compare continuous variables. The tests were performed using R (www.R-project.org) and significance was set at a probability of less than 0.05. The Uniformed Services University Institutional Review Board approved this research.

Results

The study demographics of the 518 physicians are shown in Table 1. The medical specialty of the participants was 46% General Internal Medicine and 54% Family Medicine. The gender of the participants was 64% male and 35% female. There were no significant differences between the participants and practicing physicians in terms of specialty, gender, and age. [10,11] There were no significant differences in the test scores within specialty, gender, and age, except

for slightly lower scores for physicians over 60 years of age compared to those under 60 years of age, 0.45 (SD, 0.12) and 0.48 (SD, 0.11) respectively, p = 0.003. The median time to take the test was 10.1 minutes.

The average number of correct answers was 11.4 (SD, 2.69), 48% correct. Every physician answered at least four questions correctly and no physician answered more than 20 questions correctly (Figure 1). For each question, the distribution of answers was significantly different from that expected by chance. The mean percent correct for each of the five topics is shown in Figure 2.

Three common patient management vignettes addressed the physician's clinical quality knowledge. There were five choices per question. The average number of correct answers was 1.3 (SD, 0.90), 45% correct. Fifty-five percent of the physicians knew how to manage a woman with breast cancer who tested positive for a deleterious BRCA mutation; 46%, knew the work up for an indeterminate renal mass; and 33%, knew the current approach to screening for lung cancer. In terms of the renal mass, the American College of Radiology Appropriateness Criteria[12] gave the computed tomography (CT) abdomen without and with intravenous (IV) contrast the highest appropriateness rating, 9, but this modality also had the highest radiation level. The ultrasound kidney retroperitoneal with duplex Doppler had the next highest rating, 8. The ACR states that appropriateness ratings of 9, 8, and 7 are "Usually appropriate." Forty-six percent of the physicians correctly balanced the radiation risk against the marginal additional benefit of CT and chose the ultrasound test. These results are also consistent with a recent study that found that physicians rarely have accurate expectations of the harms and benefits of clinical interventions, which the investigators attributed to a lack of knowledge. [13]

Five questions addressed physicians' knowledge of common radiation risks. There were four choices per question, each choice differed by one base-ten log. In other words, the four possible answers to the question spanned a four-log range. The average number of correct answers was 2.0 (SD, 1.14), 40% correct. Sixty-one percent of the physicians correctly identified the radiation exposure delivered by a chest x-ray, 60% correctly identified the radiation exposure delivered by a mammogram, but only 45%, could correctly identify the radiation exposure delivered by a CT scan of the abdomen and pelvis. Furthermore, in terms of population risk, only 25% of the physicians correctly chose the annual natural radiation exposure of an individual and only 11% knew the degree to which a 20 mSv of radiation exposure increased the population risk of a fatal cancer. These results are consistent with a systematic review of computed tomography and other radiographic procedures that found a similarly low level of radiology exposure knowledge among physicians. [14]

Seven questions addressed common healthcare system safety and quality issues. There were five choices per question. The average number of correct answers was 3.0 (SD, 1.27), 43% correct. Eighty-eight percent of the physicians knew the main hospital accrediting body, 74% knew the definition of beneficence, and 53% knew the Swiss Cheese model of accidents. But their accuracy was lower for questions regarding quality improvement tools, medication errors, 6-sigma, and harm detection – which were answered correctly by 34%, 19%, 19%, and 14% of the physicians, respectively. These results are consistent with a recent study of generalist and subspecialist Internal Medicine physicians which found that they correctly answered 43% of the questions regarding the U.S. Food and Drug Administration approval process. [15] They are also consistent with a study of physician knowledge of central line-associates blood stream infection quality metrics that found that they answered 61% of the questions correctly. [16]

Seven questions addressed Donabedian's [17] model for assessing safety and quality in terms of structure, process, and outcomes. There were three choices per question. The average number of correct answers was 4.7 (SD, 1.50), 67% correct. This set of questions contained the easiest question, namely, whether "The percentage of patients who are satisfied with their care" was a structure, process, or outcome measure. Ninety-six percent of the physicians correctly answered that it was an outcome. The physicians were highly accurate on classifying nosocomial infections, 89%, and staffing, 84%, but they were only 53% correct in classifying beta-blockers, 53% correct in classifying credentials, 50% correct in classifying the diabetic foot exam, and 45% correct in classifying discharge instructions.

Two questions asked physicians to identify common safety and quality definitions from the IOM. There were five choices per question. The average number of correct answers was 0.39 (SD, 0.54), 20% correct. The definitions were published 19 years ago in *To Err Is Human*. Despite the high visibility of *To Err Is Human*, only 33% of the physicians correctly identified the IOM definition of quality. The most difficult of the 24 questions was the IOM's definition of safety. Limiting the definition to "freedom from accidental injury," would not have distinguished it from other safety definitions. Therefore, the correct answer included the rest of the IOM definition, "where accidental injury can be due to error, as either the failure of a planned action to be completed as intended or the use of the wrong plan to achieve an aim." Only six percent of physicians knew the correct definition.

Conclusions

U.S. physicians answered forty-eight percent of the safety and quality questions correctly. They performed best on questions that required little safety and quality knowledge and worst on

question that required basic safety and quality knowledge. Our population was similar to the U.S. physician population in terms of specialty, gender, and age. There were no significant differences within specialty, gender, or age; although the scores of physicians over 60 years of age were slightly lower. These results are consistent with studies of physician knowledge of clinical harms and benefits, [13] radiology knowledge, [14] knowledge of the FDA approval process, [15] and of quality metrics. [16]

Physicians want to practice safe, high quality medicine, [18] but they may not be aware of how much they need to know about safety and quality. Furthermore, physicians need time to learn about safety and quality, and they need the time and expertise required to use the information in their EHRs to monitor the safety and quality of their practice. Although many health care systems consider themselves to be healthcare learning systems, [19,20] that belief does not always translate into their assisting frontline clinicians in improving their safety and quality knowledge. [21,22]

It is clear that physicians require quality and safety training. The postgraduate Clinical Learning Environment Review (CLER) was created to instruct physicians in six areas, namely, patient safety, health care quality, care transitions, supervision, duty hours/fatigue management & mitigation, and professionalism. [23] It began to be implemented in 2015 and is now fully implemented. Our test was prior to the widespread implementation of CLER. We will assess primary care physicians' safety and quality knowledge in five years. Our expectation is that the younger physicians then will perform better than they did on this initial test, and that safety and quality knowledge will even improve among older physicians. Furthermore, we expect to observe more physician-directed quality and safety programs. [24]

The main limitation of this study is that, although the questions were designed to assess enduring information, the two clinical questions and the two definitions may be outdated, resulting in 20 follow-up testing questions. Another limitation is that we may have overestimated physician knowledge because it used multiple-choice questions that probe recognition. Physician scores might have been substantially lower had they been asked to recall the correct answer to each question.

In conclusion, forty-eight percent of the physicians' answers to the safety and quality questions were correct. A national system has been put in place at the resident level to improve physician safety and quality knowledge. Since knowledge is a prerequisite for performance, we expect that in the future physicians' increased knowledge will result in their improving their safety and quality performance. We believe this to be the first prospective test of the safety and quality knowledge of practicing U.S. primary care physicians.

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Figure legends

Figure 1. Percentage of subjects answering the questions correctly

Figure 2. Mean percent correct in each of the five topics

Table 1. Physician characteristics[a]

	Study population Number and Percent	National population Percent
Medical Specialty[b]		
Family Medicine	280 (54%)	53%
Internal Medicine	238 (46%)	47%
Gender[c]		
Male	331 (64%)	66%
Female	187 (36%)	34%
Age[c]		
< 39	131 (25%)	21%
40 – 49	160 (31%)	24%
50 – 59	124 (24%)	24%
60 – 69	85 (17%)	20%
70 +	18 (3%)	11%

[a]There were no significant differences between the study population and the national population in terms of medical specialty, gender, or age.
[b]National: https://www.ahrq.gov/research/findings/factsheets/primary/pcwork1/index.html
[c]National: Young A, Chaudhry HJ, Pei X, Halbesleben K, Polk DH, Dugan M. A census of actively licensed physicians in the United States, 2014. J Med Reg 2015;101(2):8-23

Table 2. Questions and percent correct (ordered from highest to lowest percentage correct)

Questions	Percent correct
Patient management (5 choices per question)	
A 42-year-old female presents to your clinic for the first time. She is s/p a left lumpectomy for unilateral breast cancer. You order a BRCA test, which comes back positive for a deleterious mutation. You recommend:	55%
A 22-year-old female transferred to your clinic from another facility. She sees you for the first time today. She states that she has a 2 cm indeterminate renal mass that was incidentally detected during a work-up for a suspected kidney stone almost 3 years ago. Her previous physician told her that it needed to be re-imaged within 3 years. She does not remember what imaging test was used to detect the mass. She denies any new symptoms or blood in her urine. She is here for an imaging test. Pick the best test.	46%
A retired 66-year-old man presents to your clinic for a routine physical examination. He has a history of COPD. You ask about his tobacco history and he tells you that he started smoking when he was 25 years old, he smoked 1 pack-per-day for 25 years, and he stopped smoking when he was 50 years old. He wants to know if he should do something to assess his risk of lung cancer. You order:	33%
Patient management mean percent correct	**45%**
Radiation risk (4 choices per question)	
The effective dose of a two-view chest radiograph is approximately:	61%
The effective dose of a two-view mammogram is approximately:	60%
The effective dose of a single CT of the abdomen and pelvis, with and without contrast is approximately:	45%
For the average American living at sea level, the annual effective dose of radiation is approximately:	25%
Receiving at least 20 mSv (millisieverts) of radiation increases an adult person's risk of a fatal cancer by approximately:	11%
Radiation risk mean percent correct	**40%**
General Safety and Quality (5 choices per question)	
The main hospital accreditation body in the United States is:	88%
Which one of the following refers to acting in the best interest of the patient?	74%
Which of the following is the correct description of the Swiss Cheese model of accidents?	53%
Select from the list below the method that is NOT a tool for analyzing quality improvement.	34%
Which of the following is NOT a part of "6-sigma?"	19%
The most frequent reason for hospital medication errors is:	19%
Several methods for detecting harms are shown below. Used in their usual way, which method detects the most harms?	14%
Safety mean percent correct	**45%**

Structure, process, outcome (3 choices per question)	
The percentage of patients who are satisfied with their care.	96%
Percentage of patients that experience a nosocomial infection.	89%
There is enough clinical staff to care for the patients.	84%
The percentage of patients with an acute myocardial infarction who receive a beta-blocker.	53%
Clinicians are properly credentialed.	53%
The percentage of diabetic patients that have an order for an annual foot exam.	50%
The percentage of patients that are given discharge instructions.	45%
Structure, process, outcome mean percent correct	**67%**
Safety and quality definitions (IOM) (5 choices per question)	
The Institute of Medicine's definition of quality is:	33%
The Institute of Medicine's definition of safety is:	6%
Safety and quality definitions mean percent correct	**20%**
Grand mean percent correct	**48%**

Figure 1.

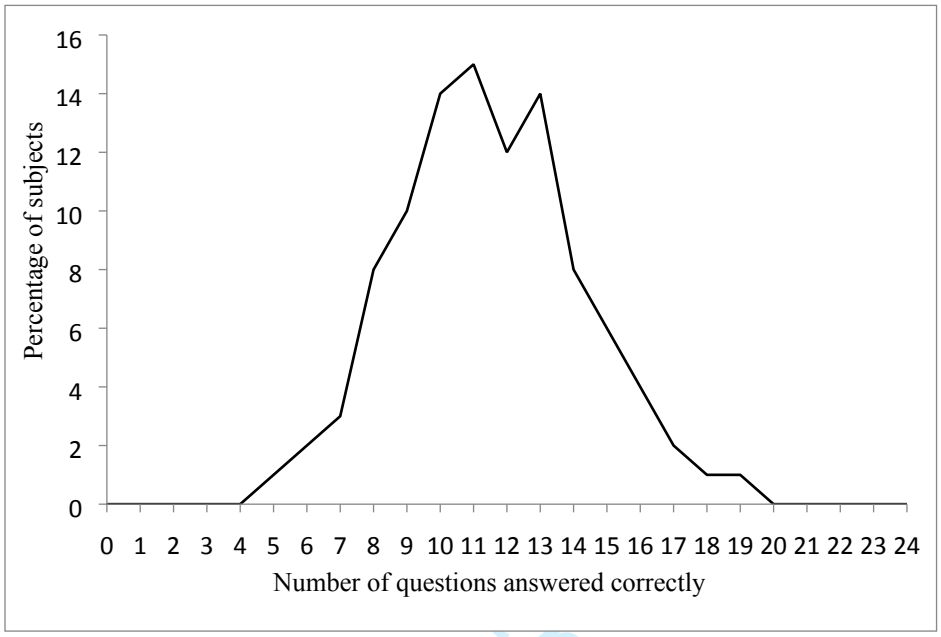
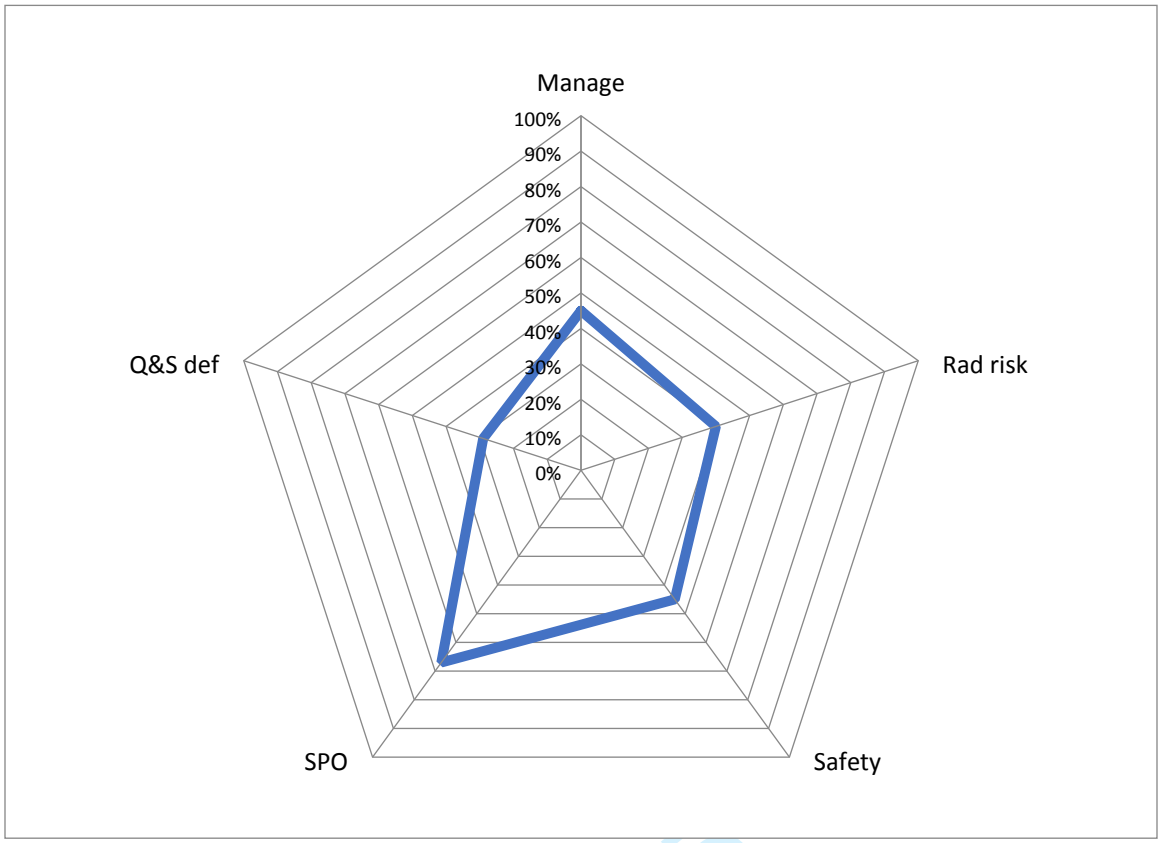


Figure 2.



APPENDIX

The correct answers are in bold. In the test the questions were presented in random order, there were no results, the correct answers were not in bold, and the questions were not referenced.

PATIENT MANAGEMENT

A 42-year-old female presents to your clinic for the first time. She is s/p a left lumpectomy for unilateral breast cancer. You order a BRCA test, which comes back positive for a deleterious mutation. You recommend:

Left breast mastectomy	48 (9%)
Bilateral mastectomy	166 (32%)
Bilateral salpingo-oophorectomy	8 (2%)
Left breast mastectomy and bilateral salpingo-oophorectomy	13 (3%)
Bilateral mastectomy and bilateral salpingo-oophorectomy[1]	**283 (55%)**

A 22-year-old female transferred to your clinic from another facility. She sees you for the first time today. She states that she has a 2 cm indeterminate renal mass that was incidentally detected during a work-up for a suspected kidney stone almost 3 years ago. Her previous physician told her that it needed to be re-imaged within 3 years. She does not remember what imaging test was used to detect the mass. She denies any new symptoms or blood in her urine. She is here for an imaging test. Pick the best test.

Arteriography kidney	1 (0%)
CT abdomen with and without contrast	114 (22%)
MRI abdomen without contrast	13 (3%)
X-ray intravenous urography	4 (1%)
CT abdomen without contrast	42 (8%)
MRI abdomen with and without contrast	32 (6%)
U/S kidney retroperitoneal with Doppler[2]	**239 (46%)**
CT abdomen with contrast	73 (14%)

A retired 66-year-old man presents to your clinic for a routine physical examination. He has a history of COPD. You ask about his tobacco history and he tells you that he started smoking when he was 25 years old, he smoked 1 pack-per-day for 25 years, and he stopped smoking when he was 50 years old. He wants to know if he should do something to assess his risk of lung cancer. You order:

No imaging[3]	**173 (33%)**
Chest x-ray, PA and lateral	72 (14%)
CT of the chest without contrast	35 (7%)
CT of the chest with and without contrast	16 (3%)
A low-dose CT of the chest	222 (43%)

RADIATION RISK

The effective dose of a two-view chest radiograph is approximately:

0.01 mSv (millisievert)	62 (12%)
0.1 mSv[4]	**316 (61%)**
1.0 mSv	112 (22%)
10.0 mSv	28 (5%)

The effective dose of a two-view mammogram is approximately:

0.04 mSv (millisievert)	116 (22%)
0.4 mSv[5]	**313 (60%)**
4.0 mSv	84 (16%)
40.0 mSv	5 (1%)

The effective dose of a single CT of the abdomen and pelvis, with and without contrast is approximately:

0.02 mSv (millisievert)	9 (2%)
0.2 mSv	69 (13%)
2.0 mSv	206 (40%)
20.0 mSv[6]	**234 (45%)**

For the average American living at sea level, the annual effective dose of radiation is approximately:

0.03 mSv (millisievert)	223 (43%)
0.3 mSv	148 (29%)
3.0 mSv[7]	**127 (25%)**
30.0 mSv	20 (4%)

Receiving at least 20 mSv (millisieverts) of radiation increases an adult person's risk of a fatal cancer by approximately:

1 in 100,000 – 1,000,000	116 (22%)
1 in 10,000 – 100,000	183 (35%)
1 in 1,000 – 10,000	164 (32%)
1 in 100 – 1,000[8]	**55 (11%)**

GENERAL SAFETY AND QUALITY

The main hospital accreditation body in the United States is:

Institute for Healthcare Improvement (IHI)	2 (0%)

American Hospital Association (AHA)	16 (3%)
National Committee for Quality Assurance (NCQA)	27 (5%)
The Joint Commission (JC)[9]	**456 (88%)**
Centers for Medicare and Medicaid Services (CMS)	17 (3%)

Which one of the following refers to acting in the best interest of the patient?

Respect for autonomy	60 (12%)
Beneficence[10]	**382 (74%)**
Nonmaleficence	62 (12%)
Justice	5 (1%)
Fairness	9 (2%)

Which of the following is the correct description of the Swiss cheese model of accidents?

Many people making the same mistake over and over again will eventually cause an accident.	65 (13%)
It usually takes several things going wrong for an accident to [11]	**274 (53%)**
If a person makes the same mistake many times, it will eventually cause an accident.	57 (11%)
It is about filling in holes in the system.	108 (21%)
A person who makes a root cause error will cause an accident.	14 (3%)

Select from the list below the method that is NOT a tool for analyzing quality improvement.

Process mapping	20 (4%)
Flow charts	58 (11%)
Fishbone diagrams	127 (25%)
Discharge checklists[12]	**177 (34%)**
Pareto charts	136 (26%)

Which of the following is NOT a part of "6-sigma?"

Its goal is to reduce errors to a rate of 3.4 errors per million opportunities to make an error.	66 (13%)
It involves a series of five steps: define, measure, analyze, improve, and control.	93 (18%)
It is especially useful for processes that do not happen frequently.[13]	**99 (19%)**
Its practitioners are known as black belts.	165 (32%)
It is six standard deviations from the average.	95 (18%)

The most frequent reason for hospital medication errors is:

Prescribing[14]	**98 (19%)**

Transcribing	244 (47%)
Dispensing	64 (12%)
Administration	93 (18%)
Monitoring	19 (4%)

Several methods for detecting harms are shown below. Used in their usual way, which method detects the most harms?

Direct observation of care	129 (25%)
Reports by clinicians	30 (6%)
IHI global trigger tools[15]	**73 (14%)**
AHRQ Patient Safety Indicators	169 (33%)
Chart reviews	117 (23%)

STRUCTURE, PROCESS, OUTCOME

Identify whether this is an example of a structure (S), process (P), or outcome (O).
Q. The percentage of patients who are satisfied with their care.

S	6 (1%)
P	17 (3%)
O[16]	**495 (96%)**

Identify whether this is an example of a structure (S), process (P), or outcome (O).
Q. Percentage of patients that experience a nosocomial infection.

S	18 (3%)
P	37 (7%)
O[16]	**463 (89%)**

Identify whether this is an example of a structure (S), process (P), or outcome (O).
Q. There is enough clinical staff to care for the patients.

S[16]	**436 (84%)**
P	46 (9%)
O	36 (7%)

Identify whether this is an example of a structure (S), process (P), or outcome (O).
Q. The percentage of patients with an acute myocardial infarction who receive a beta-blocker.

S	26 (5%)
P[16]	**274 (53%)**
O	218 (42%)

Identify whether this is an example of a structure (S), process (P), or outcome (O).

Q. Clinicians are properly credentialed.

S[16]	**272 (53%)**
P	226 (44%)
O	20 (4%)

Identify whether it is an example of a structure (S), process (P), or outcome (O).
Q. The percentage of diabetic patients that have an order for an annual foot exam.

S	55 (11%)
P[16]	**257 (50%)**
O	206 (40%)

Identify whether this is an example of a structure (S), process (P), or outcome (O).
Q. The percentage of patients that are given discharge instructions.

S	12 (2%)
P[16]	**234 (45%)**
O	272 (53%)

QUALITY AND SAFETY DEFINITIONS

The Institute of Medicine's definition of quality is:

Providing acceptable and expected medical care, where acceptable means medical care that patients understand, agree to, and can afford, and expected means performance at the current professional standard of care.	183 (35%)
Doing the right thing at the right time for the right individual to get the best possible results.	75 (14%)
The degree to which health services for individuals and populations increase the likelihood of desired health outcomes and are consistent with current professional knowledge.[17]	**170 (33%)**
A system in which organizations are accountable for continuously improving the quality of their services and safeguarding high standards of care.	65 (13%)
Receiving the best care possible for one's illness or condition.	25 (5%)

The Institute of Medicine's definition of safety is:

The minimization of the risk of any harm, and the amelioration of the effect of a harm, to a person caused by medical care.	135 (26%)
Freedom from accidental or preventable injuries produced by medical care.	60 (12%)

Assuring that all care is safe for all patients requires examining the systems and processes of care, identifying the points of failure, and modifying the factors that cause systems to break down.	90 (17%)
The avoidance, prevention, and amelioration of adverse outcomes or injuries stemming from the process of care.	200 (39%)
Freedom from accidental injury, where accidental injury can be due to error, as either the failure of a planned action to be completed as intended or the use of the wrong plan to achieve an aim.[18]	**33 (6%)**

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Assessing Physician Safety and Quality Knowledge

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Abstract

Objective

It is well known that, for physicians to practice safe, high quality medicine, they must have sufficient safety and quality knowledge. Although a great deal is known about the safety and quality perceptions, attitudes, and beliefs of physicians, little is known about their safety and quality knowledge. This study tested the safety and quality knowledge of practicing primary care physicians.

Design

Cross-sectional test of safety and quality knowledge

Setting

Primary care physicians practicing in the United States.

Participants

Study consisted of 518 U.S. practicing primary care physicians who answered an email invitation. It included 54% Family Medicine and 46% Internal Medicine physicians, who accepted an email invitation. The response rate was 66%.

Intervention

The physicians took a 24-question multiple-choice test over the Internet.

Outcome

The outcome was the percent correct.

Results

The average number of correct answers was 11.4 (SD, 2.69), 48% correct. Three common clinical vignettes questions were answered correctly by 45% of the physicians. Five physicians' knowledge of common radiation exposures questions were answered correctly by 40% of the physicians. Seven common healthcare quality and safety questions were answered correctly by 43% of the physicians. Seven Donabedian's model of structure, process, and outcome measure questions were answered correctly by 67% of the physicians. Two Institute of Medicine's definitions of quality and safety questions were answered correctly by 19.5% of the physicians.

Conclusion

Forty-eight percent of the physicians' answers to the safety and quality questions were correct. To our knowledge, this is the first assessment of the safety and quality knowledge of practicing U.S. primary care physicians.

Strengths and limitations of this study

- A strength is that it consisted of practicing primary care physicians
- A strength is that it is representative of U.S. physicians
- A strength is its large sample size
- A limitation is that, although the questions were designed to assess enduring information, a few questions may be outdated and need to be discarded, at the times of the follow-up testing.

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Disclaimer

The findings and conclusions of this paper are those of the authors and do not necessarily represent the positions or views of the U.S. Department of Defense, the Military Health System, the Defense Health Agency, or the Uniformed Services University of the Health Sciences.

Disclosures

The Uniformed Services University of the Health Sciences institutional review board approved this study.

Conflicting and/or competing interests

The authors declare that they have no conflicts or competing interests.

Author contributions

HB: originated the study idea and designed the research project, analyzed the study data and drafted the manuscript. HK: made important contributions to designing the research project and analyzing the study data, and made significant contributions to the writing of the manuscript.

Data sharing

The frequency counts for each question are shown in Table 2.

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Introduction

The landmark Institute of Medicine (IOM) report, *To Err Is Human: Building a Safer Health System,* [1] described a medical system that had become a clinical colossus, but its safety and quality had not kept pace with its size and complexity. It presented a system that was committing more errors yet detecting and correcting only a small fraction of them. It described a system with significant safety and quality deficits, some of which resulted in patient injury and death, and it recommended sweeping healthcare reforms.

Since *To Err Is Human* was published more than 20 years ago, a great deal of work has been done on improving safety and quality, [2] yet a recent IOM report, *Best Care at Lower Cost: The Path to Continuously Learning Health Care in America*, [3] and a recent study, [4] suggest that many of the errors reported in *To Err Is Human* are continuing. The persistence and frequency of errors, and our reduced tolerance for errors, has heightened the importance[3] in medical safety and quality.

Although a great deal is known about the safety and quality perceptions, attitudes, and beliefs of physicians, [5-9] little is known about their safety and quality knowledge. We designed a cross-sectional test of the safety and quality knowledge of practicing physicians. We believe this to be the first test of the safety and quality knowledge of practicing U.S. primary care physicians.

Methods

This is a cross-sectional one-time test of the safety and quality knowledge of practicing United States (U.S.) General Internal Medicine and Family Medicine physicians. Its participants were drawn from a national panel of physicians registered in Medscape. Physicians who

completed the test received a $30.00 Amazon gift card. The test was budgeted for 518 physicians completing the test. Seven hundred and eighty-eight practicing primary care physicians were randomly selected and solicited via email, which resulted in a 66% response rate. The test instrument was web-based and consisted of 24 multiple-choice questions. The questions were taken from widely available safety and quality textbooks and clinical literature, it did not assume expert safety and quality knowledge and, for the most part, represented enduring information. There were six areas of questions: patient management, radiation risk, general safety and quality, structure, process and outcome; and quality and safety definitions.

In terms of patient management, three common patient management vignettes addressed the physician's clinical quality knowledge. For the breast cancer vignette, there were five possible answers. For the renal mass, the American College of Radiology (ACR) Appropriateness Criteria[10] gave the computed tomography (CT) abdomen without and with intravenous (IV) contrast the highest appropriateness rating, 9, but this modality also had the highest radiation level. The ultrasound kidney retroperitoneal with duplex Doppler had the next highest rating, 8. The ACR states that appropriateness ratings of 9, 8, and 7 are "Usually appropriate." There were eight possible answers to the renal mass question. Finally, in terms of patient management, the lung cancer screening consisted of five possible answers.

In terms of common radiation risks, five questions addressed physicians' knowledge of common radiation risks. There were four choices per question, each choice differed by one base-ten log. In other words, the four possible answers to the question spanned a four-log range.

In terms of common healthcare system safety and quality issues, there were seven questions. There were five choices per question. In terms of Donabedian's [11] model for assessing safety and quality in terms of structure, process, and outcomes, there were seven questions.

There were three choices per question. Two questions asked physicians to identify common safety and quality definitions from the IOM. There were five choices per question. The most difficult of the 24 questions was the IOM's definition of safety. Limiting the definition to "freedom from accidental injury," would not have distinguished it from other safety definitions. Therefore, the correct answer included the rest of the IOM definition, "where accidental injury can be due to error, as either the failure of a planned action to be completed as intended or the use of the wrong plan to achieve an aim."

The questions, and their references, are shown in Table 2. [12-29] The questions were presented in a random order and no changes were made to the questions during testing. The only instruction the physicians received was that they had to answer all the questions. The deidentified results were sent to the investigators by Medscape. The questions were not weighted. For each question, the percent correct is calculated and, for each topic, the average percent correct was calculated. The Chi-square test was used to assess demographic differences and whether the categorial answer frequencies differed from chance, and the Student's t-test was used to compare continuous variables. The tests were performed using R (www.R-project.org) and significance was set at a probability of less than 0.05. The Uniformed Services University Institutional Review Board approved this research.

Results

The study demographics of the 518 physicians are shown in Table 1. The medical specialty of the participants was 46% General Internal Medicine and 54% Family Medicine. The gender of the participants was 64% male and 35% female. There were no significant differences between the participants and practicing physicians in terms of specialty, gender, and age. [30,31]

There were no significant differences in the test scores within specialty, gender, and age, except for slightly lower scores for physicians over 60 years of age compared to those under 60 years of age, 0.45 (SD, 0.12) and 0.48 (SD, 0.11) respectively, $p = 0.003$. The median time to take the test was 10.1 minutes.

The results are shown in Table 2. The average number of correct answers was 11.4 (SD, 2.69), 48% correct. Every physician answered at least four questions correctly and no physician answered more than 20 questions correctly (Figure 1). For each question, the distribution of answers was significantly different from that expected by chance ($p < 0.01$). The mean percent correct for each of the five topics is shown in Figure 2.

In terms of the three common management vignettes, the average number of correct answers was 1.3 (SD, 0.90), 45% correct. For the breast cancer vignette, fifty-five percent of the physicians knew how to manage a woman with breast cancer who tested positive for a deleterious BRCA mutation. For the renal mass vignette, 46%, knew the work up for an indeterminate renal mass. For the lung cancer screening, 33%, knew the current approach to screening for lung cancer. Forty-six percent of the physicians correctly balanced the radiation risk against the marginal additional benefit of CT and chose the ultrasound test. These results are also consistent with a recent study that found that physicians rarely have accurate expectations of the harms and benefits of clinical interventions, which the investigators attributed to a lack of knowledge. [32]

In terms of common radiation risks, the average number of correct answers was 2.0 (SD, 1.14), 40% correct. Sixty-one percent of the physicians correctly identified the radiation exposure delivered by a chest x-ray, 60% correctly identified the radiation exposure delivered by a mammogram, but only 45%, could correctly identify the radiation exposure delivered by a CT

scan of the abdomen and pelvis. Furthermore, in terms of population risk, only 25% of the physicians correctly chose the annual natural radiation exposure of an individual and only 11% knew the degree to which a 20 mSv of radiation exposure increased the population risk of a fatal cancer. These results are consistent with a systematic review of computed tomography and other radiographic procedures that found a similarly low level of radiology exposure knowledge among physicians. [33]

In terms of commons healthcare system safety and quality issues, the average number of correct answers was 3.0 (SD, 1.27), 43% correct. Eighty-eight percent of the physicians knew the main hospital accrediting body, 74% knew the definition of beneficence, and 53% knew the Swiss Cheese model of accidents. But their accuracy was lower for questions regarding quality improvement tools, medication errors, 6-sigma, and harm detection – which were answered correctly by 34%, 19%, 19%, and 14% of the physicians, respectively. These results are consistent with a recent study of generalist and subspecialist Internal Medicine physicians which found that they correctly answered 43% of the questions regarding the U.S. Food and Drug Administration approval process. [34] They are also consistent with a study of physician knowledge of central line-associates blood stream infection quality metrics that found that they answered 61% of the questions correctly. [35]

In terms of Donabedian's model, the average number of correct answers was 4.7 (SD, 1.50), 67% correct. This set of questions contained the easiest question, namely, whether "The percentage of patients who are satisfied with their care" was a structure, process, or outcome measure. Ninety-six percent of the physicians correctly answered that it was an outcome. The physicians were highly accurate on classifying nosocomial infections, 89%, and staffing, 84%, but they were only 53% correct in classifying beta-blockers, 53% correct in classifying

credentials, 50% correct in classifying the diabetic foot exam, and 45% correct in classifying discharge instructions.

In terms of common safety and quality definitions, the average number of correct answers was 0.39 (SD, 0.54), 20% correct. The definitions were published 19 years ago in *To Err Is Human*. Despite the high visibility of *To Err Is Human*, only 33% of the physicians correctly identified the IOM definition of quality. Only six percent of physicians knew the correct definition of safety.

Conclusions

U.S. physicians answered forty-eight percent of the safety and quality questions correctly. They performed best on questions that required little safety and quality knowledge and worst on question that required basic safety and quality knowledge. Our population was similar to the U.S. physician population in terms of specialty, gender, and age. There were no significant differences within specialty, gender, or age; although the scores of physicians over 60 years of age were slightly lower. These results are consistent with studies of physician knowledge of clinical harms and benefits, [32] radiology knowledge, [33] knowledge of the FDA approval process, [34] and of quality metrics. [35]

Physicians want to practice safe, high quality medicine, [36] but they may not be aware of how much they need to know about safety and quality. Furthermore, physicians need time to learn about safety and quality, and they need the time and expertise required to use the information in their EHRs to monitor the safety and quality of their practice. Although many health care systems consider themselves to be healthcare learning systems, [37,38] that belief does

not always translate into their assisting frontline clinicians in improving their safety and quality knowledge. [39,40]

The main limitation of this study is that, although the questions were designed to assess enduring information, the two clinical questions and the two definitions may be outdated, resulting in 20 follow-up testing questions. Another limitation is that we may have overestimated physician knowledge because it used multiple-choice questions that probe recognition. Physician scores might have been substantially lower had they been asked to recall the correct answer to each question.

In conclusion, forty-eight percent of the physicians' answers to the safety and quality questions were correct. A national system has been put in place at the resident level to improve physician safety and quality knowledge. Since knowledge is a prerequisite for performance, we expect that in the future physicians' increased knowledge will result in their improving their safety and quality performance. We believe this to be the first prospective test of the safety and quality knowledge of practicing U.S. primary care physicians.

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Figure legends

Figure 1. Percentage of subjects answering the questions correctly

Figure 2. An integrated view of the mean percent correct for each of the five topic domains

Table 1. Physician characteristics[a]

	Study population Number and Percent	National population Percent
Medical Specialty[b]		
Family Medicine	280 (54%)	53%
Internal Medicine	238 (46%)	47%
Gender[c]		
Male	331 (64%)	66%
Female	187 (36%)	34%
Age[c]		
< 39	131 (25%)	21%
40 – 49	160 (31%)	24%
50 – 59	124 (24%)	24%
60 – 69	85 (17%)	20%
70 +	18 (3%)	11%

[a]There were no significant differences between the study population and the national population in terms of medical specialty, gender, or age.
[b]National: https://www.ahrq.gov/research/findings/factsheets/primary/pcwork1/index.html
[c]National: Young A, Chaudhry HJ, Pei X, Halbesleben K, Polk DH, Dugan M. A census of actively licensed physicians in the United States, 2014. J Med Reg 2015;101(2):8-23

Table 2. Questions and mean percent correct

The correct answers are in bold. The grand mean percent correct is 48%.

PATIENT MANAGEMENT: Mean percent correct = 45%

A 42-year-old female presents to your clinic for the first time. She is s/p a left lumpectomy for unilateral breast cancer. You order a BRCA test, which comes back positive for a deleterious mutation. You recommend:

Left breast mastectomy	48 (9%)
Bilateral mastectomy	166 (32%)
Bilateral salpingo-oophorectomy	8 (2%)
Left breast mastectomy and bilateral salpingo-oophorectomy	13 (3%)
Bilateral mastectomy and bilateral salpingo-oophorectomy[12]	**283 (55%)**

A 22-year-old female transferred to your clinic from another facility. She sees you for the first time today. She states that she has a 2 cm indeterminate renal mass that was incidentally detected during a work-up for a suspected kidney stone almost 3 years ago. Her previous physician told her that it needed to be re-imaged within 3 years. She does not remember what imaging test was used to detect the mass. She denies any new symptoms or blood in her urine. She is here for an imaging test. Pick the best test.

Arteriography kidney	1 (0%)
CT abdomen with and without contrast	114 (22%)
MRI abdomen without contrast	13 (3%)
X-ray intravenous urography	4 (1%)
CT abdomen without contrast	42 (8%)
MRI abdomen with and without contrast	32 (6%)
U/S kidney retroperitoneal with Doppler[13]	**239 (46%)**
CT abdomen with contrast	73 (14%)

A retired 66-year-old man presents to your clinic for a routine physical examination. He has a history of COPD. You ask about his tobacco history and he tells you that he started smoking when he was 25 years old, he smoked 1 pack-per-day for 25 years, and he stopped smoking when he was 50 years old. He wants to know if he should do something to assess his risk of lung cancer. You order:

No imaging[14]	**173 (33%)**
Chest x-ray, PA and lateral	72 (14%)
CT of the chest without contrast	35 (7%)
CT of the chest with and without contrast	16 (3%)
A low-dose CT of the chest	222 (43%)

RADIATION RISK: Mean percent correct = 40%

The effective dose of a two-view chest radiograph is approximately:

0.01 mSv (millisievert)	62 (12%)
0.1 mSv[15]	**316 (61%)**
1.0 mSv	112 (22%)
10.0 mSv	28 (5%)

The effective dose of a two-view mammogram is approximately:

0.04 mSv (millisievert)	116 (22%)
0.4 mSv[16]	**313 (60%)**
4.0 mSv	84 (16%)
40.0 mSv	5 (1%)

The effective dose of a single CT of the abdomen and pelvis, with and without contrast is approximately:

0.02 mSv (millisievert)	9 (2%)
0.2 mSv	69 (13%)
2.0 mSv	206 (40%)
20.0 mSv[17]	**234 (45%)**

For the average American living at sea level, the annual effective dose of radiation is approximately:

0.03 mSv (millisievert)	223 (43%)
0.3 mSv	148 (29%)
3.0 mSv[18]	**127 (25%)**
30.0 mSv	20 (4%)

Receiving at least 20 mSv (millisieverts) of radiation increases an adult person's risk of a fatal cancer by approximately:

1 in 100,000 – 1,000,000	116 (22%)
1 in 10,000 – 100,000	183 (35%)
1 in 1,000 – 10,000	164 (32%)
1 in 100 – 1,000[19]	**55 (11%)**

GENERAL SAFETY AND QUALITY: Mean percent correct 45%

The main hospital accreditation body in the United States is:

Institute for Healthcare Improvement (IHI)	2 (0%)
American Hospital Association (AHA)	16 (3%)

National Committee for Quality Assurance (NCQA)	27 (5%)
The Joint Commission (JC)[20]	**456 (88%)**
Centers for Medicare and Medicaid Services (CMS)	17 (3%)

Which one of the following refers to acting in the best interest of the patient?

Respect for autonomy	60 (12%)
Beneficence[21]	**382 (74%)**
Nonmaleficence	62 (12%)
Justice	5 (1%)
Fairness	9 (2%)

Which of the following is the correct description of the Swiss cheese model of accidents?

Many people making the same mistake over and over again will eventually cause an accident.	65 (13%)
It usually takes several things going wrong for an accident to happen.[22]	**274 (53%)**
If a person makes the same mistake many times, it will eventually cause an accident.	57 (11%)
It is about filling in holes in the system.	108 (21%)
A person who makes a root cause error will cause an accident.	14 (3%)

Select from the list below the method that is NOT a tool for analyzing quality improvement.

Process mapping	20 (4%)
Flow charts	58 (11%)
Fishbone diagrams	127 (25%)
Discharge checklists[23]	**177 (34%)**
Pareto charts	136 (26%)

Which of the following is NOT a part of "6-sigma?"

Its goal is to reduce errors to a rate of 3.4 errors per million opportunities to make an error.	66 (13%)
It involves a series of five steps: define, measure, analyze, improve, and control.	93 (18%)
It is especially useful for processes that do not happen frequently.[24]	**99 (19%)**
Its practitioners are known as black belts.	165 (32%)
It is six standard deviations from the average.	95 (18%)

The most frequent reason for hospital medication errors is:

Prescribing[25]	**98 (19%)**
Transcribing	244 (47%)
Dispensing	64 (12%)
Administration	93 (18%)
Monitoring	19 (4%)

Several methods for detecting harms are shown below. Used in their usual way, which method detects the most harms?

Direct observation of care	129 (25%)
Reports by clinicians	30 (6%)
IHI global trigger tools[26]	**73 (14%)**
AHRQ Patient Safety Indicators	169 (33%)
Chart reviews	117 (23%)

STRUCTURE, PROCESS, OUTCOME: Mean percent correct = 67%

Identify whether this is an example of a structure (S), process (P), or outcome (O).
Q. The percentage of patients who are satisfied with their care.

S	6 (1%)
P	17 (3%)
O[27]	**495 (96%)**

Identify whether this is an example of a structure (S), process (P), or outcome (O).
Q. Percentage of patients that experience a nosocomial infection.

S	18 (3%)
P	37 (7%)
O[27]	**463 (89%)**

Identify whether this is an example of a structure (S), process (P), or outcome (O).
Q. There is enough clinical staff to care for the patients.

S[27]	**436 (84%)**
P	46 (9%)
O	36 (7%)

Identify whether this is an example of a structure (S), process (P), or outcome (O).
Q. The percentage of patients with an acute myocardial infarction who receive a beta-blocker.

S	26 (5%)
P[27]	**274 (53%)**

O	218 (42%)

Identify whether this is an example of a structure (S), process (P), or outcome (O).
Q. Clinicians are properly credentialed.

S[27]	**272 (53%)**
P	226 (44%)
O	20 (4%)

Identify whether it is an example of a structure (S), process (P), or outcome (O).
Q. The percentage of diabetic patients that have an order for an annual foot exam.

S	55 (11%)
P[27]	**257 (50%)**
O	206 (40%)

Identify whether this is an example of a structure (S), process (P), or outcome (O).
Q. The percentage of patients that are given discharge instructions.

S	12 (2%)
P[27]	**234 (45%)**
O	272 (53%)

QUALITY AND SAFETY DEFINITIONS: Mean percent correct = 48%

The Institute of Medicine's definition of quality is:

Providing acceptable and expected medical care, where acceptable means medical care that patients understand, agree to, and can afford, and expected means performance at the current professional standard of care.	183 (35%)
Doing the right thing at the right time for the right individual to get the best possible results.	75 (14%)
The degree to which health services for individuals and populations increase the likelihood of desired health outcomes and are consistent with current professional knowledge.28	**170 (33%)**
A system in which organizations are accountable for continuously improving the quality of their services and safeguarding high standards of care.	65 (13%)
Receiving the best care possible for one's illness or condition.	25 (5%)

The Institute of Medicine's definition of safety is:

The minimization of the risk of any harm, and the amelioration of the effect of a harm, to a person caused by medical care.	135 (26%)

Freedom from accidental or preventable injuries produced by medical care.	60 (12%)
Assuring that all care is safe for all patients requires examining the systems and processes of care, identifying the points of failure, and modifying the factors that cause systems to break down.	90 (17%)
The avoidance, prevention, and amelioration of adverse outcomes or injuries stemming from the process of care.	200 (39%)
Freedom from accidental injury, where accidental injury can be due to error, as either the failure of a planned action to be completed as intended or the use of the wrong plan to achieve an aim.[29]	**33 (6%)**

Figure 1. Percentage of subjects answering the questions correctly

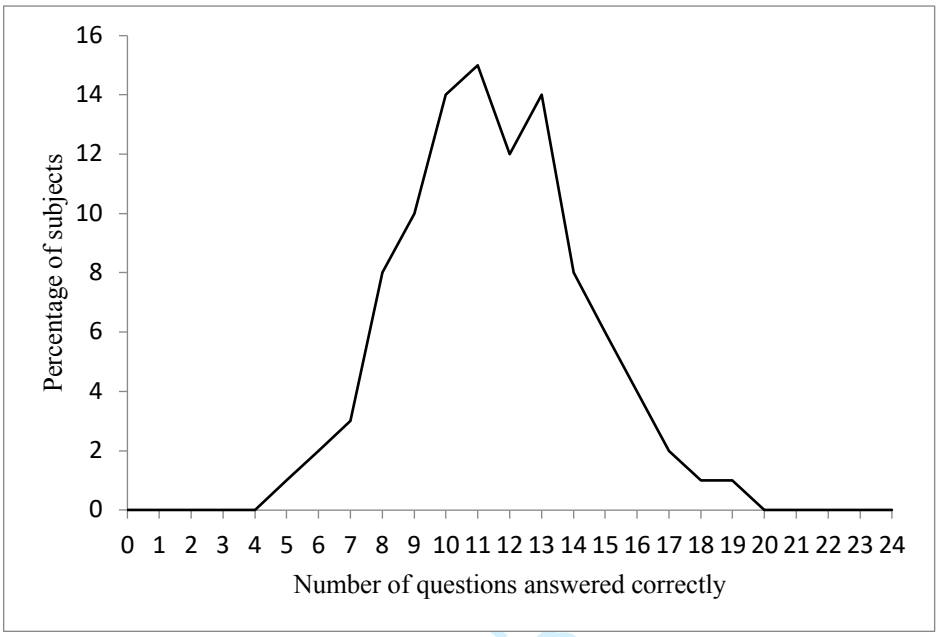
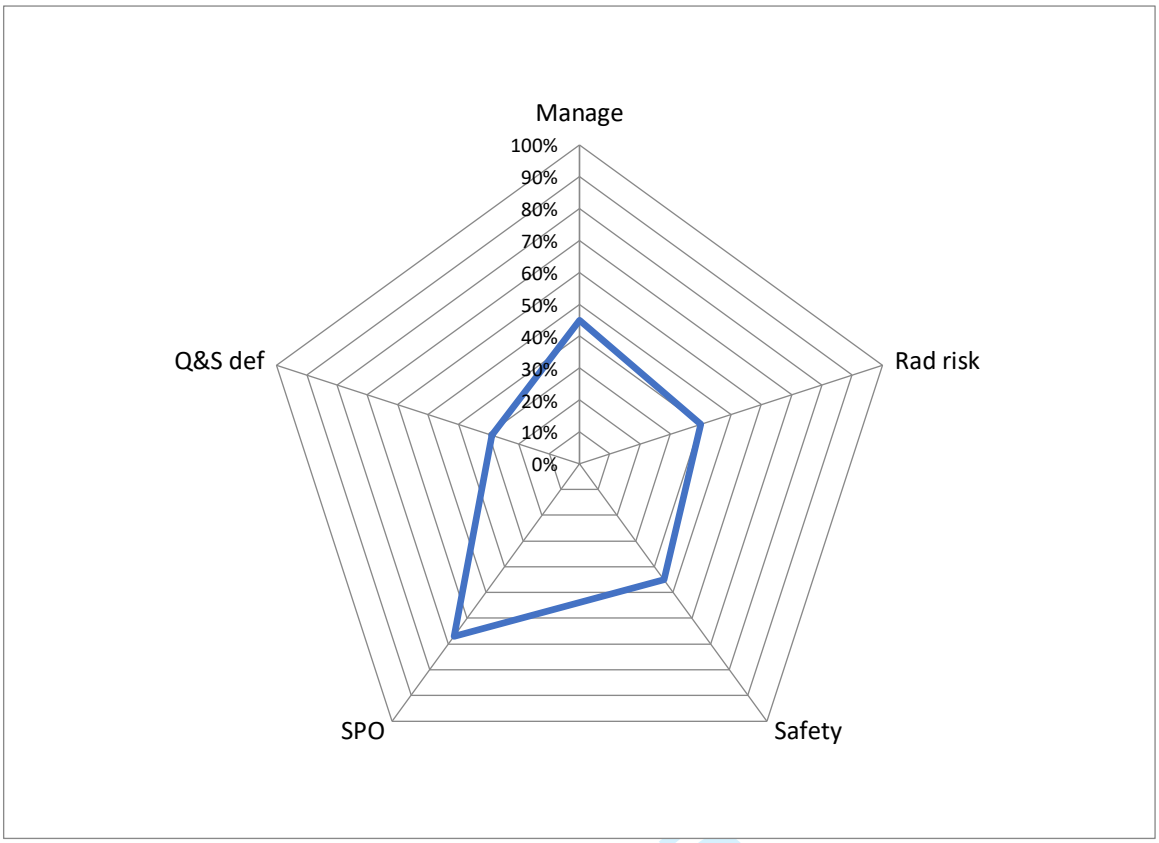


Figure 2. An integrated view of the mean percent correct for each of the five topic domains



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Original research: Responses of physicians to an objective safety and quality knowledge test: a cross-sectional study

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Abstract

Objective

It is well known that, for physicians to practice safe, high quality medicine, they must have sufficient safety and quality knowledge. Although a great deal is known about the safety and quality perceptions, attitudes, and beliefs of physicians, little is known about their safety and quality knowledge. This study tested the safety and quality knowledge of practicing primary care physicians.

Design

Cross-sectional objective test of safety and quality knowledge

Setting

Primary care physicians practicing in the United States.

Participants

Study consisted of 518 U.S. practicing primary care physicians who answered an email invitation. It included 54% Family Medicine and 46% Internal Medicine physicians, who accepted an email invitation. The response rate was 66%.

Intervention

The physicians took a 24-question multiple-choice test over the Internet.

Outcome

The outcome was the percent correct.

Results

The average number of correct answers was 11.4 (SD, 2.69), 48% correct. Three common clinical vignettes questions were answered correctly by 45% of the physicians. Five physicians' knowledge of common radiation exposures questions were answered correctly by 40% of the physicians. Seven common healthcare quality and safety questions were answered correctly by 43% of the physicians. Seven Donabedian's model of structure, process, and outcome measure questions were answered correctly by 67% of the physicians. Two Institute of Medicine's definitions of quality and safety questions were answered correctly by 19.5% of the physicians.

Conclusion

Forty-eight percent of the physicians' answers to the safety and quality questions were correct. To our knowledge, this is the first assessment of the safety and quality knowledge of practicing U.S. primary care physicians.

Strengths and limitations of this study

- A strength is that it consisted of practicing primary care physicians
- A strength is that it is representative of U.S. physicians
- A strength is its large sample size
- A limitation is that there is no conical safety and quality corpus.

Introduction

The landmark Institute of Medicine (IOM) report, *To Err Is Human: Building a Safer Health System,* [1] described a medical system that had become a clinical colossus, but its safety and quality had not kept pace with its size and complexity. It presented a system that was committing more errors yet detecting and correcting only a small fraction of them. It described a system with significant safety and quality deficits, some of which resulted in patient injury and death, and it recommended sweeping healthcare reforms.

Since *To Err Is Human* was published more than 20 years ago, a great deal of work has been done on improving safety and quality, [2] yet a recent IOM report, *Best Care at Lower Cost: The Path to Continuously Learning Health Care in America*, [3] and a recent study, [4] suggest that many of the errors reported in *To Err Is Human* are continuing. The persistence and frequency of errors, and our reduced tolerance for errors, has heightened the importance[3] in medical safety and quality.

Although a great deal is known about the safety and quality perceptions, attitudes, opinions, and beliefs of physicians, [5-9] little is known about their safety and quality knowledge. We designed a cross-sectional test of the safety and quality knowledge of practicing physicians.

We believe this to be the first test of the safety and quality knowledge of practicing U.S. primary care physicians.

Methods

This is a cross-sectional one-time test of the safety and quality knowledge of practicing United States (U.S.) General Internal Medicine and Family Medicine physicians. Its participants were drawn from a national panel of physicians registered in Medscape. Physicians who completed the test received a $30.00 Amazon gift card. The test was budgeted for 518 physicians completing the test. Seven hundred and eighty-eight practicing primary care physicians were randomly selected and solicited via email, which resulted in a 66% response rate. The test instrument was web-based and consisted of 24 multiple-choice questions. The objective questions were taken from widely available safety and quality textbooks and clinical literature and they were designed to reflect the practical safety and quality knowledge of practicing physicians. There were six areas of questions: patient management, radiation risk, general safety and quality, structure, process and outcome; and quality and safety definitions.

In terms of patient management, three common patient management vignettes addressed the physician's clinical quality knowledge. For the breast cancer vignette, there were five possible answers. [10] For the renal mass, the American College of Radiology (ACR) Appropriateness Criteria [11] gave the computed tomography (CT) abdomen without and with intravenous (IV) contrast the highest appropriateness rating, 9, but this modality also had the highest radiation level. The ultrasound kidney retroperitoneal with duplex Doppler had the next highest rating, 8. The ACR states that appropriateness ratings of 9, 8, and 7 are "Usually

appropriate." There were eight possible answers to the renal mass question. [12] Finally, in terms of patient management, the lung cancer screening consisted of five possible answers. [13]

In terms of common radiation risks, five questions addressed physicians' knowledge of common radiation risks. [14-18] There were four choices per question, each choice differed by one base-ten log. In other words, the four possible answers to the question spanned a four-log range.

In terms of common healthcare system safety and quality issues, there were seven questions. [19-25] There were five choices per question. In terms of Donabedian's [26] model for assessing safety and quality in terms of structure, process, and outcomes, there were seven questions. There were three choices per question. Two questions asked physicians to identify common quality [27] and safety [28] definitions from the IOM. There were five choices per question. The most difficult of the 24 questions was the IOM's definition of safety. Limiting the definition to "freedom from accidental injury," would not have distinguished it from other safety definitions. Therefore, the correct answer included the rest of the IOM definition, "where accidental injury can be due to error, as either the failure of a planned action to be completed as intended or the use of the wrong plan to achieve an aim."

The questions and answers are shown in Table 1. The questions were presented in a random order and no changes were made to the questions during testing. The only instruction the physicians received was that they had to answer all the questions. The deidentified results were sent to the investigators by Medscape. The questions were not weighted. For each question, the percent correct is calculated and, for each topic, the average percent correct was calculated. The Chi-square test was used to assess demographic differences and whether the categorial answer frequencies differed from chance, and the Student's t-test was used to compare continuous variables. The tests were performed using R (www.R-project.org) and significance was set at a

probability of less than 0.05. The Uniformed Services University Institutional Review Board approved this research. There was no patient or public involvement.

Results

The study demographics of the 518 physicians are shown in Table 2. The medical specialty of the participants was 46% General Internal Medicine and 54% Family Medicine. The gender of the participants was 64% male and 35% female. There were no significant differences between the participants and practicing physicians in terms of specialty, gender, and age. [29,30] There were no significant differences in the test scores within specialty, gender, and age, except for slightly lower scores for physicians over 60 years of age compared to those under 60 years of age, 0.45 (SD, 0.12) and 0.48 (SD, 0.11) respectively, $p = 0.003$. The median time to take the test was 10.1 minutes.

The results are shown in Table 1. The average number of correct answers was 11.4 (SD, 2.69), 48% correct. Every physician answered at least four questions correctly and no physician answered more than 20 questions correctly (Figure 1). For each question, the distribution of answers was significantly different from that expected by chance ($p < 0.01$). The mean percent correct for each of the five topics is shown in Figure 2.

In terms of the three common management vignettes, the average number of correct answers was 1.3 (SD, 0.90), 45% correct. For the breast cancer vignette, fifty-five percent of the physicians knew how to manage a woman with breast cancer who tested positive for a deleterious BRCA mutation. For the renal mass vignette, 46%, knew the work up for an indeterminate renal mass. For the lung cancer screening, 33%, knew the current approach to screening for lung cancer. Forty-six percent of the physicians correctly balanced the radiation

risk against the marginal additional benefit of CT and chose the ultrasound test. These results are also consistent with a recent study that found that physicians rarely have accurate expectations of the harms and benefits of clinical interventions, which the investigators attributed to a lack of knowledge. [31]

In terms of common radiation risks, the average number of correct answers was 2.0 (SD, 1.14), 40% correct. Sixty-one percent of the physicians correctly identified the radiation exposure delivered by a chest x-ray, 60% correctly identified the radiation exposure delivered by a mammogram, but only 45%, could correctly identify the radiation exposure delivered by a CT scan of the abdomen and pelvis. Furthermore, in terms of population risk, only 25% of the physicians correctly chose the annual natural radiation exposure of an individual and only 11% knew the degree to which a 20 mSv of radiation exposure increased the population risk of a fatal cancer. These results are consistent with a systematic review of computed tomography and other radiographic procedures that found a similarly low level of radiology exposure knowledge among physicians. [32]

In terms of commons healthcare system safety and quality issues, the average number of correct answers was 3.0 (SD, 1.27), 43% correct. Eighty-eight percent of the physicians knew the main hospital accrediting body, 74% knew the definition of beneficence, and 53% knew the Swiss Cheese model of accidents. But their accuracy was lower for questions regarding quality improvement tools, medication errors, 6-sigma, and harm detection – which were answered correctly by 34%, 19%, 19%, and 14% of the physicians, respectively. These results are consistent with a recent study of generalist and subspecialist Internal Medicine physicians which found that they correctly answered 43% of the questions regarding the U.S. Food and Drug Administration approval process. [33] They are also consistent with a study of physician

knowledge of central line-associates blood stream infection quality metrics that found that they answered 61% of the questions correctly. [34]

In terms of Donabedian's model, the average number of correct answers was 4.7 (SD, 1.50), 67% correct. This set of questions contained the easiest question, namely, whether "The percentage of patients who are satisfied with their care" was a structure, process, or outcome measure. Ninety-six percent of the physicians correctly answered that it was an outcome. The physicians were highly accurate on classifying nosocomial infections, 89%, and staffing, 84%, but they were only 53% correct in classifying beta-blockers, 53% correct in classifying credentials, 50% correct in classifying the diabetic foot exam, and 45% correct in classifying discharge instructions.

In terms of common safety and quality definitions, the average number of correct answers was 0.39 (SD, 0.54), 20% correct. The definitions were published 19 years ago in *To Err Is Human*. Despite the high visibility of *To Err Is Human*, only 33% of the physicians correctly identified the IOM definition of quality. Only six percent of physicians knew the correct definition of safety.

Discussion

U.S. physicians answered forty-eight percent of the safety and quality questions correctly. They performed best on questions that required little safety and quality knowledge and worst on question that required basic safety and quality knowledge. Our population was similar to the U.S. physician population in terms of specialty, gender, and age. There were no significant differences within specialty, gender, or age; although the scores of physicians over 60 years of age were slightly lower. These results are consistent with studies of physician knowledge of clinical harms

and benefits, [31] radiology knowledge, [32] knowledge of the FDA approval process, [33] and of quality metrics. [34]

Physicians want to practice safe, high quality medicine, [35] but they may not be aware of how much they need to know about safety and quality. Furthermore, physicians need time to learn about safety and quality, and they need the time and expertise required to use the information in their EHRs to monitor the safety and quality of their practice. Although many health care systems consider themselves to be healthcare learning systems, [36,37] that belief does not always translate into their assisting frontline clinicians in improving their safety and quality knowledge. [38,39]

The main limitation of this study is that there is no canonical safety and quality corpus. Another limitation is that we may have overestimated physician knowledge because it used multiple-choice questions that probe recognition. Physician scores might have been substantially lower had they been asked to recall the correct answer to each question.

Conclusions

Only forty-eight percent of the physicians' answers to the safety and quality questions were correct. A national system has been put in place at the resident level to improve physician safety and quality knowledge. Since knowledge is a prerequisite for performance, we expect that future physicians' increased knowledge will result in less patient harm and improved clinical outcomes. We believe this to be the first prospective test of the safety and quality knowledge of practicing U.S. primary care physicians.

Author contributions

HB: originated the study idea and designed the research project, analyzed the study data and drafted the manuscript. HK: made important contributions to designing the research project and analyzing the study data, and made significant contributions to the writing of the manuscript.

Conflicting and/or competing interests

The authors declare that they have no conflicts or competing interests.

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Ethics Approval

This study was approved by the Uniformed Services University of the Health Sciences IRB.

Patient and public involvement

There was no patient or public involvement in this study.

Data sharing

The frequency counts for each question are provided.

Disclaimer

The findings and conclusions of this paper are those of the authors and do not necessarily represent the positions or views of the U.S. Department of Defense, the Military Health System, the Defense Health Agency, or the Uniformed Services University of the Health Sciences.

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Figure legends

Figure 1. Percentage of subjects answering the questions correctly

Figure 2. An integrated view of the mean percent correct for each of the five topic domains

Table 1. Questions and mean percent correct

The correct answers are in bold. The grand mean percent correct is 48%.

PATIENT MANAGEMENT: Mean percent correct = 45%

A 42-year-old female presents to your clinic for the first time. She is s/p a left lumpectomy for unilateral breast cancer. You order a BRCA test, which comes back positive for a deleterious mutation. You recommend:

Left breast mastectomy	48 (9%)
Bilateral mastectomy	166 (32%)
Bilateral salpingo-oophorectomy	8 (2%)
Left breast mastectomy and bilateral salpingo-oophorectomy	13 (3%)
Bilateral mastectomy and bilateral salpingo-oophorectomy	**283 (55%)**

A 22-year-old female transferred to your clinic from another facility. She sees you for the first time today. She states that she has a 2 cm indeterminate renal mass that was incidentally detected during a work-up for a suspected kidney stone almost 3 years ago. Her previous physician told her that it needed to be re-imaged within 3 years. She does not remember what imaging test was used to detect the mass. She denies any new symptoms or blood in her urine. She is here for an imaging test. Pick the best test.

Arteriography kidney	1 (0%)
CT abdomen with and without contrast	114 (22%)
MRI abdomen without contrast	13 (3%)
X-ray intravenous urography	4 (1%)
CT abdomen without contrast	42 (8%)
MRI abdomen with and without contrast	32 (6%)
U/S kidney retroperitoneal with Doppler	**239 (46%)**
CT abdomen with contrast	73 (14%)

A retired 66-year-old man presents to your clinic for a routine physical examination. He has a history of COPD. You ask about his tobacco history and he tells you that he started smoking when he was 25 years old, he smoked 1 pack-per-day for 25 years, and he stopped smoking when he was 50 years old. He wants to know if he should do something to assess his risk of lung cancer. You order:

No imaging	**173 (33%)**
Chest x-ray, PA and lateral	72 (14%)
CT of the chest without contrast	35 (7%)
CT of the chest with and without contrast	16 (3%)
A low-dose CT of the chest	222 (43%)

RADIATION RISK: Mean percent correct = 40%

The effective dose of a two-view chest radiograph is approximately:

0.01 mSv (millisievert)	62 (12%)
0.1 mSv	**316 (61%)**
1.0 mSv	112 (22%)
10.0 mSv	28 (5%)

The effective dose of a two-view mammogram is approximately:

0.04 mSv (millisievert)	116 (22%)
0.4 mSv	**313 (60%)**
4.0 mSv	84 (16%)
40.0 mSv	5 (1%)

The effective dose of a single CT of the abdomen and pelvis, with and without contrast is approximately:

0.02 mSv (millisievert)	9 (2%)
0.2 mSv	69 (13%)
2.0 mSv	206 (40%)
20.0 mSv	**234 (45%)**

For the average American living at sea level, the annual effective dose of radiation is approximately:

0.03 mSv (millisievert)	223 (43%)
0.3 mSv	148 (29%)
3.0 mSy	**127 (25%)**
30.0 mSv	20 (4%)

Receiving at least 20 mSv (millisieverts) of radiation increases an adult person's risk of a fatal cancer by approximately:

1 in 100,000 – 1,000,000	116 (22%)
1 in 10,000 – 100,000	183 (35%)
1 in 1,000 – 10,000	164 (32%)
1 in 100 – 1,000	**55 (11%)**

GENERAL SAFETY AND QUALITY: Mean percent correct 45%

The main hospital accreditation body in the United States is:

Institute for Healthcare Improvement (IHI)	2 (0%)
American Hospital Association (AHA)	16 (3%)

National Committee for Quality Assurance (NCQA)	27 (5%)
The Joint Commission (JC)	**456 (88%)**
Centers for Medicare and Medicaid Services (CMS)	17 (3%)

Which one of the following refers to acting in the best interest of the patient?

Respect for autonomy	60 (12%)
Beneficence	**382 (74%)**
Nonmaleficence	62 (12%)
Justice	5 (1%)
Fairness	9 (2%)

Which of the following is the correct description of the Swiss cheese model of accidents?

Many people making the same mistake over and over again will eventually cause an accident.	65 (13%)
It usually takes several things going wrong for an accident to happen.	**274 (53%)**
If a person makes the same mistake many times, it will eventually cause an accident.	57 (11%)
It is about filling in holes in the system.	108 (21%)
A person who makes a root cause error will cause an accident.	14 (3%)

Select from the list below the method that is NOT a tool for analyzing quality improvement.

Process mapping	20 (4%)
Flow charts	58 (11%)
Fishbone diagrams	127 (25%)
Discharge checklists	**177 (34%)**
Pareto charts	136 (26%)

Which of the following is NOT a part of "6-sigma?"

Its goal is to reduce errors to a rate of 3.4 errors per million opportunities to make an error.	66 (13%)
It involves a series of five steps: define, measure, analyze, improve, and control.	93 (18%)
It is especially useful for processes that do not happen frequently.	**99 (19%)**
Its practitioners are known as black belts.	165 (32%)
It is six standard deviations from the average.	95 (18%)

The most frequent reason for hospital medication errors is:

Prescribing	**98 (19%)**
Transcribing	244 (47%)
Dispensing	64 (12%)
Administration	93 (18%)
Monitoring	19 (4%)

Several methods for detecting harms are shown below. Used in their usual way, which method detects the most harms?

Direct observation of care	129 (25%)
Reports by clinicians	30 (6%)
IHI global trigger tools	**73 (14%)**
AHRQ Patient Safety Indicators	169 (33%)
Chart reviews	117 (23%)

STRUCTURE, PROCESS, OUTCOME: Mean percent correct = 67%

Identify whether this is an example of a structure (S), process (P), or outcome (O).
Q. The percentage of patients who are satisfied with their care.

S	6 (1%)
P	17 (3%)
O	**495 (96%)**

Identify whether this is an example of a structure (S), process (P), or outcome (O).
Q. Percentage of patients that experience a nosocomial infection.

S	18 (3%)
P	37 (7%)
O	**463 (89%)**

Identify whether this is an example of a structure (S), process (P), or outcome (O).
Q. There is enough clinical staff to care for the patients.

S	**436 (84%)**
P	46 (9%)
O	36 (7%)

Identify whether this is an example of a structure (S), process (P), or outcome (O).
Q. The percentage of patients with an acute myocardial infarction who receive a beta-blocker.

S	26 (5%)
P	**274 (53%)**

O	218 (42%)

Identify whether this is an example of a structure (S), process (P), or outcome (O).
Q. Clinicians are properly credentialed.

S	**272 (53%)**
P	226 (44%)
O	20 (4%)

Identify whether it is an example of a structure (S), process (P), or outcome (O).
Q. The percentage of diabetic patients that have an order for an annual foot exam.

S	55 (11%)
P	**257 (50%)**
O	206 (40%)

Identify whether this is an example of a structure (S), process (P), or outcome (O).
Q. The percentage of patients that are given discharge instructions.

S	12 (2%)
P	**234 (45%)**
O	272 (53%)

QUALITY AND SAFETY DEFINITIONS: Mean percent correct = 48%

The Institute of Medicine's definition of quality is:

Providing acceptable and expected medical care, where acceptable means medical care that patients understand, agree to, and can afford, and expected means performance at the current professional standard of care.	183 (35%)
Doing the right thing at the right time for the right individual to get the best possible results.	75 (14%)
The degree to which health services for individuals and populations increase the likelihood of desired health outcomes and are consistent with current professional knowledge.	**170 (33%)**
A system in which organizations are accountable for continuously improving the quality of their services and safeguarding high standards of care.	65 (13%)
Receiving the best care possible for one's illness or condition.	25 (5%)

The Institute of Medicine's definition of safety is:

The minimization of the risk of any harm, and the amelioration of the effect of a harm, to a person caused by medical care.	135 (26%)

Freedom from accidental or preventable injuries produced by medical care.	60 (12%)
Assuring that all care is safe for all patients requires examining the systems and processes of care, identifying the points of failure, and modifying the factors that cause systems to break down.	90 (17%)
The avoidance, prevention, and amelioration of adverse outcomes or injuries stemming from the process of care.	200 (39%)
Freedom from accidental injury, where accidental injury can be due to error, as either the failure of a planned action to be completed as intended or the use of the wrong plan to achieve an aim.	**33 (6%)**

Table 2. Physician characteristics[a]

	Study population Number and Percent	National population Percent
Medical Specialty[b]		
Family Medicine	280 (54%)	53%
Internal Medicine	238 (46%)	47%
Gender[c]		
Male	331 (64%)	66%
Female	187 (36%)	34%
Age[c]		
< 39	131 (25%)	21%
40 – 49	160 (31%)	24%
50 – 59	124 (24%)	24%
60 – 69	85 (17%)	20%
70 +	18 (3%)	11%

[a]There were no significant differences between the study population and the national population in terms of medical specialty, gender, or age.
[b]National: https://www.ahrq.gov/research/findings/factsheets/primary/pcwork1/index.html
[c]National: Young A, Chaudhry HJ, Pei X, Halbesleben K, Polk DH, Dugan M. A census of actively licensed physicians in the United States, 2014. J Med Reg 2015;101(2):8-23

Figure 1. Percentage of subjects answering the questions correctly

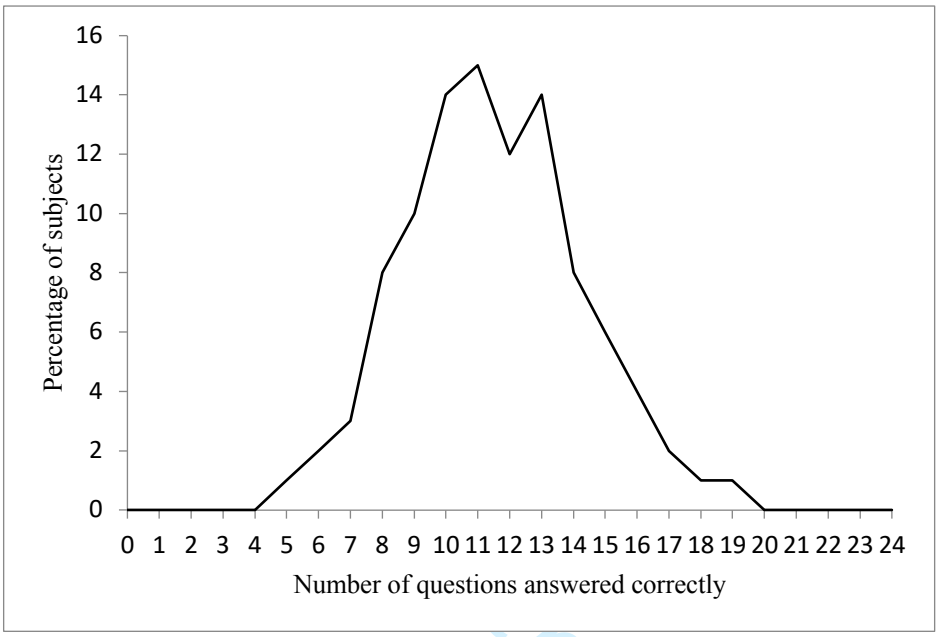
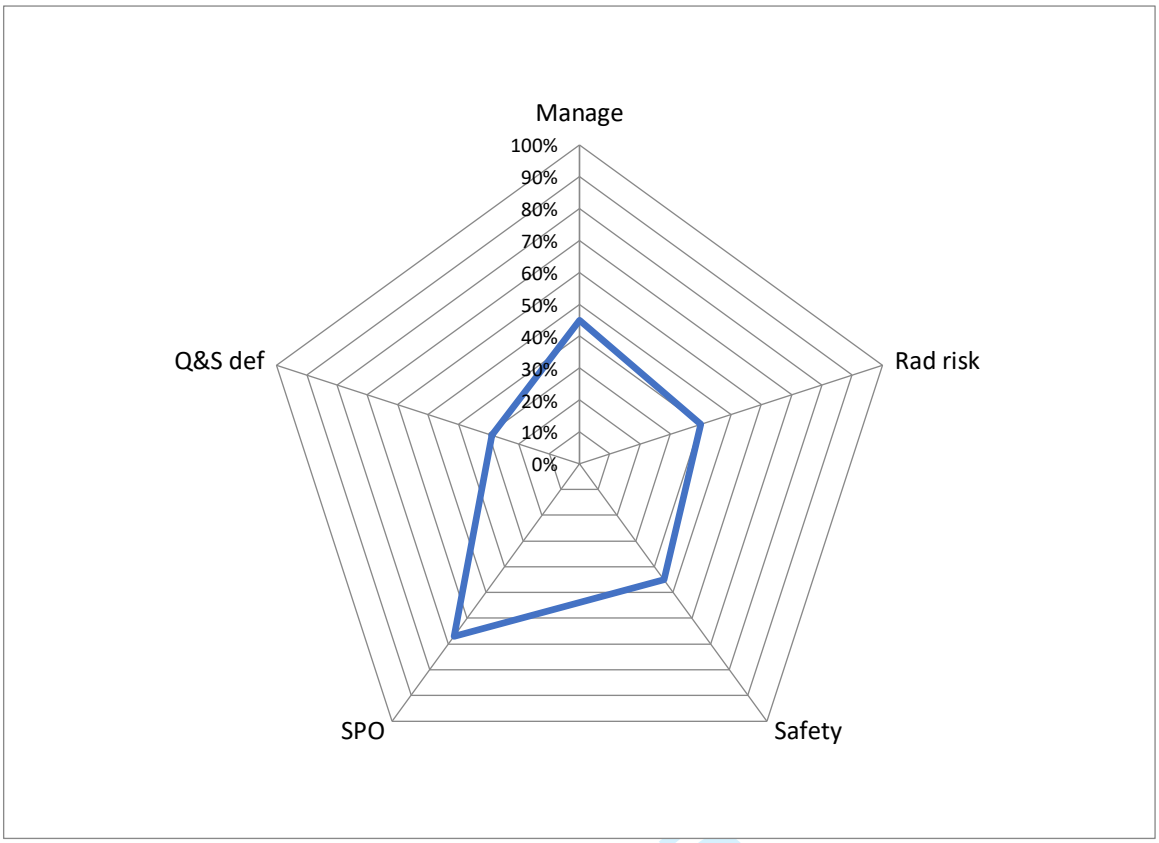


Figure 2. An integrated view of the mean percent correct for each of the five topic domains



STROBE Statement—Checklist of items that should be included in reports of ***cross-sectional studies***

	Item No	Recommendation
Title and abstract P1L4 P2	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found
Introduction		
Background/rationale P4L4-20	2	Explain the scientific background and rationale for the investigation being reported
Objectives P4L16-20	3	State specific objectives, including any prespecified hypotheses
Methods		
Study design P5L1-2	4	Present key elements of study design early in the paper
Setting P5L1-11	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection
Participants P5L1-3	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants
Variables P5L12-23, P6L1-10	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable
Data sources/ measurement P5L7-10	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group
Bias P5L2-3	9	Describe any efforts to address potential sources of bias
Study size P5L4-6	10	Explain how the study size was arrived at
Quantitative variables P6L14-19	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why
Statistical methods P6L14-19	12	(*a*) Describe all statistical methods, including those used to control for confounding
		(*b*) Describe any methods used to examine subgroups and interactions
		(*c*) Explain how missing data were addressed
		(*d*) If applicable, describe analytical methods taking account of sampling strategy
		(*e*) Describe any sensitivity analyses
Results		
Participants P7L1	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed
		(b) Give reasons for non-participation at each stage
		(c) Consider use of a flow diagram
Descriptive data P7L2-7	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders
		(b) Indicate number of participants with missing data for each variable of interest
Outcome data P7-9	15*	Report numbers of outcome events or summary measures
Main results P7-9	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were

		adjusted for and why they were included
		(*b*) Report category boundaries when continuous variables were categorized
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period
Other analyses NA	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses
Discussion		
Key results P9L15-22	18	Summarise key results with reference to study objectives
Limitations P10L6-9	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias
Interpretation P10L12-17	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence
Generalisability P10L13-16	21	Discuss the generalisability (external validity) of the study results
Other information		
Funding P3L14	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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Responses of physicians to an objective safety and quality knowledge test: a cross-sectional study

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Abstract

Objective

It is well known that, for physicians to practice safe, high quality medicine, they must have sufficient safety and quality knowledge. Although a great deal is known about the safety and quality perceptions, attitudes, and beliefs of physicians, little is known about their safety and quality knowledge. This study tested the safety and quality knowledge of practicing primary care physicians.

Design

Cross-sectional objective test of safety and quality knowledge

Setting

Primary care physicians practicing in the United States.

Participants

Study consisted of 518 U.S. practicing primary care physicians who answered an email invitation. It included 54% Family Medicine and 46% Internal Medicine physicians, who accepted an email invitation. The response rate was 66%.

Intervention

The physicians took a 24-question multiple-choice test over the Internet.

Outcome

The outcome was the percent correct.

Results

The average number of correct answers was 11.4 (SD, 2.69), 48% correct. Three common clinical vignettes questions were answered correctly by 45% of the physicians. Five physicians' knowledge of common radiation exposures questions were answered correctly by 40% of the physicians. Seven common healthcare quality and safety questions were answered correctly by 43% of the physicians. Seven Donabedian's model of structure, process, and outcome measure questions were answered correctly by 67% of the physicians. Two Institute of Medicine's definitions of quality and safety questions were answered correctly by 19.5% of the physicians.

Conclusion

Forty-eight percent of the physicians' answers to the safety and quality questions were correct. To our knowledge, this is the first assessment of the safety and quality knowledge of practicing U.S. primary care physicians.

Strengths and limitations of this study

- A strength is that it consisted of practicing primary care physicians
- A strength is that it is representative of U.S. physicians
- A strength is its large sample size
- A limitation is that there is no canonical safety and quality corpus.

Introduction

The landmark Institute of Medicine (IOM) report, *To Err Is Human: Building a Safer Health System,* [1] described a medical system that had become a clinical colossus, but its safety and quality had not kept pace with its size and complexity. It presented a system that was committing more errors yet detecting and correcting only a small fraction of them. It described a system with significant safety and quality deficits, some of which resulted in patient injury and death, and it recommended sweeping healthcare reforms.

Since *To Err Is Human* was published more than 20 years ago, a great deal of work has been done on improving safety and quality, [2] yet a recent IOM report, *Best Care at Lower Cost: The Path to Continuously Learning Health Care in America*, [3] and a recent study, [4] suggest that many of the errors reported in *To Err Is Human* are continuing. The persistence and frequency of errors, and our reduced tolerance for errors, has heightened the importance[3] in medical safety and quality.

Although a great deal is known about the safety and quality perceptions, attitudes, opinions, and beliefs of physicians, [5-9] little is known about their safety and quality knowledge. We designed a cross-sectional test of the safety and quality knowledge of practicing physicians.

We believe this to be the first test of the safety and quality knowledge of practicing U.S. primary care physicians.

Methods

This is a cross-sectional one-time test of the safety and quality knowledge of practicing United States (U.S.) General Internal Medicine and Family Medicine physicians. Its participants were drawn from a national panel of physicians registered in Medscape. Physicians who completed the test received a $30.00 Amazon gift card. The test was budgeted for 518 physicians completing the test. Seven hundred and eighty-eight practicing primary care physicians were randomly selected and solicited via email, which resulted in a 66% response rate. The test instrument was web-based and consisted of 24 multiple-choice questions. The objective questions were taken from widely available safety and quality textbooks and clinical literature and they were designed to reflect the practical safety and quality knowledge of practicing physicians. There were six areas of questions: patient management, radiation risk, general safety and quality, structure, process and outcome; and quality and safety definitions.

In terms of patient management, three common patient management vignettes addressed the physician's clinical quality knowledge. For the breast cancer vignette, there were five possible answers. [10] For the renal mass, the American College of Radiology (ACR) Appropriateness Criteria [11] gave the computed tomography (CT) abdomen without and with intravenous (IV) contrast the highest appropriateness rating, 9, but this modality also had the highest radiation level. The ultrasound kidney retroperitoneal with duplex Doppler had the next highest rating, 8. The ACR states that appropriateness ratings of 9, 8, and 7 are "Usually

appropriate." There were eight possible answers to the renal mass question. [12] Finally, in terms of patient management, the lung cancer screening consisted of five possible answers. [13]

In terms of common radiation risks, five questions addressed physicians' knowledge of common radiation risks. [14-18] There were four choices per question, each choice differed by one base-ten log. In other words, the four possible answers to the question spanned a four-log range.

In terms of common healthcare system safety and quality issues, there were seven questions. [19-25] There were five choices per question. In terms of Donabedian's [26] model for assessing safety and quality in terms of structure, process, and outcomes, there were seven questions. There were three choices per question. Two questions asked physicians to identify common quality [27] and safety [28] definitions from the IOM. There were five choices per question. The most difficult of the 24 questions was the IOM's definition of safety. Limiting the definition to "freedom from accidental injury," would not have distinguished it from other safety definitions. Therefore, the correct answer included the rest of the IOM definition, "where accidental injury can be due to error, as either the failure of a planned action to be completed as intended or the use of the wrong plan to achieve an aim."

The questions and answers are shown in Table 1. The questions were presented in a random order and no changes were made to the questions during testing. The only instruction the physicians received was that they had to answer all the questions. The deidentified results were sent to the investigators by Medscape. The questions were not weighted. For each question, the percent correct is calculated and, for each topic, the average percent correct was calculated. The Chi-square test was used to assess demographic differences and whether the categorial answer frequencies differed from chance, and the Student's t-test was used to compare continuous variables. The tests were performed using R (www.R-project.org) and significance was set at a

probability of less than 0.05. The Uniformed Services University Institutional Review Board approved this research.

Patient and Public Involvement

There was no patient and public involvement.

Results

The study demographics of the 518 physicians are shown in Table 2. The medical specialty of the participants was 46% General Internal Medicine and 54% Family Medicine. The gender of the participants was 64% male and 35% female. There were no significant differences between the participants and practicing physicians in terms of specialty, gender, and age. [29,30] There were no significant differences in the test scores within specialty, gender, and age, except for slightly lower scores for physicians over 60 years of age compared to those under 60 years of age, 0.45 (SD, 0.12) and 0.48 (SD, 0.11) respectively, $p = 0.003$. The median time to take the test was 10.1 minutes.

The results are shown in Table 1. The average number of correct answers was 11.4 (SD, 2.69), 48% correct. Every physician answered at least four questions correctly and no physician answered more than 20 questions correctly (Figure 1). For each question, the distribution of answers was significantly different from that expected by chance ($p < 0.01$). The mean percent correct for each of the five topics is shown in Figure 2.

In terms of the three common management vignettes, the average number of correct answers was 1.3 (SD, 0.90), 45% correct. For the breast cancer vignette, fifty-five percent of the physicians knew how to manage a woman with breast cancer who tested positive for a deleterious BRCA mutation. For the renal mass vignette, 46%, knew the work up for an

indeterminate renal mass. For the lung cancer screening, 33%, knew the current approach to screening for lung cancer. Forty-six percent of the physicians correctly balanced the radiation risk against the marginal additional benefit of CT and chose the ultrasound test. These results are also consistent with a recent study that found that physicians rarely have accurate expectations of the harms and benefits of clinical interventions, which the investigators attributed to a lack of knowledge. [31]

In terms of common radiation risks, the average number of correct answers was 2.0 (SD, 1.14), 40% correct. Sixty-one percent of the physicians correctly identified the radiation exposure delivered by a chest x-ray, 60% correctly identified the radiation exposure delivered by a mammogram, but only 45%, could correctly identify the radiation exposure delivered by a CT scan of the abdomen and pelvis. Furthermore, in terms of population risk, only 25% of the physicians correctly chose the annual natural radiation exposure of an individual and only 11% knew the degree to which a 20 mSv of radiation exposure increased the population risk of a fatal cancer. These results are consistent with a systematic review of computed tomography and other radiographic procedures that found a similarly low level of radiology exposure knowledge among physicians. [32]

In terms of commons healthcare system safety and quality issues, the average number of correct answers was 3.0 (SD, 1.27), 43% correct. Eighty-eight percent of the physicians knew the main hospital accrediting body, 74% knew the definition of beneficence, and 53% knew the Swiss Cheese model of accidents. But their accuracy was lower for questions regarding quality improvement tools, medication errors, 6-sigma, and harm detection – which were answered correctly by 34%, 19%, 19%, and 14% of the physicians, respectively. These results are consistent with a recent study of generalist and subspecialist Internal Medicine physicians which

found that they correctly answered 43% of the questions regarding the U.S. Food and Drug Administration approval process. [33] They are also consistent with a study of physician knowledge of central line-associates blood stream infection quality metrics that found that they answered 61% of the questions correctly. [34]

In terms of Donabedian's model, the average number of correct answers was 4.7 (SD, 1.50), 67% correct. This set of questions contained the easiest question, namely, whether "The percentage of patients who are satisfied with their care" was a structure, process, or outcome measure. Ninety-six percent of the physicians correctly answered that it was an outcome. The physicians were highly accurate on classifying nosocomial infections, 89%, and staffing, 84%, but they were only 53% correct in classifying beta-blockers, 53% correct in classifying credentials, 50% correct in classifying the diabetic foot exam, and 45% correct in classifying discharge instructions.

In terms of common safety and quality definitions, the average number of correct answers was 0.39 (SD, 0.54), 20% correct. The definitions were published 19 years ago in *To Err Is Human*. Despite the high visibility of *To Err Is Human*, only 33% of the physicians correctly identified the IOM definition of quality. Only six percent of physicians knew the correct definition of safety.

Discussion

U.S. physicians answered forty-eight percent of the safety and quality questions correctly. They performed best on questions that required little safety and quality knowledge and worst on question that required basic safety and quality knowledge. Our population was similar to the U.S. physician population in terms of specialty, gender, and age. There were no significant differences

within specialty, gender, or age; although the scores of physicians over 60 years of age were slightly lower. These results are consistent with studies of physician knowledge of clinical harms and benefits, [31] radiology knowledge, [32] knowledge of the FDA approval process, [33] and of quality metrics. [34]

We take the assessment of safety and quality knowledge to mean the results of an objective test of either recall or recognition of facts related to safety and quality. Several studies have assessed physicians' agreement with several safety statements [35] and with their judgment regarding the effectiveness of certain interventions in reducing medical errors. [36] Finally, a multi-disciplinary study in Western Lithuania of physicians, nurses, and nurse assistants found a low level of safety knowledge. [37]

Physicians want to practice safe, high quality medicine, [38] but they may not be aware of how much they need to know about safety and quality. Furthermore, physicians need time to learn about safety and quality, and they need the time and expertise required to use the information in their EHRs to monitor the safety and quality of their practice. Although many health care systems consider themselves to be healthcare learning systems, [36,37] that belief does not always translate into their assisting frontline clinicians in improving their safety and quality knowledge. [38,39]

The main limitation of this study is that there is no canonical safety and quality corpus. Another limitation is that we may have overestimated physician knowledge because it used multiple-choice questions that probe recognition. Physician scores might have been substantially lower had they been asked to recall the correct answer to each question.

Conclusions

Only forty-eight percent of the physicians' answers to the safety and quality questions were correct. A national system has been put in place at the resident level to improve physician safety and quality knowledge. Since knowledge is a prerequisite for performance, we expect that future physicians' increased knowledge will result in less patient harm and improved clinical outcomes. Future studies should objectively measure and track changes in physicians' objective knowledge of safety and quality. We believe this to be the first prospective test of the safety and quality knowledge of practicing U.S. primary care physicians.

Author contributions

HB: originated the study idea and designed the research project, analyzed the study data and drafted the manuscript. HK: made important contributions to designing the research project and analyzing the study data, and made significant contributions to the writing of the manuscript.

Conflicting and/or competing interests

The authors declare that they have no conflicts or competing interests.

Funding sources

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Ethics Approval

This study was approved by the Uniformed Services University of the Health Sciences Institutional Review Board.

Patient and public involvement

There was no patient or public involvement in this study.

Data sharing

The frequency counts for each question are the data and they are provided in Table 2.

Disclaimer

The findings and conclusions of this paper are those of the authors and do not necessarily represent the positions or views of the U.S. Department of Defense, the Military Health System, the Defense Health Agency, or the Uniformed Services University of the Health Sciences.

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Figure legends

Figure 1. Percentage of subjects answering the questions correctly

Figure 2. An integrated view of the mean percent correct for each of the five topic domains

Table 1. Questions and mean percent correct

The correct answers are in bold. The grand mean percent correct is 48%.

PATIENT MANAGEMENT: Mean percent correct = 45%

A 42-year-old female presents to your clinic for the first time. She is s/p a left lumpectomy for unilateral breast cancer. You order a BRCA test, which comes back positive for a deleterious mutation.* You recommend:

Left breast mastectomy	48 (9%)
Bilateral mastectomy	166 (32%)
Bilateral salpingo-oophorectomy	8 (2%)
Left breast mastectomy and bilateral salpingo-oophorectomy	13 (3%)
Bilateral mastectomy and bilateral salpingo-oophorectomy	**283 (55%)**

A 22-year-old female transferred to your clinic from another facility. She sees you for the first time today. She states that she has a 2 cm indeterminate renal mass that was incidentally detected during a work-up for a suspected kidney stone almost 3 years ago. Her previous physician told her that it needed to be re-imaged within 3 years. She does not remember what imaging test was used to detect the mass. She denies any new symptoms or blood in her urine. She is here for an imaging test.* Pick the best test.

Arteriography kidney	1 (0%)
CT abdomen with and without contrast	114 (22%)
MRI abdomen without contrast	13 (3%)
X-ray intravenous urography	4 (1%)
CT abdomen without contrast	42 (8%)
MRI abdomen with and without contrast	32 (6%)
U/S kidney retroperitoneal with Doppler	**239 (46%)**
CT abdomen with contrast	73 (14%)

A retired 66-year-old man presents to your clinic for a routine physical examination. He has a history of COPD. You ask about his tobacco history and he tells you that he started smoking when he was 25 years old, he smoked 1 pack-per-day for 25 years, and he stopped smoking when he was 50 years old. He wants to know if he should do something to assess his risk of lung cancer.* You order:

No imaging	**173 (33%)**
Chest x-ray, PA and lateral	72 (14%)
CT of the chest without contrast	35 (7%)
CT of the chest with and without contrast	16 (3%)
A low-dose CT of the chest	222 (43%)

* These are hypothetical patients that were included as test questions.

RADIATION RISK: Mean percent correct = 40%

The effective dose of a two-view chest radiograph is approximately:

0.01 mSv (millisievert)	62 (12%)
0.1 mSv	**316 (61%)**
1.0 mSv	112 (22%)
10.0 mSv	28 (5%)

The effective dose of a two-view mammogram is approximately:

0.04 mSv (millisievert)	116 (22%)
0.4 mSv	**313 (60%)**
4.0 mSv	84 (16%)
40.0 mSv	5 (1%)

The effective dose of a single CT of the abdomen and pelvis, with and without contrast is approximately:

0.02 mSv (millisievert)	9 (2%)
0.2 mSv	69 (13%)
2.0 mSv	206 (40%)
20.0 mSv	**234 (45%)**

For the average American living at sea level, the annual effective dose of radiation is approximately:

0.03 mSv (millisievert)	223 (43%)
0.3 mSv	148 (29%)
3.0 mSy	**127 (25%)**
30.0 mSv	20 (4%)

Receiving at least 20 mSv (millisieverts) of radiation increases an adult person's risk of a fatal cancer by approximately:

1 in 100,000 – 1,000,000	116 (22%)
1 in 10,000 – 100,000	183 (35%)
1 in 1,000 – 10,000	164 (32%)
1 in 100 – 1,000	**55 (11%)**

GENERAL SAFETY AND QUALITY: Mean percent correct 45%

The main hospital accreditation body in the United States is:

Institute for Healthcare Improvement (IHI)	2 (0%)
American Hospital Association (AHA)	16 (3%)

National Committee for Quality Assurance (NCQA)	27 (5%)
The Joint Commission (JC)	**456 (88%)**
Centers for Medicare and Medicaid Services (CMS)	17 (3%)

Which one of the following refers to acting in the best interest of the patient?

Respect for autonomy	60 (12%)
Beneficence	**382 (74%)**
Nonmaleficence	62 (12%)
Justice	5 (1%)
Fairness	9 (2%)

Which of the following is the correct description of the Swiss cheese model of accidents?

Many people making the same mistake over and over again will eventually cause an accident.	65 (13%)
It usually takes several things going wrong for an accident to happen.	**274 (53%)**
If a person makes the same mistake many times, it will eventually cause an accident.	57 (11%)
It is about filling in holes in the system.	108 (21%)
A person who makes a root cause error will cause an accident.	14 (3%)

Select from the list below the method that is NOT a tool for analyzing quality improvement.

Process mapping	20 (4%)
Flow charts	58 (11%)
Fishbone diagrams	127 (25%)
Discharge checklists	**177 (34%)**
Pareto charts	136 (26%)

Which of the following is NOT a part of "6-sigma?"

Its goal is to reduce errors to a rate of 3.4 errors per million opportunities to make an error.	66 (13%)
It involves a series of five steps: define, measure, analyze, improve, and control.	93 (18%)
It is especially useful for processes that do not happen frequently.	**99 (19%)**
Its practitioners are known as black belts.	165 (32%)
It is six standard deviations from the average.	95 (18%)

The most frequent reason for hospital medication errors is:

Prescribing	**98 (19%)**
Transcribing	244 (47%)
Dispensing	64 (12%)
Administration	93 (18%)
Monitoring	19 (4%)

Several methods for detecting harms are shown below. Used in their usual way, which method detects the most harms?

Direct observation of care	129 (25%)
Reports by clinicians	30 (6%)
IHI global trigger tools	**73 (14%)**
AHRQ Patient Safety Indicators	169 (33%)
Chart reviews	117 (23%)

STRUCTURE, PROCESS, OUTCOME: Mean percent correct = 67%

Identify whether this is an example of a structure (S), process (P), or outcome (O).
Q. The percentage of patients who are satisfied with their care.

S	6 (1%)
P	17 (3%)
O	**495 (96%)**

Identify whether this is an example of a structure (S), process (P), or outcome (O).
Q. Percentage of patients that experience a nosocomial infection.

S	18 (3%)
P	37 (7%)
O	**463 (89%)**

Identify whether this is an example of a structure (S), process (P), or outcome (O).
Q. There is enough clinical staff to care for the patients.

S	**436 (84%)**
P	46 (9%)
O	36 (7%)

Identify whether this is an example of a structure (S), process (P), or outcome (O).
Q. The percentage of patients with an acute myocardial infarction who receive a beta-blocker.

S	26 (5%)
P	**274 (53%)**

O	218 (42%)

Identify whether this is an example of a structure (S), process (P), or outcome (O).
Q. Clinicians are properly credentialed.

S	**272 (53%)**
P	226 (44%)
O	20 (4%)

Identify whether it is an example of a structure (S), process (P), or outcome (O).
Q. The percentage of diabetic patients that have an order for an annual foot exam.

S	55 (11%)
P	**257 (50%)**
O	206 (40%)

Identify whether this is an example of a structure (S), process (P), or outcome (O).
Q. The percentage of patients that are given discharge instructions.

S	12 (2%)
P	**234 (45%)**
O	272 (53%)

QUALITY AND SAFETY DEFINITIONS: Mean percent correct = 48%

The Institute of Medicine's definition of quality is:

Providing acceptable and expected medical care, where acceptable means medical care that patients understand, agree to, and can afford, and expected means performance at the current professional standard of care.	183 (35%)
Doing the right thing at the right time for the right individual to get the best possible results.	75 (14%)
The degree to which health services for individuals and populations increase the likelihood of desired health outcomes and are consistent with current professional knowledge.	**170 (33%)**
A system in which organizations are accountable for continuously improving the quality of their services and safeguarding high standards of care.	65 (13%)
Receiving the best care possible for one's illness or condition.	25 (5%)

The Institute of Medicine's definition of safety is:

The minimization of the risk of any harm, and the amelioration of the effect of a harm, to a person caused by medical care.	135 (26%)

Freedom from accidental or preventable injuries produced by medical care.	60 (12%)
Assuring that all care is safe for all patients requires examining the systems and processes of care, identifying the points of failure, and modifying the factors that cause systems to break down.	90 (17%)
The avoidance, prevention, and amelioration of adverse outcomes or injuries stemming from the process of care.	200 (39%)
Freedom from accidental injury, where accidental injury can be due to error, as either the failure of a planned action to be completed as intended or the use of the wrong plan to achieve an aim.	**33 (6%)**

Table 2. Physician characteristics[a]

	Study population Number and Percent	National population Percent
Medical Specialty[b]		
Family Medicine	280 (54%)	53%
Internal Medicine	238 (46%)	47%
Gender[c]		
Male	331 (64%)	66%
Female	187 (36%)	34%
Age[c]		
< 39	131 (25%)	21%
40 – 49	160 (31%)	24%
50 – 59	124 (24%)	24%
60 – 69	85 (17%)	20%
70 +	18 (3%)	11%

[a]There were no significant differences between the study population and the national population in terms of medical specialty, gender, or age.
[b]National: https://www.ahrq.gov/research/findings/factsheets/primary/pcwork1/index.html
[c]National: Young A, Chaudhry HJ, Pei X, Halbesleben K, Polk DH, Dugan M. A census of actively licensed physicians in the United States, 2014. J Med Reg 2015;101(2):8-23

Figure 1. Percentage of subjects answering the questions correctly

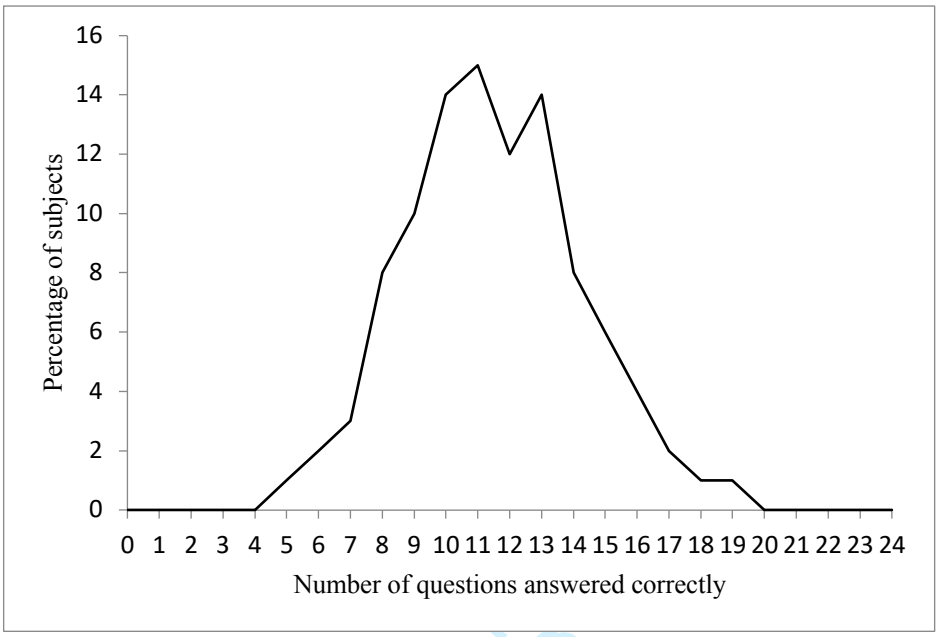
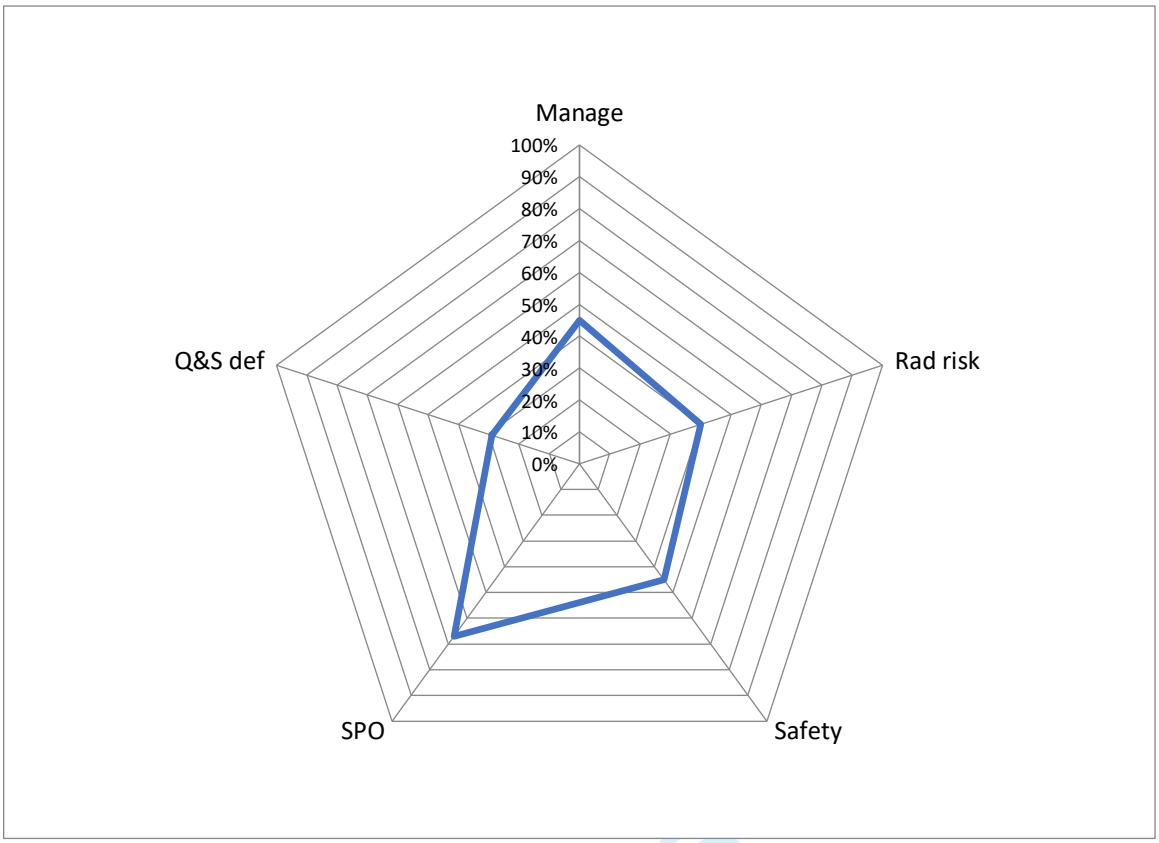


Figure 2. An integrated view of the mean percent correct for each of the five topic domains



STROBE Statement—Checklist of items that should be included in reports of ***cross-sectional studies***

	Item No	Recommendation
Title and abstract P1L1 P2	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found
Introduction		
Background/rationale P3-4, L112-123	2	Explain the scientific background and rationale for the investigation being reported
Objectives P3-4, L124-170	3	State specific objectives, including any prespecified hypotheses
Methods		
Study design P4L174-175	4	Present key elements of study design early in the paper
Setting P4L1-175-176	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection
Participants P4L174-184	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants
Variables P4-5L185-213	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable
Data sources/ measurement P5L214	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group
Bias P5L2214-217	9	Describe any efforts to address potential sources of bias
Study size P4L177-179	10	Explain how the study size was arrived at
Quantitative variables P5L217-218	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why
Statistical methods P5L219-232	12	(*a*) Describe all statistical methods, including those used to control for confounding
		(*b*) Describe any methods used to examine subgroups and interactions
		(*c*) Explain how missing data were addressed
		(*d*) If applicable, describe analytical methods taking account of sampling strategy
		(*e*) Describe any sensitivity analyses
Results		
Participants P6L236	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed
		(b) Give reasons for non-participation at each stage
		(c) Consider use of a flow diagram
Descriptive data P6L236-243	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders
		(b) Indicate number of participants with missing data for each variable of interest
Outcome data P6-8	15*	Report numbers of outcome events or summary measures
Main results P6-8	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were

		adjusted for and why they were included
		(*b*) Report category boundaries when continuous variables were categorized
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period
Other analyses NA	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses
Discussion		
Key results P8L330-335	18	Summarise key results with reference to study objectives
Limitations P9L372375	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias
Interpretation P9-10L378-407	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence
Generalisability P10L410-411	21	Discuss the generalisability (external validity) of the study results
Other information		
Funding P11L426-429	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.