TITLE PAGE

Systematic Review: Teaching Quality Improvement and Patient Safety to Trainees

Brian M. Wong, MD, Edward E. Etchells, MD, MSc, Ayelet Kuper, MD, DPhil, Wendy Levinson, MD, and Kaveh G. Shojania, MD

Dr. Wong is a lecturer in the Department of Medicine, University of Toronto, and an associate scientist at the Center for Health Services Sciences, Sunnybrook Health Sciences Center (Toronto, Ontario, Canada).

Dr. Etchells is an associate professor of medicine, University of Toronto, the director of Patient Safety Improvement Research, Center for Health Services Sciences, Sunnybrook Health Sciences Center, and the associate director of the University of Toronto Center for Patient Safety (Toronto, Ontario, Canada).

Dr. Kuper is an assistant professor of medicine, University of Toronto, an associate scientist with the Centre for Health Services Sciences, and a clinician/educator researcher

at the Wilson Center for Research in Education, University Health Network/University of Toronto (Toronto, Ontario, Canada).

Dr. Levinson is a professor of medicine and the Sir John and Lady Eaton Chair of Medicine, University of Toronto (Toronto, Ontario, Canada).

Dr. Shojania is an associate professor of medicine, University of Toronto, and the director of the University of Toronto Centre for Patient Safety (Toronto, Ontario, Canada).

Address correspondence to Dr. Wong, Department of Medicine, Sunnybrook Health Sciences Centre

ABSTRACT

Background: Quality improvement (QI) and patient safety (PS) have gained widespread acceptance as core topics that should be taught broadly to trainees. The purpose was to systematically review published QI and PS curricula for medical students and/or residents to: (1) determine their educational content and teaching methods; (2) assess the learning outcomes achieved; and (3) identify factors that promoted or hindered curricular implementation.

Methods: Data sources searched included MEDLINE (to January 2009), EMBASE, HealthSTAR; article bibliographies. Studies selected included QI and PS curricula that, at a minimum, outlined specific educational content and teaching format. Two reviewers independently extracted curricular descriptors. For articles that included an evaluative component, we abstracted methodological features, such as study design, outcomes reported, and the main results. For all articles, we also conducted a thematic analysis to identify factors that influenced successful implementation of the included curricula.

Results: Of 41 included curricula, 14 targeted medical students, 24 targeted residents, and 3 targeted both. Common educational content included continuous quality improvement, root cause analysis, and systems thinking. Among 27 reports that included an evaluation, curricula were generally well accepted, with the exception of 2 curricula directed at medical students in pre-clinical years. Most curricula demonstrated improved knowledge. Thirteen studies (32%) successfully implemented local changes in care delivery; seven (17%) significantly improved target processes of care. Factors that affected the successful curricular implementation included having sufficient numbers of faculty familiar with QI and PS content, addressing competing educational demands, and

ensuring learner buy-in and enthusiasm. Participants in some curricula also commented

on discrepancies between curricular material and local institutional practice or culture.

Conclusions: QI and PS curricula that target trainees usually improve learner knowledge

and frequently result in changes in clinical processes. However, successfully

implementing such curricula requires attention to a number of learner, faculty, and

organizational factors.

INTRODUCTION

The quality improvement (QI) and patient safety (PS) movements in recent years have had important implications for undergraduate and graduate medical education, including focused attention on duty hour reductions [1-4], appropriate supervision of trainees [4, 5], and communication during resident hand-offs [6]. Furthermore, there is a growing imperative to teach QI and PS in medical education.

The Association of American Medical Colleges (AAMC) now endorses the introduction of formal QI education across the medical education continuum, spanning undergraduate, postgraduate and continuing medical education levels [7, 8]. Both the Accreditation Council for Graduate Medical Education (ACGME) [, 9] and CanMEDS [10, 11] competency frameworks define essential physician competencies that relate to quality and safety. These developments coincide with the recognition that engagement in QI represents an emerging career path for clinicians [12].

A previous systematic review of quality improvement education for clinicians found that most curricula demonstrated improvement in learners' knowledge by applying sound adult learning principles [13]. However, only 10 of the 39 studies targeted trainees (of which only two involved medical students). Given the increasing recognition of the need to teach QI to students, we systematically reviewed published curricula in QI or PS specifically directed at medical students or resident trainees. We sought to: (1) describe their educational content and teaching methods used; (2) assess the learning outcomes achieved; and (3) determine factors that promoted or limited the successful implementation of these curricula.

METHODS

Literature Search

We searched for relevant English-language studies from January 1, 2000 to December 31, 2008 using electronic literature databases including MEDLINE, EMBASE, and HealthSTAR. We chose January 2000 as the cut-off of the search period in order to capture articles describing educational efforts that arose following release of the Institute of Medicine's "To Err is Human" report [14], which initiated the current widespread interest in QI and PS.

The search strategies combined Medical Subject Headings (MeSH terms) and text words related to QI and PS (e.g., *medical errors*, *safety*, *quality assurance*) with those related to undergraduate and graduate medical education (search strategy available on request from the authors). We also hand searched bibliographies of all included reports and relevant review articles.

Eligibility Criteria

We included any article that, at a minimum, described a curriculum that explicitly identified its goal as exposing medical students or residents to concepts in QI or PS and outlined specific teaching methods used to achieve this educational goal. We identified concepts in QI or PS by screening for descriptors in the articles' title or text, including general terms such as quality improvement, systems learning, systems-based practice, patient safety, as well as specific topics widely recognized as falling within the domains of QI (e.g., continuous quality improvement, audit and feedback, change management)

and PS (e.g., systems thinking, root cause analysis, human factors engineering, incident reporting, and error disclosure).

Studies were excluded if they (1) primarily focused on practicing clinicians (e.g., if the intervention targeted members of an academic clinic, some of whom happened to be trainees); (2) were predominantly QI interventions that happened to be delivered in training settings (e.g., an audit and feedback intervention delivered in a resident clinic); (3) described curricula in which QI or PS topics were included as a minor component of a larger curriculum (e.g., a single lecture on QI in a broad curriculum on managed care).

Article Review Process

Two investigators (BW and KS) independently reviewed titles and abstracts to identify eligible articles. When in doubt, the full text of each article was obtained to finalize article inclusion or exclusion. The article screening process was followed by independent abstraction by two reviewers (from BW, KS, and EE) using a structured data entry form. Disagreements at both the article screening and data abstraction stages were resolved by consensus, involving a third reviewer if necessary.

Consistent with the Best Evidence Medical Education (BEME) review protocol [15], we extracted curricular descriptors as well as key methodological features for those articles that included an evaluative component. We classified learning outcomes using Kirkpatrick's model [16], which includes impacts on learners' satisfaction (Level 1), changes in learner attitudes (Level 2A), measures of learner knowledge and skills (Level 2B), changes in learner behavior (Level 3), changes to clinical processes (Level 4A), and benefits to patients (Level 4B).

We supplemented the structured data abstraction with a detailed thematic analysis of each article's text to identify factors that the authors regarded as promoting or limiting curricular implementation. One investigator (BW) established a framework for key factors that influenced curricular implementation based on an initial detailed reading of all included studies as well as existing literature on curricular development and implementation in medical education more generally [17]. After iterative review and modification by other investigators, two investigators (from BW, KS and AK) independently applied the final framework to code each study.

Assessment of Study Quality

For studies with an evaluative component, we assessed the strength of the findings using a modified version of the BEME protocol [15]. The BEME rating system for strength of findings assigns a rating of Level 1 when no clear conclusions can be drawn, Level 2 when results are ambiguous but exhibit a trend, Level 3 when conclusions can probably be based on the results, Level 4 when results are clear and very likely to be true, and Level 5 when results are unequivocal. Although widely used, the BEME protocol does not include explicit features to guide these judgments. We therefore adopted the protocol to inform ratings of the strength of study findings using considerations of sample size, number of sites, study design, completeness of data, and response rate.

Analysis

We anticipated substantial heterogeneity of study design and reported outcomes, so chose not to pursue quantitative synthesis. We summarized educational content, teaching

methods, and learning outcomes (for studies with an evaluative component only) using simple descriptive statistics. We included themes identified by the detailed thematic analysis if they were observed in two independent sources. We summarized these themes and highlighted key excerpts that illustrate these themes to describe important factors that limited or promoted implementation of QI and PS curricula.

All data were previously published and publicly available. Therefore, our study did not meet criteria for submission to the local institutional review board for ethical approval.

RESULTS

Characteristics of Included Curricula

Of 953 citations identified by the electronic search, 41 curricula met eligibility criteria [18-58] (Figure 1), 27 (66%) of which provided a curricular description along with some form of evaluation [18-44]. The vast majority (93%) of reports came from US training programs, with the others including 2 (5%) from Canada [47, 58] and 1 (2%) from the UK [37]. Participating learners consisted of medical students in 14 studies (34%), residents in 24 (59%), and both in 3 (7%). Curricula for residents primarily came from Internal Medicine (58%) and Family Medicine (21%) training programs. Twenty-five (61%) of the curricula for students and residents were mandatory.

Curricular Features

The curricula addressed a range of QI and PS content (Table 1 and 2), but the most common topics consisted of continuous quality improvement (21 studies, 51%),

root cause analysis (17 studies, 41%) and systems thinking (16 studies, 39%). Most curricula combined didactic and experiential learning; detailed case discussions and web-based learning were less frequently used.

Among curricula targeting medical students, 7 targeted pre-clinical medical students and 7 targeted clinical medical students. Some curricula were integrated into one course or rotation, while others were delivered as stand-alone sessions. The majority of these curricula generally involved fewer than 10 contact hours, often consisting of a single session. Five curricula involved medical students in QI or PS projects.

QI and PS curricula targeting residents were similarly brief (approximately 10 contact hours), but more often involved multiple encounters (i.e., 2 to 5). Approximately half of the curricula incorporated their content into existing core rotations; others occurred as stand-alone sessions or elective rotations. All curricula for residents were delivered in clinical settings (e.g., ambulatory clinic or inpatient teaching unit). Residents participated in QI or PS projects in 14 (58%) curricula.

Study Designs and Outcomes

Table 2 summarize the outcomes, designs, and main results of the 27 studies that included an evaluative component (a more detailed summary of the study outcomes is provided in the appendix table). The most common design was a simple before-after comparison (11, 42%). Five (19%) [28, 29, 34, 35, 38] evaluations included a contemporaneous control, and 2 of these used a randomized design [29, 35]. One of these randomized, controlled studies evaluated a curriculum implemented at 7 US training programs [29], while the other evaluated programs at 18 US teaching hospitals [38]. However, most

studies (24, 92%) came from single-centers and had methodological concerns that undermined the results, such as low response rates and small sample sizes (median 41 participants, interquartile range 20 to 106).

Evaluations of curricula targeting medical students primarily measured learner knowledge, with a lesser emphasis on behavior change. Only one medical student curriculum targeted changes in clinical processes [49]. Curricula for residents more commonly involved residents in QI projects (14, 58%) and frequently reported outcomes that measured improvements in process of care. Only two studies reported benefits to patients [24, 28].

Table 3 reports Kirkpatrick learning outcomes by training level. The following section summarizes each learning outcome in greater detail.

Learner Satisfaction

Satisfaction was usually measured on a Likert scale from poor to excellent. The majority of learners were satisfied with the QI curricula, consistently rating the curricula as relevant and useful. Only two studies reported low satisfaction ratings. One was conducted in first year medical students [35] and reported early termination of the study due to learner dissatisfaction with the curriculum. The other study involved second year medical students [24]. Students participating in this curriculum also expressed a number of concerns, including skepticism about the project being an efficient use of time. Among their concerns, 84% of students reported dissatisfaction with the chart audit exercise.

Learner Attitudes

Learners generally exhibited positive attitudes prior to exposure to the curricula. For instance, the majority of learners already regarded QI and PS as important topics relevant to future practice. Given these positive baseline attitudes, most curricula reported minimal impacts on attitudinal outcomes.

Knowledge Acquisition

Acquisition of curricular content was usually assessed using tests of knowledge designed by study teams, though some studies used established assessment tools such as the Quality Improvement Knowledge Assessment Tool (QIKAT) [59]. With self-assessed knowledge outcomes, learners generally rated their knowledge highly and improved from baseline. All 8 studies that quantified knowledge acquisition reported statistically significant improvements.

Behavioral Change

The 5 studies [21, 26, 30, 37, 43] that reported behavioral changes all used self-reported outcomes. Nonetheless, only 2 studies suggested any improvements in the behaviors targeted by the curricula. One study reported that while many students had disclosed errors to a peer (71%) or faculty member (46%), only 7% had ever used a web-based reporting system highlighted in the curriculum [30]. The other study that reported an outcome related to learner behavior targeted disclosure of medical errors to patients and found that only 7% of learners reported having made such a disclosure following exposure to the curriculum [26].

Changes in Clinical Processes

A number of studies involved chart audits, modified morbidity and mortality conferences, or participation in a QI project. Seven of the 13 studies (54%) reported significant improvements in processes of care [20, 24, 28, 31, 36, 41, 43], including increased microalbuminuria screening [20], documentation of foot and eye examinations [24], and increased monofilament testing [28] for patients with diabetes, increased screening for elevated body mass index in an ambulatory internal medicine clinic [36], reduction in inappropriate telemetry use on an in-patient medical service [43], increased discharge dictations with complete medication information [41], and increased immunizations in a pediatric clinic [31].

Benefits to Patients

Two studies measured benefits to patients in terms of intermediate clinical outcomes (serum HbA1c in both cases). In one study, 13 internal medicine residents performed chart audits on patients with diabetes and reflected on solutions to identified problems [28]. This study reported a decrease in HbA1c levels of 0.4% for patients cared for by participants in the intervention group compared with an increase of 0.7% in the control group ($p<0.001$). The other study, in which 77 second year medical students audited charts for patients with diabetes [24], reported a reduction in HbA1c levels from 7.7% before implementation of the QI curriculum to 7.2% afterwards ($p<0.001$).

Factors that influenced curricular implementation

Of the 41 included reports, 34 (83%) described factors that influenced implementation of QI and PS curricula (Table 4). Commonly cited barriers related to learners included competing educational demands and the level of initial buy-in or enthusiasm. For faculty, many reports highlighted the problem of inadequate numbers of teachers with requisite expertise, and the time commitment required for those few faculty members (often only 1 or 2 at a given institution with such expertise). Barriers related to the curricula themselves included achieving the appropriate balance of didactic and experiential learning and scheduling the curriculum amidst existing classes and rotations. Important aspects of the learning environment included the institutional culture with respect to quality and safety, hospital operational support (e.g., some authors noted the positive impact on trainees of including hospital executives or faculty role models involved in local improvement efforts), as well as the availability of information systems that could facilitate QI projects undertaken by trainees.

Many of the same implementation issues emerged across all curricula irrespective of the learner level (i.e., undergraduate or postgraduate). However, some factors were more commonly cited as important factors only for curricula targeting residents (e.g., time pressures and the need for ongoing financial, educational, institutional and operational support), perhaps because of the greater inclusion of QI or PS projects in curricula for residents. A barrier unique to curricula that targeted medical students in the pre-clinical years was the perceived unimportance of the material compared with traditional clinical content.

DISCUSSION

We identified 41 QI and PS curricula that specifically targeted medical students or residents. Concepts of continuous quality improvement, systems thinking and root-cause analysis constituted the most common topics covered, and specific projects undertaken often involved chart audits. Despite the heterogeneity in educational content and teaching methods, most curricula were well accepted and led to learner knowledge acquisition. Resident involvement in experiential QI projects such as chart audits also frequently led to significant improvements in processes of care.

Few studies demonstrated changes in learner behavior or potential patient benefits. While some reports suggest that educational interventions have the potential to change behavior or improve health outcomes, most studies lack good quality evidence to support their findings [60]. There are examples of well-designed continuing medical education interventions that are sequenced and make use of interactive techniques that lead to changes in learner behaviors and health outcomes. However, these studies often centered on screening, smoking cessation and communication skills, and may not translate to more complex curricular content areas, such as QI and PS. [61-63]. In fact, for QI and PS, improving patient outcomes as a result of educational efforts represents a particularly daunting task given that intensive, large scale QI efforts often fail to demonstrate improvements in health outcomes [64, 65]. Also for some tools of QI and PS, including ones that commonly appeared in the curricula we reviewed (e.g., root-cause analysis), little empiric evidence guides recommendations on how to design or use these tools [65]. Consequently, even with optimal delivery of the target educational content, the degree to which organizational or patient outcomes might improve remains unclear.

15

Our results complement those of a systematic review of educational efforts in QI for clinicians in general [13] in that well-established adult learning techniques (e.g., experiential learning) were identified as key factors for success in delivering curricula in QI and PS. However, our review, which included 34 newer reports of curricula specifically targeting trainees, demonstrated that resident involvement in QI and PS curricula can lead to meaningful improvements in clinical processes, a novel finding compared with the previous review.

Our review also identified important barriers and facilitators to implementation that are likely unique to curricula in the undergraduate and postgraduate settings. Many of the studies identified barriers commonly encountered with new curricular initiatives in general [17]. For example, most of the curricula relied on small numbers of faculty members with a personal interest in QI or patient safety to teach the curriculum, often resulting in burdensome time commitments. Many reports highlighted the need for greater faculty development to achieve sufficient numbers of teachers of QI and PS topics for both medical student and resident curricula. Some curricula addressed these issues by developing teaching materials that circumvented the need to have faculty experienced in QI or PS [36].

Competing educational demands and learner buy-in also represented major issues for curricula at all levels. However, the only 2 reports [24, 35] that noted these as potentially insurmountable obstacles were ones that targeted medical students at pre-clinical stages. Learners reported significant dissatisfaction with key elements of the curricula, which may reflect the fact that clinical experience represents a prerequisite for appreciating the importance and relevance of QI or PS concepts.

Curricula that targeted residents may require special consideration, perhaps because they more commonly involved the learners in experiential projects, adding to time pressures and increasing the need for supporting infrastructure. Many residents did not complete their projects due to time constraints. Some programs addressed this problem by scheduling their curricula during less busy clinical rotations or research years [19]. Having adequate personnel, financial, and technological resources to support curricula involving experiential projects was also important. For example, studies that made use of chart audits required administrative support to retrieve charts. Also, many QI projects depended on efficient availability of clinical data through information systems to determine whether improvements occurred.

Finally, a number of studies emphasized the importance of a local "safety culture," substantially enhancing the curricular success when present and undermining it when absent. Other curricula that target non-medical competencies (e.g., professionalism) also highlight the importance of the so-called hidden curriculum, where there is a discrepancy between the concepts trainees learn in formal educational venues and what trainees observe when supervised by attending staff in routine clinical practice[66-68]. Preparing trainees for the fact that behavior of faculty in routine practice, design of the delivery systems in which they work, and institutional culture may not conform to accepted principles of QI and PS, may reduce the discomfort reported by participants in some of the curricula we reviewed.

Our systematic review has several limitations. The literature examining the effectiveness of educational interventions in QI and PS exhibited substantial heterogeneity in terms of the content delivered, educational methods used, learners

targeted, and learning outcomes reported. Also, many curricular evaluations involved weak study designs, occurred in single centers, had small numbers of learners, and often exhibited other methodological concerns. Consequently, we did not regard quantitative synthesis as appropriate.

Our thematic textual analysis of all included curricular reports identified a number of potentially important factors that promote or hinder implementation efforts. However, most of these reports did not have the identification of facilitators and barriers to implementation as their primary aim. Consequently, authors may not have recognized or reported aspects of the curricular implementation in a systematic fashion. Moreover, the vast majority of reports did not comment on the degree to which curricula had been sustained.

CONCLUSIONS

Improving the quality and safety of patient care has gained widespread acceptance as a central activity for the healthcare system. Clinicians will be expected to have acquired core concepts in QI and PS in order to apply them to improve their personal practices and help support institutional improvement efforts. Consequently, a consensus has emerged that QI and PS should be broadly taught to trainees, with ACGME [9] and CanMEDS [10] mandating such education, and some students actively requesting it [69]. Despite this emerging consensus, few medical schools in the United States and Canada report having explicit curricula in QI and PS [70].

The existing literature indicates that educational curricula focused on QI and PS are generally well accepted by trainees, effectively improve knowledge in these domains,

and can even lead to important improvements in processes of care. Programs undertaking

the development of curricula in QI or PS must recognize the significant time pressures

and competing educational demands for trainees, as well as the requirements for adequate

numbers of faculty with appropriate expertise and support for their contributions. To

succeed, these curricula require engagement of educational and organizational

stakeholders to promote adoption. Future research must better characterize the learner,

faculty, and institutional factors that facilitate or hinder uptake in order to promote

sustained educational efforts focused on QI and PS for medical students and postgraduate

trainees.

REFERENCES

1. Fletcher KE, Underwood Wr, Davis SQ, Mangrulkar RS, McMahon LFJ, Saint S.
    Effects of work hour reduction on residents' lives: a systematic review. JAMA
    2005; 294, 1088-1100.

2. Ogden PE, Sibbitt S, Howell M et al. Complying with ACGME resident duty hours
    restrictions: restructuring the 80-hour workweek to enhance education and patient
    safety at Texas A&M/Scott & White Memorial Hospital. Acad Med 2006; 81,
    1026-1031.

3. Okie S. An elusive balance--residents' work hours and the continuity of care. N
    Engl J Med 2007; 356, 2665-2667.

4. Shojania KG, Fletcher KE, Saint S. Graduate medical education and patient safety:
    a busy--and occasionally hazardous--intersection. Ann Intern Med 2006; 145, 592-
    598.

5. Kennedy TJ, Regehr G, Baker GR, Lingard L. Preserving professional credibility:
    grounded theory study of medical trainees' requests for clinical support. BMJ 2009;
    338, b128.

6. Vidyarthi AR, Arora V, Schnipper JL, Wall SD, Wachter RM. Managing
    discontinuity in academic medical centers: strategies for a safe and effective
    resident sign-out. J Hosp Med 2006; 1, 257-266.

7. AAMC Contemporary issues in medicine: Education in safe and effective
    prescribing practices. Report 10. Medical school objectives project. Association of
    American Medical Colleges, Washington, DC, 2008. Last accessed at:
    http://www.aamc.org/meded/msop/ (December 2, 2009).

8.   AAMC Contemporary issues in medicine: Quality of care. Report 5. Medical school objectives project. Association of American Medical Colleges, Washington, DC, 2001. Last accessed at: http://www.aamc.org/meded/msop/ (December 2, 2009).

9.   ACGME Outcome Project, Competency Descriptions. Accreditation Council for Graduate Medical Education 2009. Last accessed at: http://www.acgme.org/outcome/comp/compCPRL.asp (December 2, 2009).

10. Frank JR, Danoff D. The CanMEDS initiative: implementing an outcomes-based framework of physician competencies. Med Teach 2007; 29, 642-647.

11. Scheele F, Teunissen P, Van Luijk S et al. Introducing competency-based postgraduate medical education in the Netherlands. Med Teach 2008; 30, 248-253.

12. Shojania KG, Levinson W. Clinicians in quality improvement: a new career pathway in academic medicine. JAMA 2009; 301, 766-768.

13. Boonyasai RT, Windish DM, Chakraborti C, Feldman LS, Rubin HR, Bass EB. Effectiveness of teaching quality improvement to clinicians: a systematic review. JAMA 2007; 298, 1023-1037.

14. Kohn LT, Corrigan J, Donaldson MS. To err is human : building a safer health system. Washington, D.C: National Academy Press, 2000.

15. Best Evidence in Medical Education (BEME) Collaboration: Starting a Review. Best Evidence in Medical Education 2009. Last accessed at: http://www.bemecollaboration.org/beme/pages/start.html (December 2, 2009)

16. Kirkpatrick DL. Evaluation of training. In: R C, L B, eds. Training and development handbook. New York: McGraw-Hill, 1967:87-112.

17. Kern DE, Thomas PA, Howard DM, Bass EB. Chapter 6: Implementation. eds. Curriculum Development for Medical Education: A Six-Step Approach. The Johns Hopkins University Press, 1998

18. Bechtold ML, Scott S, Nelson K, Cox KR, Dellsperger KC, Hall LW. Educational quality improvement report: outcomes from a revised morbidity and mortality format that emphasised patient safety. Qual Saf Health Care 2007; 16, 422-427.

19. Canal DF, Torbeck L, Djuricich AM. Practice-based learning and improvement: a curriculum in continuous quality improvement for surgery residents. Arch Surg 2007; 142, 479-82; discussion 482-3.

20. Coleman MT, Nasraty S, Ostapchuk M, Wheeler S, Looney S, Rhodes S. Introducing practice-based learning and improvement ACGME core competencies into a family medicine residency curriculum. Jt Comm J Qual Saf 2003; 29, 238-247.

21. Coyle YM, Mercer SQ, Murphy-Cullen CL, Schneider GW, Hynan LS. Effectiveness of a graduate medical education program for improving medical event reporting attitude and behavior. Qual Saf Health Care 2005; 14, 383-388.

22. Djuricich AM, Ciccarelli M, Swigonski NL. A continuous quality improvement curriculum for residents: addressing core competency, improving systems. Acad Med 2004; 79, S65-7.

23. Frey K, Edwards F, Altman K, Spahr N, Gorman RS. The 'Collaborative Care' curriculum: an educational model addressing key ACGME core competencies in primary care residency training. Med Educ 2003; 37, 786-789.

24. Gould BE, Grey MR, Huntington CG et al. Improving patient care outcomes by teaching quality improvement to medical students in community-based practices. Acad Med 2002; 77, 1011-1018.

25. Gunderson A, Tekian A, Mayer D. Teaching interprofessional health science students medical error disclosure. Med Educ 2008; 42, 531-532.

26. Halbach JL, Sullivan LL. Teaching medical students about medical errors and patient safety: evaluation of a required curriculum. Acad Med 2005; 80, 600-606.

27. Henley E. A quality improvement curriculum for medical students. Jt Comm J Qual Improv 2002; 28, 42-48.

28. Holmboe ES, Prince L, Green M. Teaching and improving quality of care in a primary care internal medicine residency clinic. Acad Med 2005; 80, 571-577.

29. Kerfoot BP, Conlin PR, Travison T, McMahon GT. Web-based education in systems-based practice: a randomized trial. Arch Intern Med 2007; 167, 361-366.

30. Madigosky WS, Headrick LA, Nelson K, Cox KR, Anderson T. Changing and sustaining medical students' knowledge, skills, and attitudes about patient safety and medical fallibility. Acad Med 2006; 81, 94-101.

31. Mohr JJ, Randolph GD, Laughon MM, Schaff E. Integrating improvement competencies into residency education: a pilot project from a pediatric continuity clinic. Ambul Pediatr 2003; 3, 131-136.

32. Moskowitz E, Veloski JJ, Fields SK, Nash DB. Development and evaluation of a 1-day interclerkship program for medical students on medical errors and patient safety. Am J Med Qual 2007; 22, 13-17.

33. Newell P, Harris S, Aufses AJ, Ellozy S. Student perceptions of medical errors: incorporating an explicit professionalism curriculum in the third-year surgery clerkship. J Surg Educ 2008; 65, 117-119.

34. Ogrinc G, Headrick LA, Morrison LJ, Foster T. Teaching and assessing resident competence in practice-based learning and improvement. J Gen Intern Med 2004; 19, 496-500.

35. Ogrinc G, West A, Eliassen MS, Liuw S, Schiffman J, Cochran N. Integrating practice-based learning and improvement into medical student learning: evaluating complex curricular innovations. Teach Learn Med 2007; 19, 221-229.

36. Oyler J, Vinci L, Arora V, Johnson J. Teaching internal medicine residents quality improvement techniques using the ABIM's practice improvement modules. J Gen Intern Med 2008; 23, 927-930.

37. Patey R, Flin R, Cuthbertson BH et al. Patient safety: helping medical students understand error in healthcare. Qual Saf Health Care 2007; 16, 256-259.

38. Peters AS, Kimura J, Ladden MD, March E, Moore GT. A self-instructional model to teach systems-based practice and practice-based learning and improvement. J Gen Intern Med 2008; 23, 931-936.

39. Tomolo A, Caron A, Perz ML, Fultz T, Aron DC. The outcomes card. Development of a systems-based practice educational tool. J Gen Intern Med 2005; 20, 769-771.

40. Varkey P, Karlapudi SP, Bennet KE. Teaching quality improvement: a collaboration project between medicine and engineering. Am J Med Qual 2008; 23, 296-301.

41. Varkey P, Reller MK, Smith A, Ponto J, Osborn M. An experiential interdisciplinary quality improvement education initiative. Am J Med Qual 2006; 21, 317-322.

42. Voss JD, May NB, Schorling JB et al. Changing conversations: teaching safety and quality in residency training. Acad Med 2008; 83, 1080-1087.

43. Weingart SN, Tess A, Driver J, Aronson MD, Sands K. Creating a quality improvement elective for medical house officers. J Gen Intern Med 2004; 19, 861-867.

44. Ziegelstein RC, Fiebach NH. "The mirror" and "the village": a new method for teaching practice-based learning and improvement and systems-based practice. Acad Med 2004; 79, 83-88.

45. Cosby KS, Croskerry P. Patient safety: a curriculum for teaching patient safety in emergency medicine. Acad Emerg Med 2003; 10, 69-78.

46. Esselman PC, Dillman-Long J. Morbidity and management conference: an approach to quality improvement in brain injury rehabilitation. J Head Trauma Rehabil 2002; 17, 257-262.

47. Farquhar D, Myers K, Benjamin D. Education in quality of care in an internal medicine residency program. Acad Med 2001; 76, 562.

48. Gosbee J. A patient safety curriculum for residents and students: the VA healthcare system's pilot project. ACGME Bulletin 2002; 2.

49. Gould BE, O'Connell MT, Russell MT, Pipas CF, McCurdy FA. Teaching quality measurement and improvement, cost-effectiveness, and patient satisfaction in

undergraduate medical education: the UME-21 experience. Fam Med 2004; 36 Suppl, S57-62.

50. Krajewski K, Siewert B, Yam S, Kressel HY, Kruskal JB. A quality assurance elective for radiology residents. Acad Radiol 2007; 14, 239-245.

51. Paulman P, Medder J. Teaching the quality improvement process to junior medical students: the Nebraska experience. Fam Med 2002; 34, 421-422.

52. Rosenfeld JC. Using the Morbidity and Mortality conference to teach and assess the ACGME General Competencies. Curr Surg 2005; 62, 664-669.

53. Schillinger D, Wheeler M, Fernandez A. The populations and quality improvement seminar for medical residents. Acad Med 2000; 75, 562-563.

54. Singh R, Naughton B, Taylor JS et al. A comprehensive collaborative patient safety residency curriculum to address the ACGME core competencies. Med Educ 2005; 39, 1195-1204.

55. Thompson DA, Cowan J, Holzmueller C, Wu AW, Bass E, Pronovost P. Planning and implementing a systems-based patient safety curriculum in medical education. Am J Med Qual 2008; 23, 271-278.

56. Varkey P. Educating to improve patient care: integrating quality improvement into a medical school curriculum. Am J Med Qual 2007; 22, 112-116.

57. Weeks WB, Robinson JL, Brooks WB, Batalden PB. Using early clinical experiences to integrate quality-improvement learning into medical education. Acad Med 2000; 75, 81-84.

58. Wong RY, Hollohan K, Roberts M, Hatala R, Ma IW, Kassen BO. A descriptive report of an innovative curriculum to teach quality improvement competencies to

internal medicine residents. Canadian Journal of General Internal Medicine 2008; 3, 26-29.

59.   Morrison LJ, Headrick LA, Ogrinc G, Foster T. The quality improvement knowledge application tool: an instrument to assess knowledge application in practice-based learning and improvement. J Gen Intern Med 2003; 18 (Suppl 1), 250.

60.   Marinopoulos SS, Dorman T, Ratanawongsa N et al. Effectiveness of Continuing Medical Education. Evidence Report/Technology Assessment No. 149 (Prepared by the Johns Hopkins Evidence-based Practice Center, under Contract No. 290-02-0018). AHRQ Publication No 07-E006; Rockville, MD: Agency for Healthcare Research and Quality. February 2007. Last accessed at: http://www.ahrq.gov/clinic/tp/cmetp.htm (December 2, 2009)

61.   Belfield C, Thomas H, Bullock A, Eynon R, Wall D. Measuring effectiveness for best evidence medical education: a discussion. Med Teach 2001; 23, 164-170.

62.   Davis D. Does CME work? An analysis of the effect of educational activities on physician performance or health care outcomes. Int J Psychiatry Med 1998; 28, 21-39.

63.   Davis D, O'Brien MA, Freemantle N, Wolf FM, Mazmanian P, Taylor-Vaisey A. Impact of formal continuing medical education: do conferences, workshops, rounds, and other traditional continuing education activities change physician behavior or health care outcomes? JAMA 1999; 282, 867-874.

64. Schouten LM, Hulscher ME, van Everdingen JJ, Huijsman R, Grol RP. Evidence for the impact of quality improvement collaboratives: systematic review. BMJ 2008; 336, 1491-1494.

65. Wu AW, Lipshutz AK, Pronovost PJ. Effectiveness and efficiency of root cause analysis in medicine. JAMA 2008; 299, 685-687.

66. Brainard AH, Brislen HC. Viewpoint: learning professionalism: a view from the trenches. Acad Med 2007; 82, 1010-1014.

67. D'Eon M, Lear N, Turner M, Jones C. Perils of the hidden curriculum revisited. Med Teach 2007; 29, 295-296.

68. Gofton W, Regehr G. What we don't know we are teaching: unveiling the hidden curriculum. Clin Orthop Relat Res 2006; 449, 20-27.

69. Nazem AG. A piece of my mind. Teach us how. JAMA 2008; 300, 2463-2464.

70. Alper E, Rosenberg EI, O'Brien KE, Fischer M, Durning SJ. Patient safety education at U.S. and Canadian medical schools: results from the 2006 Clerkship Directors in Internal Medicine survey. Acad Med 2009; 84, 1672-1676.

Table 1: Features of 41 Quality of Care and Patient Safety Curricula Published Between 2000 and 2008

	Undergraduate (n=17)*		Postgraduate* (n=24)	Total (n=41)
	Preclinical (n=7)	Clinical (n=10)		
Educational Setting, n (%)				
Classroom / Non-clinical setting	7 (100)	5 (50)	11 (46)	23 (56)
Ambulatory care	3 (43)	2 (20)	13 (54)	18 (44)
Inpatient hospital	0 (0)	0 (0)	7 (29)	7 (17)
Mixed clinical setting	0 (0)	0 (0)	3 (13)	3 (7)
Distance learning	0 (0)	1 (10)	1 (4)	2 (5)
Not stated	0 (0)	2 (20)	0 (0)	2 (5)
Teaching Methods, n (%)				
Didactic lectures	6 (86)	7 (70)	18 (75)	31 (76)
Small group discussion	5 (71)	6 (60)	5 (21)	16 (39)
Case discussion	2 (29)	2 (20)	8 (33)	12 (29)
Experiential learning	7 (100)	7 (70)	19 (79)	33 (80)
Web-based module	2 (29)	1 (10)	3 (13)	6 (15)
Educational Content, n (%)				
Quality topics	5 (71)	3 (30)	19 (79)	27 (66)
Quality of care in general	3 (43)	1 (1)	11 (46)	15 (37)
Continuous quality improvement (e.g., PDSA)	4 (57)	2 (20)	15 (67)	21 (51)
Audit and feedback	2 (29)	1 (10)	4 (17)	7 (17)
Process mapping	1 (14)	0 (0)	6 (25)	7 (17)
Change management	2 (29)	1 (10)	6 (25)	9 (22)
Patient safety topics	4 (57)	9 (90)	16 (63)	29 (70)
Patient safety in general	2 (29)	4 (40)	8 (33)	14 (34)
Systems thinking	4 (57)	3 (30)	9 (38)	16 (39)
Root cause analysis	3 (43)	2 (20)	12 (50)	17 (41)
Human factors	0 (0)	1 (10)	2 (8)	3 (7)
Error / incident reporting	3 (43)	6 (60)	4 (17)	13 (32)
Dealing with errors	0 (0)	3 (30)	0 (0)	3 (7)
Safety culture (i.e., avoiding blame / shame)	0 (0)	3 (30)	2 (8)	5 (12)
Disclosure of error	3 (43)	1 (10)	0 (0)	4 (10)

* Three studies that targeted both undergraduate and postgraduate learners were classified by the lowest training level (i.e., undergraduate clinical)

Table 2: Characteristics, Teaching Methods, Educational Content and Learning Outcomes of 41 Curricula in Quality Improvement or Patient Safety for Trainees†

Source	Setting	Learners	Intervention	Teaching Methods	Educational Content	Learning Outcomes*	Main Findings
Studies with a Curricular Description and an Evaluative Component (N=27)							
Highest Kirkpatrick Learning Outcome Achieved = Satisfaction (Level 1), Learner Attitudes (Level 2A), or Knowledge (Level 2B) (N=10)							
Undergraduate Learners (n=5)							
Newell, 2008 [33]	Single US medical school	123 3rd year medical students (surgical clerkship)	Two mandatory sessions (total 3 hours)	Large and small group discussions	Medical error, coping with error	Attitudes (Level 2A)	Improvement in attitudes towards medical errors (increased awareness of normative medical errors from 2% → 21%)
Gunderson, 2008 [25]	Single US medical school	18 final year health sciences students (5 disciplines)	One 3-hour elective session	Didactic sessions, experiential role playing, use of video clips	Disclosing errors, root cause analysis	Knowledge (Level 2B)	Improvement in observed disclosure of medical error (2/14 failed to include essential elements of full disclosure compared to 14/14 before the session)
Moskowitz, 2007 [32]	Single US medical school	229 third year medical students	One-day mandatory interclerkship program	Plenary sessions, small-group workshops, role playing	Patient safety overview, patient safety improvement tools, discussing and reporting medical errors, clinical quality improvement, legal aspects of patient safety	Attitudes (Level 2A) Knowledge (Level 2B)	Improvement in self-reported attitudes and knowledge on 14 of 21 questionnaire items
Ogrinc, 2007 [35]	Single US medical school	39 1st year medical students (41 additional first year medical students assigned to late-intervention group acted as the control group)	Incorporation of a mandatory longitudinal PBLI module into an existing 1st year medical school course (four 10-minute overview sessions);	Small group didactic lectures, practical application of PBLI methods to improve personal skills	Knowledge and skills for improving systems, PDSA cycle, assessment of system performance, how to make changes to a system	Satisfaction (Level 1) Attitudes (Level 2A) Knowledge (Level 2B)	Low satisfaction rating (30 – 40 out of 100) Increase in QIKAT knowledge scores in intervention group (8.5 → 9.3) versus decrease in QIKAT scores in control group (8.3 → 7.9); p<0.05

Source	Setting	Learners	Intervention	Teaching Methods	Educational Content	Learning Outcomes*	Main Findings
Henley, 2002 [27]	Single US medical school	30 third year medical students	Weekly mandatory QI curriculum (45 – 60 minutes per week)	Didactic, video, chart audits	QI theory, audit and feedback, systems thinking, effecting change	Satisfaction (Level 1) Attitudes (Level 2A) Knowledge (Level 2B)	Moderate satisfaction (50 – 60% of students felt teaching was useful) Scored 84% on a 6-item end-of-rotation quiz on QI concepts
Postgraduate Learners (n=4)							
Peters, 2008 [38]	18 US teaching hospitals	78 Internal Medicine residents (PGY2 and PGY3 residents) (72 Internal Medicine residents served as controls)	Four-module elective online learning course (Achieving Competency Today)	Web-facilitated, self-directed and action learning and the development of a Quality Improvement Plan	Systems thinking, PDSA cycle, root cause analysis, effort yield tables	Attitudes (Level 2A) Knowledge (Level 2B)	Increase in test of knowledge scores from 55.2 → 59.6 compared to 50.2 → 48.3 in control group, no significant difference in attitude change pre- versus postintervention
Varkey, 2008 [40]	1 US teaching hospital	2 Preventive Medicine and 7 Endocrinology Fellows (PGY4 and PGY6)	Three-week QI elective block	Didactic lecture, small group discussion, case-based discussion, QI project	QI overview, PDSA cycle, process mapping, patient safety overview, incident error reporting, root cause analysis, failure mode effects analysis	Satisfaction (Level 1) Attitudes (Level 2A) Knowledge (Level 2B)	High satisfaction (5/9 rated above average, 4/9 rated superior) Significant increase in learner QIKAT scores postrotation (11.89/15) compared to prerotation (7.33/15), p<0.004 Improvement in patient understanding of care (11% increase in number of patients who understood why tests were ordered, 12% increase in the number of patients who understood recommended treatment)
Djuricich, 2004 [22]	Single US residency program (Internal medicine and pediatrics programs)	PGY-3 Internal medicine and PGY-2 Pediatric residents (44 residents total, split not specified)	Three hour mandatory curriculum during ambulatory block	Didactic lectures, design of QI project (although actual project not carried through)	QI overview, PDSA and model for improvement	Attitudes (Level 2A) Knowledge (Level 2B)	Increase in score on 5-item quiz from 48% → 89% on pre-post testing of CQI knowledge
Frey, 2003 [23]	Single US residency program (Family Medicine)	12 PGY3 Family Medicine Residents (6 residents from 2 separate years)	Longitudinal mandatory team CQI project	Didactic seminars, CQI project (practice guideline implementation)	CQI process, audit and feedback	Attitudes (Level 2A) Knowledge (Level 2B)	High overall confidence in knowledge and attitudes (3.5 – 4.1 out of 5)
Undergraduate and Postgraduate Learners (n=1)							

Source	Setting	Learners	Intervention	Teaching Methods	Educational Content	Learning Outcomes*	Main Findings
Kerfoot, 2007 [29]	Seven US residencies (1 Emergency medicine, 1 Internal medicine, 2 OBGYN, 3 Surgery) and 2 medical schools	315 residents (PGY-1 to PGY-5) and 325 2nd and 3rd year medical students	Three web-based learning modules (each taking ~ 30 minutes to complete)	Interactive web-based modules using audio and video clips, multiple choice questions, animations	Patient safety overview, error prevention, systems theory	Satisfaction (Level 1) Knowledge (Level 2B)	High satisfaction rating (4 out of 5) Increase in MCQ test scores compared to baseline (16% increase from baseline of 58%) Knowledge sustained over 4 weeks (test scores)
Highest Kirkpatrick Learning Outcome Achieved = Level 3 (Behavior) or Level 4 (Clinical Process Change or Patient Benefits) (N=17)							
Undergraduate Learners (n=4)							
Patey, 2007 [37]	Single UK medical school	110 final year medical students	Two mandatory sessions 3 days apart (total 5 hours)	Large group lectures, small group discussions, student presentation, audio-video case discussions, role playing	Understanding medical errors, factors influencing adverse events, skills required to deal with error, reporting errors, focusing on cause rather than culprit	Satisfaction (Level 1) Attitudes (Level 2A) Knowledge (Level 2B) Behavior (Level 3)	High satisfaction rating (4 – 5 out of 5) Improvement in some self-assessed attitudes and knowledge Majority planned to report medical errors that they make (51 out of 70, 73%)
Madigosky, 2006 [30]	Single US medical school	92 second year medical students	Integrated mandatory curriculum into existing pre-clerkship course (10.5 contact hours)	Lectures, panel discussions, demonstrations, role playing, learning exercises	Patient safety overview, error reporting, system versus human approach, safety tools, disclosure, root cause analysis	Satisfaction (Level 1) Attitudes (Level 2A) Knowledge (Level 2B) Behavior (Level 3)	High satisfaction rating (72 – 82 out of 100) Multidirectional changes in self-reported attitudes and knowledge questionnaire items Low impact on behavior – 7% reported an error through a formal process
Halbach, 2005 [26]	Single US medical school	572 third year medical students over 3 years	Four-hour mandatory curriculum during Family Medicine clerkship rotation	Lecture, small group discussion, readings, videotaped simulation with standardized patient	Discussing/ reporting medical errors, patient safety overview	Satisfaction (Level 1) Attitudes (Level 2A) Knowledge (Level 2B) Behavior (Level 3)	High satisfaction rating (82 – 94 out of 100) High self-reported ratings of attitudes and knowledge regarding error disclosure 21 of 307 (7%) reported having disclosed a medical error to a patient

Source	Setting	Learners	Intervention	Teaching Methods	Educational Content	Learning Outcomes*	Main Findings
Gould, 2002 [24]	Single US medical school	77 second year medical students (plus 893 charts)	Mandatory QI curriculum integrated into weekly ambulatory block (total time not stated)	Didactic, small group discussion, QI project, chart audit	QI theory, CQI process, QI measurement, audit and feedback	Satisfaction (Level 1) Attitudes (Level 2A) Knowledge (Level 2B) Clinical Process Change (Level 4A) Patient Benefits (Level 4B)	General dissatisfaction with chart-audit learning experience (16% positive rating) Overall improvement in 27 of 40 survey items measuring self-reported attitudes and knowledge towards CQI Increased rates of foot (51 → 70%; p<0.001) and eye (27 →38%; p<0.001) exams on pre-post chart audits HbA1c mean value decreased from 7.7% → 7.2% on pre-post chart audits (p<0.001)
Postgraduate Learners (n=13)							
Oyler, 2008 [36]	1 US teaching hospital	34 Internal Medicine residents (PGY2)	Four mandatory 90 minute seminars x 2 ambulatory blocks (total 12 hours + project time)	Didactic lecture, small group discussion, QI project, web-based chart audit	QI overview, PDSA cycle, process mapping, change management	Attitudes (Level 2A) Knowledge (Level 2B) Clinical Process Change (Level 4A)	Improvement in self-assessed knowledge (comfort using PDSA cycle increased from 9% → 89%) Improvement in several processes of care (increased documentation of height for BMI screening from 11% → 88% (p=0.001), decrease in the number of "inaccurate medication lists" from 25% → 9% (p<0.001))
Voss, 2008 [42]	Single US residency program (Internal Medicine)	34 PGY1 and PGY2 residents	Longitudinal mandatory QI and safety curriculum (7 x 3 hour seminars)	Didactic seminars, experiential involvement in QI project	CQI (PDSA), root cause analysis, systems thinking, human factors, change management, process mapping	Satisfaction (Level 1) Knowledge (Level 2B) Clinical Process Change (Level 4A)	High satisfaction rating (4.4 – 4.7 out of 5) High self-reported knowledge scores (4.4 – 4.8 out of 5) Several QI projects implemented (no outcomes reported)
Bechtold, 2007 [18]	Single US residency program (Department of Internal Medicine)	90 Internal medicine residents and fellows	Mandatory monthly 1-hour long revised patient safety morbidity and	Large group discussion of cases that highlight important healthcare system safety issues	Systems thinking, factors influencing adverse events, modified root cause	Attitudes (Level 2A) Knowledge (Level 2B) Clinical Process Change (Level 4A)	No significant change in 14 of 20 survey items related to attitude and knowledge 59% of recommendations for

34

Source	Setting	Learners	Intervention	Teaching Methods	Educational Content	Learning Outcomes*	Main Findings
			mortality conference		analysis process		improvement that were identified from M&M rounds were implemented at 1-year
Canal, 2007 [19]	Single US residency program (Department of Surgery)	15 PGY-3 surgical residents	Six week elective curriculum during research year (PGY-3)	Didactic lectures, design and implementation of an improvement project	PDSA cycle within the Model for Improvement	Attitudes (Level 2A) Knowledge (Level 2B) Clinical Process Change (Level 4A)	Increase in self-reported attitude (3.7 → 4.4 out of 5) and knowledge (1.9 → 4.6 out of 5) scores Several QI projects implemented to reduce surgical consultation wait-times (no outcomes reported)
Varkey, 2006 [41]	Single US academic medical center	5 residents (2 Preventive medicine, 1 Internal medicine, 2 Family medicine)	Four-week elective curriculum (actual time commitment not specified)	Didactic lectures, small group discussions and exercises, case-based learning, QI project	QI and patient safety overview, process mapping and root cause analysis, PDSA, medical error reporting	Satisfaction (Level 1) Knowledge (Level 2B) Clinical Process Change (Level 4A)	High satisfaction rating (4.1 out of 5) Increase in QIKAT knowledge scores from 2.3 → 3.4 after intervention Improvement in medication reconciliation – increased completeness of dictated medication lists from 38 → 75% (p-value not reported)
Coyle, 2005 [21]	Single US residency program (Department of Family medicine)	30 Family medicine residents (10 from each year)	Six mandatory 1-hour conferences	Didactic lectures, case discussions (small and large group)	Patient safety overview, causes of errors, error reporting, root cause analysis	Attitudes (Level 2A) Behavior (Level 3)	No change in mean attitude and behavior scores (medical event reporting) before and 6-months after education program
Holmboe, 2005 [28]	Single US residency program (Department of Internal Medicine)	13 PGY-2 Internal medicine residents	Weekly half-day elective for 4 weeks (quality of care rotation) + longitudinal chart audit	Self reading, learning exercises, small group discussions (to discuss strategies to improve care), chart audit	Patient safety overview (excerpts from IOM reports), self-audit	Attitudes (Level 2A) Clinical Process Change (Level 4A) Patient Benefits (Level 4B)	8 of 12 (67%) systems-based changes recommended by residents were carried through at 6 months Increased rate of monofilament testing (13% vs 1%; p=0.02) and ordering of baseline EKG (17% vs 10%; p=0.01) Change in pre-post HbA1c of -0.4% in the intervention group compared to +0.7% in the control group (p<0.001)

Source	Setting	Learners	Intervention	Teaching Methods	Educational Content	Learning Outcomes*	Main Findings
Tomolo, 2005 [39]	Single US residency program (Internal Medicine program)	45 Internal Medicine residents (PGY1 18%, PGY2 40%, PGY3 35%, PGY4 7%)	Two 1-hour sessions, and the use of an "Outcomes Card" (residents complete these cards to capture cases which highlight important patient safety issues)	Didactic lectures, experiential activities	Patient safety overview, systems thinking, safety culture, human factors engineering	Attitudes (Level 2A) Knowledge (Level 2B) Clinical Process Change (Level 4A)	High satisfaction rating (12.3 out of 15) High self-assessment scores for knowledge (48 out of 60) Several organizational practice changes implemented (no outcomes measured)
Ogrinc, 2004 [34]	Two US residency programs (Internal Medicine, and Combined Internal Medicine programs)	11 residents (3 PGY-2, 7 PGY-3, 1 PGY-4) (22 residents matched by specialty and year of training served as controls)	Longitudinal PBLI elective (at least 4 weeks, 4-8 hours per week – time logs indicated mean time ~120 hours)	Didactic lectures and experiential learning (resident improvement project)	Foundations of PBLI, PDSA cycle, process and systems change	Satisfaction (Level 1) Attitudes (Level 2A) Knowledge (Level 2B) Clinical Process Change (Level 4A)	High satisfaction rating (4.4 – 4.7 out of 5) Increase in QIKAT knowledge scores from 9.2 → 11.4 compared to 8.2 → 8.7 in control group Several organizational practice changes implemented (no outcomes measured)
Weingart, 2004 [43]	Single US residency program (Department of General Medicine)	19 Internal medicine residents	Quality improvement elective during ambulatory block (20 hours per week for 3 weeks)	Didactic lectures and experiential learning (resident improvement project, QI exercises)	QI and patient safety overview, rapid cycle improvement, root cause analysis	Satisfaction (Level 1) Attitudes (Level 2A) Knowledge (Level 2B) Behavior (Level 3) Clinical Process Change (Level 4A)	High satisfaction rating (71 to 87% rating) Positive responder ratings for self-assessed attitudes, knowledge, 56% reported a change in behavior Several organizational practice changes with positive outcomes (i.e., 62% decrease in inappropriate use of telemetry for chest pain patients; p-value not reported)
Ziegelstein, 2004 [44]	Single US residency program (Internal medicine program)	44 Internal medicine residents (trainee level not specified)	Multifaceted intervention (weekly morbidity and mortality conference, improvement exercises during ambulatory block and continuity clinic), all	Large group discussion at morbidity and mortality rounds – discussion of cases with focus on systems-practice issues; chart audits	Audit and feedback, systems thinking	Attitudes (Level 2A) Knowledge (Level 2B) Clinical Process Change (Level 4A)	High satisfaction rating (76 – 92% rating) Improved self-rated scores for knowledge and attitude (1.6 → 2.5 out of 5) Organizational practice change implemented to improve mammography rates (no outcomes reported)

Source	Setting	Learners	Intervention	Teaching Methods	Educational Content	Learning Outcomes*	Main Findings
			mandatory				
Coleman, 2003 [20]	Single US residency program (Family Medicine)	24 Family Medicine residents (PGY1-3)	Longitudinal mandatory QI project (6 months) – with hourly sessions, project time not stated	Didactic sessions, QI project	PDSA, root cause analysis, audit-feedback, implementing change	Satisfaction (Level 1) Attitudes (Level 2A) Clinical Process Change (Level 4A)	Moderate satisfaction scores (60 – 70% rating) for rating of value of intervention Organizational practice changes resulted from 3 QI projects (increased completion of patient data summary sheets from 14% $\rightarrow$ 40% (p<0.001); increased screening of diabetic patients for microalbuminuria from 5% $\rightarrow$ 29% (p=0.017); increased medication list completion from 10% $\rightarrow$ 44% (p<0.001))
Mohr, 2003 [31]	Single US residency program (Pediatric community clinic)	8 residents (of 36 senior residents voluntarily recruited)	Participation in an elective year-long QI program	Didactic lectures, learning exercises, participation in a QI project	Key principles of QI, process mapping, implementing process changes	Clinical Process Change (Level 4A)	Increase in childhood immunization rates from 60% $\rightarrow$ 86% (p=0.04)
Studies with a Curricular Description Only (N=14)							
Undergraduate Learners (n=5)							
Thompson, 2008 [55]	Single US medical school	First year medical students	Five mandatory weekly 2-hour sessions (total 10 hours)	Didactic sessions, small group discussion, experiential role playing, audio-video case discussion	Systems thinking, reporting errors, disclosing errors, root cause analysis, teamwork and communication		
Varkey, 2007 [56]	Single US medical school	Medical students from all four years (42 third year medical students included in evaluation of knowledge, total number not specified)	Four year longitudinal curriculum integrated into existing curriculum with mandatory and elective components	Didactic lectures, small group sessions, panel discussions, simulation, online modules, case discussions, QI project	Basic principles of QI and patient safety, systems thinking, medical error (and reporting/ disclosure), root cause analysis		
Gould, 2004 [49]	11 US medical	Medical students from	Multiple	Didactic lectures, small	CQI, PDSA, audit and		

Source	Setting	Learners	Intervention	Teaching Methods	Educational Content	Learning Outcomes*	Main Findings
	schools	all 4 years (actual number not specified)	interventions of varying intensity integrated into existing curriculum	group discussions, learning exercises, chart audit, web module, QI project	feedback, change management, quality theory		
Paulman, 2002 [51]	Single US medical school	120 "junior" medical students	Mandatory QI learning project integrated in rural rotation	Learning exercise (identify problem, collect data to define problem, design intervention)	CQI process		
Weeks, 2000 [57]	Single US medical school	First and second year medical school	Integrated mandatory QI curriculum (7 months) with elective component	Didactic lectures, learning exercises, involvement in QI project	CQI, systems theory, process mapping		
Postgraduate Learners (n=7)							
Wong, 2008 [58]	Single Canadian residency program (Internal Medicine)	31 PGY1 residents	Longitudinal mandatory QI curriculum (2x 3.5 hour sessions, plus team based QI project – 1h per week protected time x 10 months)	Didactic lectures, experiential involvement in QI project	QI theory (PDSA), model of improvement, process mapping, CQI process		
Krajewski, 2007 [50]	Single US residency program (Radiology)	Radiology residents (PGY2 and above)	One month elective during radiology training program	Didactic lectures, web-facilitated self-directed learning, experiential involvement in QI project	QI and patient safety overview, root cause analysis, change management		
Rosenfeld, 2005 [52]	Single US residency program (Department of Surgery)	Surgical residents (actual number not reported)	Weekly mandatory morbidity and mortality conference	Large group discussion of cases as they relate to the ACGME core competencies, practice-based improvement exercise	Systems-based practice, root cause analysis, practice-based improvement		
Singh, 2005 [54]	Single US residency	46 Family medicine	Four-hour	Didactic lectures, active	Patient safety		

Source	Setting	Learners	Intervention	Teaching Methods	Educational Content	Learning Outcomes*	Main Findings
	program (Department of Family Medicine)	residents (70% overall participation, PGY1 80%, PGY3 60%)	mandatory workshop presented during residency programme orientation series, plus 3 1-hour sessions	learning, experiential activities (i.e., chart audits)	overview, strategies for safety improvement, culture of safety, behavioral skills for patient safety, medication safety, systems thinking, audit feedback, root cause analysis		
Esselman, 2002 [46]	Single US rehabilitation center	Physiatry residents (actual number not specified)	Monthly mandatory rehabilitation morbidity and mortality conference	Discussion of cases that highlight important rehabilitation quality and safety issues	Systems thinking, root cause		
Farquhar, 2001 [47]	Single Canadian residency (Internal Medicine)	Internal Medicine residents	Quality of Care curriculum (mandatory 1/2 day seminars and monthly noon hour sessions)	Didactic sessions, case discussions to highlight process of care	QI theory, how to improve quality, systems thinking		
Schillinger, 2000 [53]	Single US residency (Internal Medicine)	Internal Medicine residents	Mandatory QI project and seminar series	Didactic lectures, learning exercise, participation in a QI project	QI theory, process improvement, outcomes measurement		
Undergraduate and Postgraduate Learners (n=2)							
Cosby, 2003 [45]	Not stated	Emergency Medicine residents and students	Patient safety curriculum (topic outlines and suggested teaching methods described)	Didactic sessions, small group discussion, use of video, case discussion, modified M&M rounds, learning exercises	Medical error, safety culture, models of error, cognitive error, systems thinking, coping with error		
Gosbee, 2002 [48]	12 US VA facilities	Residents (Internal Medicine, Pediatrics, Anesthesia, Family Medicine, Surgery) and students	Five separate modules (topic outlines and suggested teaching methods described)	Didactic and small group sessions	Patient safety overview, safety culture, human factors, root cause analysis, patient safety		

Source	Setting	Learners	Intervention	Teaching Methods	Educational Content	Learning Outcomes*	Main Findings
					interventions		

* Learner outcomes are classified using Kirkpatrick's model[16], which includes impacts on learners' satisfaction (Level 1), changes in learner attitudes (Level 2A), measures of learner knowledge and skills (Level 2B), changes in learner behavior (Level 3), changes to clinical processes (Level 4A), and benefits to patients (Level 4B).

† BMI indicates body mass index; CQI, continuous quality improvement; EKG, electrocardiogram; HbA1c, hemoglobin A1c; M&M, morbidity and mortality; MCQ, multiple choice questionnaire; PBLI, practice-based learning and improvement; PDSA, plan-do-study-act; PGY, postgraduate year; QI, quality improvement; QIKAT, quality improvement knowledge assessment tool

Table 3: Kirkpatrick Learning Outcomes[16] by Trainee Level

Learning Outcomes	Undergraduate (N=10)*	Postgraduate (N=18)*
Learner satisfaction	7 (70%)	7 (39%)
Learner Attitudes	8 (80%)	14 (78%)
Knowledge Acquisition	9 (90%)	14 (78%)
Behavioral Change	3 (30%)	2 (11%)
Changes in Clinical Practice	1 (10%)	12 (67%)
Benefits to Patients	1 (10%)	1 (6%)

* Total n=28 because 1 study included both medical students and residents (27 total studies)

Table 4: Factors that Influence the Successful Implementation of Quality of Care or Patient Safety Curricula*	
Factors	Example
Learner Factors	
Level of learner enthusiasm or buy-in towards curriculum	"Until trainees appreciate the clinical relevance of systems-based practice competencies, educational programs in this domain may be perceived as unwelcome training requirements." – Kerfoot, 2007 [29] "Medical student demand for [patient safety] has helped capture the attention of the Johns Hopkins School of Medicine Curriculum Reform Committee…The committee is considering the best method for incorporating patient safety-related issues into the 4-year medical school curriculum." – Thompson, 2008 [55]
Competing educational demands of medical students and residents	"A program must successfully compete with other new technologies, diseases, and treatments, all of which may seem more exciting and pertinent to the developing physician." – Gould, 2002 [24] "Despite a lack of familiarity with QI principles, residents were reluctant to 'sacrifice' valuable curricular sessions to learn to use QI tools." – Coleman, 2003 [20]
Teacher Factors	
Adequate number of faculty with expertise in teaching quality and safety	"Challenges to implementing this curriculum include finding adequate faculty with QI experience." – Oyler, 2008 [36] "A critical component of this effort is a faculty development initiative that will enhance the ability of teacher-clinicians in general and hospital medicine to teach residents about quality and safety in health care." – Weingart, 2004 [43]
Involvement of faculty role models committed to patient	"An additional factor in the success of our curriculum was the participation of a stable cadre of committed faculty…such faculty role models discuss not only the knowledge and skills required

safety	for safe practice, but also demonstrate the attitudes required." – Halbach, 2005 [26]
Faculty recognition and support	"An internal grant process helped to focus and support faculty efforts." – Weingart, 2004 [43]
Level of faculty enthusiasm or buy-in towards curriculum	"Quality improvement is one of the key strategic objectives of the clinic…thus most faculty were enthusiastic and supportive of integrating QI components into their courses and eager to enhance their learning about the subject matter." – Varkey, 2007 [56]
Time burden on faculty to teach the curriculum	"An easily imported, ready-made design to overcome the high barrier of creating a program where both the director's time and expertise were limited." – Peters, 2008 [38]
Curricular Factors	
Curriculum should combine didacting and experiential teaching methods	"Learning must be experience based…by having residents identify a problem, create an aim, study the work process, measure the processes and outcomes, and recommend improvements, they applied PBLI to real situations that were important to them." – Ogrinc, 2004 [34] "The QI elective, now in its fourth year, demonstrates the feasibility and durability of an approach that balances didactic and experiential learning…the experiential component…provided the residents with an immediate and relevant 'in-the-trenches' opportunity that often resulted in a tangible contribution to the quality of care." – Weingart, 2004 [43]
Providing adequate time to carry out curriculum (especially those involving QI projects)	"The greatest challenge was to identify meaningful projects that could be completed within 3 weeks." – Weingart, 2004 [43] "The time-limited nature of the elective limited the resident's ability to make and follow changes." – Ogrinc, 2004 [34]
Scheduling of curriculum to optimize likelihood of completing QI projects	"Many PGY3 residents wished to implement their projects but could not do so because they needed additional time to complete the projects, yet were near graduation…the curriculum was therefore moved to the PGY2 year." – Djuricich, 2004 [22] "We believe that providing this curriculum during the research year, when clinical demands are

	not competing, is more likely to produce projects that could come to fruition." – Canal, 2007 [19]
Integration into existing curriculum longitudinally and stand-alone experiences have both been found to be effective	"The longitudinal nature of the curriculum helps to ensure its' sustainability." – Holmboe, 2005 [28] "Although some may argue that this issue [medical errors] needs to be integrated throughout the medical school curriculum, evidence indicates that curricular change has little impact on students' perceptions unless there is a concentrated time devoted to unique topics." – Moskowitz, 2007 [32]
Learning Environment Factors	
Institutional culture regarding QI to support educational efforts	"In order for a program to be successful in adopting this educational intervention…a residency program that supports patient safety curriculum [is essential]" – Tomolo, 2004 [39] "Fear of tort action and reporting to licensing boards is a barrier to role modeling behaviors of reporting, investigating systems failures, and disclosing errors to patients" – Madigosky, 2006 [30]
Linking curriculum to hospital leadership or operational activities	" The greatest success has been achieved by selecting projects that already have organizational momentum." – Schillinger, 2000 [53]
Financial support to fund educational efforts and promote changes from QI projects	"A project on improving communication…was delayed because of the inability to obtain funding needed to purchase a wireless telephone." – Canal et al 2007
Information systems that can provide easy access to health data	"Access to clinical data is important to plan improvements and to evaluate project successes." – Voss, 2008 [42]

* Themes were included if they were identified in at least two independent sources

Appendix Table: Kirkpatrick Learning Outcomes [16], Study Design and Quality of 27 Curricula in Quality Improvement or Patient Safety for Trainees with Evaluative Components

Study	Learning Outcomes (Kirkpatrick Level)*	Study Design	Main Findings‡	Strength of Findings†
Highest Kirkpatrick Learning Outcome Achieved = Satisfaction (Level 1), Learner Attitudes (Level 2A), or Knowledge (Level 2B) (N=10)				
Undergraduate Learners (n=5)				
Newell, 2008 [33]	Attitudes (Level 2A)	Prospective before and after study	Improvement in attitudes towards medical errors (increased awareness of normative medical errors from 2% → 21%)	Level 2 No methodological concerns (response rate 100%), single-centered, good sample size
Gunderson, 2008 [25]	Knowledge (Level 2B)	Prospective before and after study	Improvement in observed disclosure of medical error (2/14 failed to include essential elements of full disclosure compared to 14/14 before the session)	Level 1 Some methodological concerns (response rate 78%), single-centered, small sample size
Moskowitz, 2007 [32]	Attitudes (Level 2A) Knowledge (Level 2B)	Prospective before and after study	Improvement in self-reported attitudes and knowledge on 14 of 21 questionnaire items	Level 2 Methodological concerns (post-test response rate 54%), single-centered
Ogrinc, 2007 [35]	Satisfaction (Level 1) Attitudes (Level 2A) Knowledge (Level 2B)	Prospective clustered randomized two-group trial (early vs late intervention groups)	Low satisfaction rating (30 – 40 out of 100) Increase in QIKAT knowledge scores in intervention group (8.5 → 9.3) versus decrease in QIKAT scores in control group (8.3 → 7.9); $p<0.05$	Level 2 No methodological concerns (response rate 83 – 100%), single-centered, small sample size
Henley, 2002 [27]	Satisfaction (Level 1) Attitudes (Level 2A) Knowledge (Level 2B)	Non-comparative observational study	Moderate satisfaction (50 – 60% of students felt teaching was useful) Scored 84% on a 6-item end-of-	Level 1 Methodological concerns (non-comparative design),

Study	Learning Outcomes (Kirkpatrick Level)*	Study Design	Main Findings‡	Strength of Findings†
			rotation quiz on QI concepts	single-centered, small sample size
Postgraduate Learners (n=4)				
Peters, 2008 [38]	Attitudes (Level 2A) Knowledge (Level 2B)	Prospective non-randomized, controlled study	Increase in test of knowledge scores from 55.2 → 59.6 compared to 50.2 → 48.3 in control group, no significant difference in attitude change pre- versus postintervention	Level 1 Methodological concerns (response rate as low as 38% in the control group), single-centered
Varkey, 2008 [40]	Satisfaction (Level 1) Attitudes (Level 2A) Knowledge (Level 2B)	Prospective before and after study	High satisfaction (5/9 rated above average, 4/9 rated superior) Significant increase in learner QIKAT scores postrotation (11.89/15) compared to prerotation (7.33/15), p<0.004 Improvement in patient understanding of care (11% increase in number of patients who understood why tests were ordered, 12% increase in the number of patients who understood recommended treatment)	Level 1 No methodological concerns (response rate 89%), single-centered, small sample size
Djuricich, 2004 [22]	Attitudes (Level 2A) Knowledge (Level 2B)	Prospective before and after study	Increase in score on 5-item quiz from 48% → 89% on pre-post testing of CQI knowledge	Level 3 No methodological concerns (95% response rate), single-centered (but included 2 different groups of residents), small sample size
Frey, 2003 [23]	Attitudes (Level 2A) Knowledge (Level 2B)	Non-comparative observational study	High overall confidence in knowledge and attitudes (3.5 – 4.1 out of 5)	Level 2 No methodological concerns (100% response rate), single-

Study	Learning Outcomes (Kirkpatrick Level)*	Study Design	Main Findings‡	Strength of Findings†
				centered, small sample size
Undergraduate and Postgraduate Learners (n=1)				
Kerfoot, 2007 [29]	Satisfaction (Level 1) Knowledge (Level 2B)	Prospective randomized cross-over study	High satisfaction rating (4 out of 5) Increase in MCQ test scores compared to baseline (16% increase from baseline of 58%) Knowledge sustained over 4 weeks (1% decay in MCQ test scores)	Level 5 No methodological concerns (80% response rate), multi-centered, large sample size
Highest Kirkpatrick Learning Outcome Achieved = Level 3 (Behavior) or Level 4 (Clinical Process Change or Patient Benefits) (N=17)				
Undergraduate Learners (n=4)				
Patey, 2007 [37]	Satisfaction (Level 1) Attitudes (Level 2A) Knowledge (Level 2B) Behavior (Level 3)	Prospective before and after study	High satisfaction rating (4 – 5 out of 5) Improvement in some self-assessed attitudes and knowledge Majority planned to report medical errors that they make (51 out of 70, 73%)	Level 1 Methodological concerns (response rate 29% at 1-year), single-centered
Madigosky, 2006 [30]	Satisfaction (Level 1) Attitudes (Level 2A) Knowledge (Level 2B) Behavior (Level 3)	Prospective before and after study	High satisfaction rating (72 – 82 out of 100) Multidirectional changes in self-reported attitudes and knowledge questionnaire items Low impact on behavior – 7% reported an error through a formal process	Level 1 Methodological concerns (response rate 55%), single-centered, small sample size
Halbach, 2005 [26]	Satisfaction (Level 1)	Prospective before	High satisfaction rating (82 – 94 out	Level 3

Study	Learning Outcomes (Kirkpatrick Level)*	Study Design	Main Findings‡	Strength of Findings†
	Attitudes (Level 2A) Knowledge (Level 2B) Behavior (Level 3)	and after study	of 100) High self-reported ratings of attitudes and knowledge regarding error disclosure 21 of 307 (7%) reported having disclosed a medical error to a patient	Some methodological concerns (response rate 54%) but sound study design, single centered, large sample size
Gould, 2002 [24]	Satisfaction (Level 1) Attitudes (Level 2A) Knowledge (Level 2B) Clinical Process Change (Level 4A) Patient Benefits (Level 4B)	Prospective before and after study	General dissatisfaction with chart-audit learning experience (16% positive rating) Overall improvement in 27 of 40 survey items measuring self-reported attitudes and knowledge towards CQI Increased rates of foot (51 → 70%; $p<0.001$) and eye (27 →38%; $p<0.001$) exams on pre-post chart audits HbA1c mean value decreased from 7.7% → 7.2% on pre-post chart audits ($p<0.001$)	Level 1 Methodological concerns (response rate 69%), single-centered, small sample size
Postgraduate Learners (n=13)				
Oyler, 2008[36]	Attitudes (Level 2A) Knowledge (Level 2B) Clinical Process Change (Level 4A)	Prospective before and after study	Improvement in self-assessed knowledge (comfort using PDSA cycle increased from 9% → 89%) Improvement in several processes of care (increased documentation of height for BMI screening from 11% → 88% ($p=0.001$), decrease in the number of "inaccurate medication lists" from 25% → 9% ($p<0.001$))	Level 2 No methodological concerns (response rate 82%), measured clinically important outcomes for change in clinical processes, single-centered, small sample size

Study	Learning Outcomes (Kirkpatrick Level)*	Study Design	Main Findings‡	Strength of Findings†
Voss, 2008 [42]	Satisfaction (Level 1) Knowledge (Level 2B) Clinical Process Change (Level 4A)	Non-comparative observational study, qualitative study	High satisfaction rating (4.4 – 4.7 out of 5) High self-reported knowledge scores (4.4 – 4.8 out of 5) Several QI projects implemented (no outcomes reported)	Level 1 Methodological concerns (response rate unclear), single-centered, small sample size
Bechtold, 2007 [18]	Attitudes (Level 2A) Knowledge (Level 2B) Clinical Process Change (Level 4A)	Prospective before and after study	No significant change in 14 of 20 survey items related to attitude and knowledge 59% of recommendations for improvement that were identified from M&M rounds were implemented at 1-year	Level 1 Methodological concerns (post-test response rate 52%), single-centered, small sample size
Canal, 2007 [19]	Attitudes (Level 2A) Knowledge (Level 2B) Clinical Process Change (Level 4A)	Prospective before and after study	Increase in self-reported attitude (3.7 → 4.4 out of 5) and knowledge (1.9 → 4.6 out of 5) scores Several QI projects implemented to reduce surgical consultation wait-times (no outcomes reported)	Level 2 No methodological concerns, but single-centered, small sample size
Varkey, 2006 [41]	Satisfaction (Level 1) Knowledge (Level 2B) Clinical Process Change (Level 4A)	Prospective before and after study	High satisfaction rating (4.1 out of 5) Increase in QIKAT knowledge scores from 2.3 → 3.4 after intervention Improvement in medication reconciliation – increased completeness of dictated medication lists from 38 → 75% (p-value not reported)	Level 1 No significant methodological concerns, but single-centered, very small sample size
Coyle, 2005 [21]	Attitudes (Level 2A) Behavior (Level 3)	Prospective before and after study	No change in mean attitude and behavior scores (medical event reporting) before and 6-months after	Level 1 Methodological concerns (level of significance of

Study	Learning Outcomes (Kirkpatrick Level)*	Study Design	Main Findings‡	Strength of Findings†
			education program	results not reported, 100% response rate), single-centered, small sample size
Holmboe, 2005 [28]	Attitudes (Level 2A) Clinical Process Change (Level 4A) Patient Benefits (Level 4B)	Prospective, non-randomized, controlled study	8 of 12 (67%) systems-based changes recommended by residents were carried through at 6 months Increased rate of monofilament testing (13% vs 1%; p=0.02) and ordering of baseline EKG (17% vs 10%; p=0.01) Change in pre-post HbA1c of -0.4% in the intervention group compared to +0.7% in the control group (p<0.001)	Level 3 No methodological concerns (92% response rate), measured clinically important outcomes for patients, single-centered, small sample size
Tomolo, 2005 [39]	Attitudes (Level 2A) Knowledge (Level 2B) Clinical Process Change (Level 4A)	Non-comparative observational study	High satisfaction rating (12.3 out of 15) High self-assessment scores for knowledge (48 out of 60) Several organizational practice changes implemented (no outcomes measured)	Level 1 Methodological concerns (57% response rate, non-comparative design), single-centered, small sample size
Ogrinc, 2004 [34]	Satisfaction (Level 1) Attitudes (Level 2A) Knowledge (Level 2B) Clinical Process Change (Level 4A)	Prospective non-randomized, controlled study	High satisfaction rating (4.4 – 4.7 out of 5) Increase in QIKAT knowledge scores from 9.2 → 11.4 compared to 8.2 → 8.7 in control group Several organizational practice changes implemented (no outcomes measured)	Level 4 No methodological concerns (100% response rate), multi-centered, small sample size
Weingart, 2004 [43]	Satisfaction (Level 1)	Non-comparative	High satisfaction rating (71 to 87%	Level 1

Study	Learning Outcomes (Kirkpatrick Level)*	Study Design	Main Findings‡	Strength of Findings†
	Attitudes (Level 2A) Knowledge (Level 2B) Behavior (Level 3) Clinical Process Change (Level 4A)	observational study	rating) Positive responder ratings for self-assessed attitudes, knowledge, 56% reported a change in behavior Several organizational practice changes with positive outcomes (i.e., 62% decrease in inappropriate use of telemetry for chest pain patients; p-value not reported)	Methodological concerns (non-comparative study), 100% response rate, single-centered, small sample size
Ziegelstein, 2004 [44]	Attitudes (Level 2A) Knowledge (Level 2B) Clinical Process Change (Level 4A)	Retrospective pre-post observational study	High satisfaction rating (76 – 92% rating) Improved self-rated scores for knowledge and attitude (1.6 → 2.5 out of 5) Organizational practice change implemented to improve mammography rates (no outcomes reported)	Level 1 Methodological concerns (66-70% response rate), single-centered, small sample size
Coleman, 2003 [20]	Satisfaction (Level 1) Attitudes (Level 2A) Clinical Process Change (Level 4A)	Prospective before and after study for clinical impact (non-comparative observational study for satisfaction)	Moderate satisfaction scores (60 – 70% rating) for rating of value of intervention Organizational practice changes resulted from 3 QI projects (increased completion of patient data summary sheets from 14% → 40% (p<0.001); increased screening of diabetic patients for microalbuminuria from 5% → 29% (p=0.017); increased medication list completion from 10% → 44% (p<0.001))	Level 2 No methodological concerns (response rate 79%), measured clinically important outcomes for change in organizational practice, single-centered, small sample size

Study	Learning Outcomes (Kirkpatrick Level)*	Study Design	Main Findings‡	Strength of Findings†
Mohr, 2003 [31]	Clinical Process Change (Level 4A)	Prospective before and after study	Increase in childhood immunization rates from 60% → 86% (p=0.04)	Level 1 Methodological concerns (inception cohort unclear for chart review), single-centered, small sample size

* Learner outcomes are classified using Kirkpatrick's model[16], which includes impacts on learners' satisfaction (Level 1), changes in learner attitudes (Level 2A), measures of learner knowledge and skills (Level 2B), changes in learner behavior (Level 3), changes to clinical processes (Level 4A), and benefits to patients (Level 4B).

† Strength of findings was assessed using the Best Evidence in Medical Education (BEME) rating system [15] which assigns a rating of Level 1 when no clear conclusions can be drawn, Level 2 when results are ambiguous but exhibit a trend, Level 3 when conclusions can probably be based on the results, Level 4 when results are clear and very likely to be true, and Level 5 when results are unequivocal.

‡ BMI indicates body mass index; CQI, continuous quality improvement; EKG, electrocardiogram; HbA1c, hemoglobin A1c; M&M, morbidity and mortality; MCQ, multiple choice questionnaire; PDSA, plan-do-study-act; QI, quality improvement; QIKAT, quality improvement knowledge assessment tool

Figure 1: Literature search and study selection process for identifying quality improvement and patient safety curricula published between 2000 and 2008.
(figure included in a separate Word file)