Chapter 2

Systematic review: evaluations of patient safety education for residents offer suggestions for graduate medical education

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Submitted
Abstract

Background
Residents are considered an important target group for patient safety education. Because they are key figures in delivering current and future care, they can play a major role in patient safety improvement. This systematic review aimed at gaining insight into the characteristics and effects of patient safety education for residents.

Methods
Original articles published before February 2010 were searched for reports on patient safety education for residents and for evaluation results. Sources included PubMed, Cochrane Library, EMBASE, CINAHL, PsycINFO and ERIC. Citations were reviewed independently by at least two authors.

Results
Seventeen studies met the inclusion criteria. Interventions mostly consisted of multiple sessions with interactive and experiential educational methods (i.e. discussions, feedback, role-play, simulations). Educational topics found most frequently were “learning from mistakes: error reporting and analysis” and “systems thinking and cultural change”. Evaluations contained non-comparative data in 13 (76%) studies, 9 (53%) studies used pre-post design. Two (12%) studies were randomized trials. Sixteen (94%) studies used subjective outcome measures (i.e. self-assessment), 9 (53%) included objective outcome measures (i.e. chart audit). All studies described positive effects, 8 (47%) articles mentioned equivocal results as well. Evaluations mostly focused on attendants’ participation or on modification of knowledge, skills or behavior. Strength of findings was limited in all studies.

Conclusions
Various experiences with educating residents in patient safety are described and can offer inspiration for the development of patient safety education elsewhere. Studies mainly described positive effects in short term. However, the effectiveness of the education was difficult to judge from literature.
Introduction

Patient safety education for health care workers aims at improving knowledge and skills to recognize and handle unsafe situations in an early stage and should therefore contribute to a reduction in risk-full situations for patients. The importance of education about safety principles was advocated by non-medical high-risk industries, like aviation and petrochemical industries, long before it was acknowledged in health care. Since the extent of adverse events in health care became visible ten years ago, the need for patient safety education has been adopted in policy plans in many countries. For several reasons it is expected that patient safety education for medical residents can lead to particularly valuable results. Firstly, residents provide much of the direct patient care. Secondly, they are considered a fragile link in the care process. Research revealed that a lack of work experience and high pressure of work among residents increases risky situations. Besides, research showed that medical trainees across a broad range of training levels, degrees and specialties had limited knowledge of patient safety. A final argument for training residents in patient safety is that they are considered to be a group which can provide long-lasting benefits, as these physicians are the medical specialists of the future.

As a result of the increased attention to patient safety education, initiatives have been set up to educate residents in patient safety subjects. The growing number of these initiatives, and hence the increasing costs, make it increasingly relevant to gain insight into the effects of patient safety education for residents. However, we did not find a review addressing the effects of patient safety education for residents in literature. The present article provides an overview of studies that assessed the effectiveness of the non-technical aspects of patient safety education for residents. We sought to answer the following questions:

- Which teaching methods were used?
- Which specific contents were taught?
- How were the educational interventions evaluated?
- What were the effects of the education?

Methods

Search strategy

The following databases were searched by JJ and JCFK from inception to February 2010: PubMed, Cochrane Library, EMBASE, CINAHL, PsycINFO and ERIC. The literature was searched using the following terms, either as thesaurus terms or title or as abstract terms with synonyms and closely related words: "risk management", "patient safety" or "accident prevention" and "medical education", "internship" or "residency" and "evaluation" or "questionnaire" (figure 1). We limited these searches to articles written in English, French, Dutch or German. Subsequently, key journals (i.e. Journal of Patient Safety) were hand searched and reference lists of eligible articles were screened. The full search strategy is available on request from the first author.
Study selection
We included original data studies if they contained results of empirical evaluations of patient safety education for residents. Patient safety education was defined in this review as training to obtain knowledge or skills concerning non-technical aspects of patient safety improvement; i.e. how to handle or prevent the occurrence of adverse medical events. Studies were included regardless of their design: pre/post evaluation design or post-only design, with or without controls. As we were particularly interested in the results on the residents’ level, we excluded articles that described team training together with other health care workers (i.e. nurses or medical specialists) if results for residents were not described separately. Studies were also excluded if they only assessed training of technical skills. We focused on non-technical skills, which, in literature, are most often found to be important for patient safety education.\textsuperscript{15-17} Besides, a focus on non-technical skills, which are not discipline-specific, allows for the inclusion and comparison of training programs.
for various medical specialties. Studies that poorly described outcome measures or had none at all were also excluded from our review.

Data extraction & analysis
The reference management software package Reference Manager 10 was used to organize all search results. Firstly, titles and abstracts of identified articles were reviewed independently by two of the authors (JDJ & CW or ABB). If an article was considered possibly relevant by one author, the full text was reviewed by both authors. In case of disagreement about the inclusion or exclusion of a full text, three authors (JDJ, CW & ABB) discussed the issue until consensus was reached. Prior to this consensus discussion, kappa statistics were used to measure the inter-rater reliability.\(^{18}\)

Included articles were abstracted by one author (JDJ) according to a coding sheet based on the guidelines of the Best Evidence Medical Education collaboration (BEME).\(^{19}\) Impact of interventions was classified according to the levels of Kirkpatrick’s evaluation framework that were defined in the BEME coding sheet: 1] participation; 2a] modification of attitudes / perceptions; 2b] modification of knowledge / skills; 3] behavioral change; 4a] change in organizational practice; and 4b] benefits to patients.

Participation covers learners views on the learning experience, its organization, presentation, content, teaching methods and aspects of the instructional organization. Modification of attitudes / perceptions relates to changes in the reciprocal attitudes or perceptions between participant groups towards the educational intervention. Modification of knowledge relates to the acquisition of concepts, procedures and principles. Modification of skills relates to the acquisition of thinking or problem-solving skills, psychomotor skills and social skills. Behavioral change documents the transfer of learning to the workplace or the willingness of learners to apply new knowledge and skills. Change in organizational practice relates to wider changes in the organization or delivery of care, attributable to the educational program. Benefits to patients include any improvement in the health and well-being of patients / clients as a direct result of the educational program.

Abstractions of the patient safety topics dealt with in the training courses were added to the prototype coding sheet of BEME. These curriculum topics were based on results of an educational needs assessment for improving patient safety, which was conducted by the National Patient Safety Foundation.\(^{16}\) The topics were distinguished as follows: A] defining healthcare error and patient safety; B] technology and human factors: dealing with complexity, product design and fatigue; C] physician-patient communication (including disclosure of errors and injuries to patients and families); D] (communicating within) the healthcare team; E] learning from mistakes: error reporting and analysis (at the system level); F] financial and legal implications of healthcare error; G] systems thinking and cultural change.

Following data extraction of each paper, three authors (JDJ, CW & ABB) discussed the strength of findings on a scale of I to V according to the BEME coding sheet: I] no clear conclusions can be drawn / not significant; II] results ambiguous, but there appears to be a trend; III] conclusions can probably be based on the results; IV] results are clear and very likely to be true; V] results are unequivocal. The study design as well as the reported outcomes were of influence on the assessment of the strength of findings. If articles
offered insufficient information for completion of the abstraction procedure, authors were asked for specific information about their study.

Results

Of 1511 unique citations that were identified, seventeen studies fulfilled all criteria for inclusion and abstraction (figure 1). Educational programs focused on internal medicine (6, 35%), family medicine (4, 24%), mixed disciplines (4, 24%), surgery (1, 6%), anesthesia (1, 6%) or emergency medicine (1, 6%) (table 1). Inter-rater reliability was substantial before consensus was reached through discussion of full-texts (overall agreement = 99%, Kappa = 0.70, \( p < 0.001 \)). Consensus was reached in all cases. The most common area requiring discussion was determining whether an educational intervention could be considered patient safety education.

All studies were carried out in the United States (US). Of the studies included, three were carried out at the Patient Safety Research Center of the State University of New York and two were carried out at the Beth Israel Deaconess Medical Center in Boston. However, since all these studies differed in educational program or residents they were all described separately in our review.

Educational methods (table 1)

Five (29%) studies described single-session interventions, 9 (53%) evaluated multiple sessions within less than one year, 3 (18%) studies focused on multiple sessions over multiple residency years. Duration of sessions varied from 15 minutes to 6 hours. Twelve (71%) articles described interventions in which residents were trained individually and as a group, 5 (29%) assessed individual education only. All articles described multiple teaching methods, including interactive learning. Fourteen (82%) articles described experiential learning and 9 (53%) described didactics. One (6%) intervention was entirely computer-based, 6 (35%) described a minor role for computers to stimulate the learning process.

Content of education (table 2)

All articles described the content of the educational intervention, but the extent of this description varied greatly. All pre-defined patient safety topics were found in several of the educational descriptions, and most curricula included multiple patient safety topics (table 2), but none of the educational programs included all of the patient safety topics. Thirteen (76%) articles described training related to the topic “learning from mistakes: error reporting and analysis (at the system level) (E)”. Eleven (65%) articles mentioned topics concerning “systems thinking and cultural change (G)”. Ten (59%) articles described inclusion of the topics “defining healthcare error and patient safety (A)”, and 9 (53%) referred to “(communication within) the healthcare team (D)”. Seven (41%) of the interventions paid attention to “physician-patient communication (C)”. “Technology and human factors (B)” were a topic in 5 (29%) of the interventions. “Financial and legal implications of healthcare error (F)” were found in 3 (18%) of the curricula descriptions.
Most of the interventions were developed according to the framework of the Accreditation Council for Graduate Medical Education (ACGME) competencies and focused on the competencies “systems-based practice” and “practice-based learning and improvement”. Two (17%) studies did not mention the use of a theoretical framework (table 2).  

**Evaluation methods (table 1 & 3)**

Four (24%) articles described multicenter studies. Thirteen (76%) articles described results following non-comparative data collection. Some of these articles also described data collection methods in a before-and-after study design. In total 9 (53%) studies took measurements before and after the training. Three (18%) studies included control groups; two with random allocation to groups and one with non-random allocation to groups. However, none of the applied data collection methods were validated, although one article earmarked the validation of assessment tools as a topic for future research.

Fourteen (76%) articles used multiple outcome measures. Except for one study, all studies included subjective outcome measures, such as self-assessment of knowledge gained or attitudes concerning education. Subjective outcome measures focused on attendants’ thoughts and beliefs. In one study, attendants were also asked to provide factual information on their reporting behavior. Eight (47%) studies included objective outcome measures like conference attendance or OSCE performance one of which was related to clinical outcomes.

Four (24%) studies described effects beyond the end of the educational program. Most studies measured effects on several levels of Kirkpatrick’s evaluation hierarchy. Eleven (65%) included the assessment of effects on the level of “participation (1)”. “Modification of attitudes/perceptions (2A)” was measured by 4 (24%) articles, and “modification of knowledge/skills (2B)” by 11 (65%). Eleven (65%) studies measured “behavioral change (3)”.

“What change in organizational practice (4A)” was used as an outcome measure in 4 (24%) studies. Two (12%) studies included assessment of the “benefits to patients (4B)”.

**Effects educational interventions (table 3)**

All studies described positive effects in short term. Eight (47%) articles mentioned equivocal results as well, such as a limited execution of the assignments, or the fact that not all aspects related to attitude or behavior changed in the desired direction. The strength of findings differed among the various studies. “No clear conclusions could be drawn, and/or no significant results (I)” were found in 5 (29%) of the studies. Seven (41%) studies demonstrated “ambiguous results, but there appeared to be a trend (II)”.

Five (29%) articles described “conclusions that can probably be based on the results (III)”.

None of the studies described “results that were clear and likely to be true (IV)” or “results that were unequivocal (V)”.

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Table 1. Curricular characteristics and evaluation design

<table>
<thead>
<tr>
<th>Author &amp; year of publication</th>
<th>Evaluation design (data collection methods)</th>
<th>Duration of formal education*</th>
<th>Responding residents’ characteristics (n)</th>
<th>Stated teaching methods</th>
</tr>
</thead>
<tbody>
<tr>
<td>Balcezak et al. 1998&lt;sup&gt;30&lt;/sup&gt;</td>
<td>Single center. Randomized trial (questionnaire after education) + non-comparative (ND).</td>
<td>6 x 15-minute</td>
<td>US internal medicine (study: 16; control: 18)</td>
<td>Individual learning; web-based modules.</td>
</tr>
<tr>
<td>Bechtold et al. 2007&lt;sup&gt;31&lt;/sup&gt;</td>
<td>Single center. Before and after study (questionnaire, observation) + non-comparative study (observation).</td>
<td>11 x 1-hour monthly</td>
<td>US internal medicine (90)</td>
<td>Small group discussions; case presentations; electronic mailings.</td>
</tr>
<tr>
<td>Berenholtz et al. 2009&lt;sup&gt;33&lt;/sup&gt;</td>
<td>Single center. Non-comparative study (questionnaire).</td>
<td>Monthly 2 x 1-hour over max. 1 year</td>
<td>US multiple disciplines (18)</td>
<td>Case presentations; interdisciplinary discussions; assignments; mentoring.</td>
</tr>
<tr>
<td>Brannick et al. 2009&lt;sup&gt;34&lt;/sup&gt;</td>
<td>Single center. Randomized trial (video record) + before and after study (questionnaire) + non-comparative study (observation; questionnaire).</td>
<td>1 session, duration ND</td>
<td>US surgery (study: 19; control: 13)</td>
<td>Video including lecture and behaviour modelling; role-play; patient simulator; feedback.</td>
</tr>
<tr>
<td>Coyle et al. 2005&lt;sup&gt;26&lt;/sup&gt;</td>
<td>Single center. Before and after study (questionnaire).</td>
<td>7 x 1-hour over ½ year</td>
<td>US family medicine (30)</td>
<td>Lecture; small and large group discussions; video; e-mailings.</td>
</tr>
<tr>
<td>Holland et al. 2009&lt;sup&gt;8&lt;/sup&gt;</td>
<td>Single center. Before and after study (questionnaire) + non-comparative study (questionnaire).</td>
<td>4 weeks minus 2 days</td>
<td>US internal medicine (26)</td>
<td>Interactive web-based modules; readings; assignments; department-wide presentations.</td>
</tr>
<tr>
<td>Janus et al. 2006&lt;sup&gt;28&lt;/sup&gt;</td>
<td>Single center. Non-comparative study (questionnaire).</td>
<td>1 x 3½-hour</td>
<td>US multiple specialties (570)</td>
<td>OSCE (including standardized patients); feedback; written cases; MC-exam; take-home literature; web-based; video.</td>
</tr>
<tr>
<td>Pian-Smith et al. 2009&lt;sup&gt;15&lt;/sup&gt;</td>
<td>Single center. Before and after study (video record)</td>
<td>1 x 30 to 45-minute</td>
<td>US anesthesiology (36)</td>
<td>Debriefing; simulated cases; phrase experimenting; feedback.</td>
</tr>
<tr>
<td>Reznek et al. 2003&lt;sup&gt;36&lt;/sup&gt;</td>
<td>Single center. Non-comparative study (questionnaire).</td>
<td>1 x 2½-hour</td>
<td>US emergency medicine (13)</td>
<td>Simulations; discussions; lecture; video; book.</td>
</tr>
<tr>
<td>Singh et al. 2005&lt;sup&gt;27&lt;/sup&gt;</td>
<td>Multicenter. Before and after study (chart audit) + non-comparative study (safety journal; questionnaire; focus group discussion).</td>
<td>1 x 4-hour + 16 x 1-hour over 3 years</td>
<td>US family medicine (45)</td>
<td>Workshops; didactics; portfolios; group exercises (including chart reviews, case presentations and quality improvement projects); discussions; OSCE (including standardized patient interviews, simulations and written examination); videos.</td>
</tr>
</tbody>
</table>

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<table>
<thead>
<tr>
<th>Authors</th>
<th>Setting</th>
<th>Intervention Duration</th>
<th>Specialty</th>
<th>Methods</th>
</tr>
</thead>
<tbody>
<tr>
<td>Singh et al. 2007</td>
<td>Multicenter. Before and after study (safety journal).</td>
<td>4 x 1-hour over 1 year</td>
<td>US family medicine (30)</td>
<td>Didactics; experiential learning; case presentations; feedback.</td>
</tr>
<tr>
<td>Singh et al. 2009</td>
<td>Multicenter. Non-randomized trial (OSCE) + before and after study (questionnaire).</td>
<td>1 x 4-hour + 16 x 1-hour over 3 years</td>
<td>US family medicine (study: 47; internal control: 16; external control: 10)</td>
<td>Workshops; didactics; portfolios; group exercises (including chart reviews, case presentations and quality improvement projects); discussions; OSCE (including standardized patient interviews, simulations and written examination); videos.</td>
</tr>
<tr>
<td>Tess et al. 2009</td>
<td>Single center. Before and after study (questionnaire) + non-comparative study (observation).</td>
<td>3 weeks + monthly sessions, duration ND, over 1 year</td>
<td>US internal medicine (124)</td>
<td>Portfolio; web-based modules; mentoring; department-wide presentations; assignments; discussions.</td>
</tr>
<tr>
<td>Tomolo et al. 2005</td>
<td>Single center. Non-comparative study (questionnaire; outcomes card; observation).</td>
<td>2 x 1-hour weekly</td>
<td>US internal medicine (45)</td>
<td>Didactics; experiential learning; case presentations; discussions; feedback.</td>
</tr>
<tr>
<td>Voss et al. 2008</td>
<td>Single center. Non-comparative study (questionnaire; interview; observation).</td>
<td>7 x 3-hour over 2 years</td>
<td>US internal medicine (81)</td>
<td>Seminars; experiential learning; discussions; role-play; interviews; case presentations; site visits; exercises; computer simulations; video.</td>
</tr>
<tr>
<td>Weingart et al. 2004</td>
<td>Single center. Non-comparative study (questionnaire; narrative).</td>
<td>3 x 1-hour weekly</td>
<td>US multiple specialties (16)</td>
<td>Didactics; discussions; experiential learning; case presentations; syllabus with relevant references.</td>
</tr>
</tbody>
</table>

ND=Not Defined. MC=Multiple Choice. OSCE=Objective structured clinical examination. US=United States. *This is excluding self-study and other activities outside the formal educational program.*
## Table 2. Content of education

<table>
<thead>
<tr>
<th>Author &amp; year of publication</th>
<th>Described patient safety educational content</th>
<th>Summary of patient safety topics*</th>
<th>Theoretical background of education</th>
</tr>
</thead>
<tbody>
<tr>
<td>Balcezak et al. 1998&lt;sup&gt;20&lt;/sup&gt;</td>
<td>The legal setting; malpractice; avoiding malpractice; patient’s rights; medical record&lt;sup&gt;31&lt;/sup&gt;</td>
<td>A, C, D, E, F</td>
<td>None described</td>
</tr>
<tr>
<td>Bechtold et al. 2007&lt;sup&gt;21&lt;/sup&gt;</td>
<td>System thinking; adverse events and reasons contributing to their occurrence; departmental culture; root cause analysis.</td>
<td>A, E, G</td>
<td>ACGME competencies</td>
</tr>
<tr>
<td>Berenholtz et al. 2009&lt;sup&gt;31&lt;/sup&gt;</td>
<td>Learning from defects; systems thinking; standardize what can be standardized; create redundancy for key processes; communication in patient outcomes; teamwork; challenges at implementing changes.</td>
<td>B, D, E, G</td>
<td>ACGME competencies; Model of Systems.</td>
</tr>
<tr>
<td>Brannick et al. 2009&lt;sup&gt;31&lt;/sup&gt;</td>
<td>Judgment errors; asking for help; inattention errors, problem understanding errors.</td>
<td>A, D, E</td>
<td>Taxonomy of general surgical errors</td>
</tr>
<tr>
<td>Coyle et al. 2005&lt;sup&gt;26&lt;/sup&gt;</td>
<td>Impact of medical error; patient safety definitions; conditions that promote medical events; root cause analysis; medical event reporting system; interventions for prevention.</td>
<td>A, E</td>
<td>None described</td>
</tr>
<tr>
<td>Holland et al. 2009&lt;sup&gt;24&lt;/sup&gt;</td>
<td>Introduction to patient safety and quality improvement; root-cause analysis; medical error from a systems perspective; human factors engineering; patient safety interventions.</td>
<td>A, B, E, G</td>
<td>ACGME competencies; Plan Do Study Act cycles.</td>
</tr>
<tr>
<td>Janus et al. 2006&lt;sup&gt;26&lt;/sup&gt;</td>
<td>Order-writing techniques; response to critical values; evaluation of the medical literature; communication skills; hand hygiene to prevent health care associate infection; accurate patient identification ensuring performance of correct procedure at correct body site.</td>
<td>C</td>
<td>WHO patient safety solutions; ACGME competencies.</td>
</tr>
<tr>
<td>Pian-Smith et al. 2009&lt;sup&gt;31&lt;/sup&gt;</td>
<td>Responsibility for safety and the obligation to speak up; challenging authority; advocacy and inquiry.</td>
<td>D, F</td>
<td>Two-challenge approach; collaborative conversational techniques of organizational behavior.</td>
</tr>
<tr>
<td>Reznek et al. 2003&lt;sup&gt;31&lt;/sup&gt;</td>
<td>Human and system errors; anticipation/planning; communication; leadership/assertiveness; awareness and utilization of available resources; distribution of workload and mobilization of help; routine re-evaluation of situation; awareness and utilization of all information; prioritization; coping with disruptions.</td>
<td>B, D, G</td>
<td>Human error principles; Crisis Resource Management principles</td>
</tr>
<tr>
<td>Singh et al. 2005&lt;sup&gt;27&lt;/sup&gt;</td>
<td>Teamwork; error disclosure; quality/safety improvement process with staff; medication safety; systems approach to patient safety; failure modes and effects analysis; root cause analysis; communication; safety culture; safety ethics.</td>
<td>A, C, D, E, G</td>
<td>ACGME competencies</td>
</tr>
</tbody>
</table>
Singh et al. 2007\textsuperscript{28}

- Systems approach to patient safety; culture of safety; quality improvement cycle; principles and strategies for system improvement; failure modes and effects analysis; root cause analysis.

Singh et al. 2009\textsuperscript{29}

- Teamwork; error disclosure; quality/safety improvement process together with staff; medication safety; systems approach to patient safety; retrospective and prospective analysis tools; communication; safety culture; safety ethics.

Tess et al. 2009\textsuperscript{25}

- Systems thinking; adverse event review; basic QI-principles; error disclosure; medication errors; hand hygiene; failure to rescue; teamwork; patient satisfaction; communication and handoffs; improving discharge process.

Tomolo et al. 2005\textsuperscript{22}

- Basic epidemiology and terminology associated with patient safety; systems thinking; human factors engineering; safety culture; error classification.

Voss et al. 2008\textsuperscript{23}

- Critical concepts and skills of patient safety and quality improvement; systems thinking; human factors analysis; root cause analysis; process mapping.

Wagner et al. 2009\textsuperscript{31}

- Data gathering; written communication; patient-centered communication; timely/efficient patient care; team functioning/inter-professional communication; infection prevention.

Weingart et al. 2004\textsuperscript{32}

- Terminology; medication safety; learning from errors or complaints (root cause analysis and propose solutions); legal and regulatory environment; hospital’s quality improvement activities and systems for delivering and improving care.

\*A=defining healthcare error and patient safety; B=technology and human factors: dealing with complexity, product design and fatigue; C=physician-patient communication (including disclosure of errors and injuries to patients and families); D=communicating within the healthcare team; E=learning from mistakes: error reporting and analysis (at the system level); F=financial and legal implications of healthcare error; G��s thinking and cultural change.

ACGME=Accreditation Council for Graduate Medical Education. WHO=World Health Organization.
<table>
<thead>
<tr>
<th>Author &amp; year of publication</th>
<th>Evaluation outcomes</th>
<th>Outcome results*</th>
<th>Level of impact</th>
<th>Strength of findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Balcezak et al. 1998&lt;sup&gt;20&lt;/sup&gt;</td>
<td>Attendants’ knowledge about risk management principles and medical-legal regulations, and attitudes about education.</td>
<td>K: trainees scored higher than controls (p&lt;.001). A: mainly positive, education was considered informative and easy to use.</td>
<td>1, 2B</td>
<td>II</td>
</tr>
<tr>
<td>Bechtold et al. 2007&lt;sup&gt;21&lt;/sup&gt;</td>
<td>Attendants’ changes in attitudes about conference design in relation to blame/shame, systems thinking, patient safety culture, error reporting and disclosure. Conference attendance. Number of identified contributing factors and system improvement recommendations and actions.</td>
<td>A: 4 of 20 items improved in desired direction (p&lt;.05). S: conference attendance increased (p&lt;.03). 150 contributing factors and 121 system improvements identified, 59% of improvements implemented over next year, 28% partially implemented/in progress, 13% abandoned. Following the identification of system issues requiring creation of performance improvement teams, 7 residents volunteered.</td>
<td>2A, 3, 4A</td>
<td>II</td>
</tr>
<tr>
<td>Berenholz et al. 2009&lt;sup&gt;33&lt;/sup&gt;</td>
<td>Attendants’ attitudes about education.</td>
<td>A: education considered valuable: improved understanding of safe systems and better prepared to address patient safety defects.</td>
<td>1</td>
<td>I</td>
</tr>
<tr>
<td>Brannick et al. 2009&lt;sup&gt;34&lt;/sup&gt;</td>
<td>Attendants’ complication and error registrations, attitudes about education, training behavior and predicted behavior (situational judgment).</td>
<td>C: complications and errors decreased. No significant improvements in training behavior. A: favorable overall. S: 1/3 of situational judgment items improved significantly.</td>
<td>1, 2A, 3,</td>
<td>III</td>
</tr>
<tr>
<td>Coyle et al. 2005&lt;sup&gt;26&lt;/sup&gt;</td>
<td>Attendants’ changes in attitudes and behavior concerning incident reporting.</td>
<td>S/A: median change not significant, positive correlation with program attendance (p&lt;.05).</td>
<td>2A, 3</td>
<td>II</td>
</tr>
<tr>
<td>Holland et al. 2009&lt;sup&gt;24&lt;/sup&gt;</td>
<td>Attendants’ knowledge, perceived learning and attitudes about education. Number of QI proposals and extent of carrying out.</td>
<td>K/A: improved knowledge and attitudes about patient safety and QI (p&lt;.05), positive faculty and rotation evaluations. S: 20 QI project proposals, 50% implemented hospital-wide.</td>
<td>1, 2B, 3,</td>
<td>III</td>
</tr>
<tr>
<td>Janus et al. 2006&lt;sup&gt;30&lt;/sup&gt;</td>
<td>Attendants’ reported changes in skills.</td>
<td>S: 74% stated they had learned new clinical skills.</td>
<td>2B</td>
<td>I</td>
</tr>
<tr>
<td>Pian-Smith et al. 2009&lt;sup&gt;35&lt;/sup&gt;</td>
<td>Attendants’ change in language when challenging attending faculty and nurses.</td>
<td>S: increased use of advocacy and inquiry toward attending faculty (p&lt;.002), not toward nurses.</td>
<td>3</td>
<td>III</td>
</tr>
<tr>
<td>Reznik et al. 2003&lt;sup&gt;36&lt;/sup&gt;</td>
<td>Attendants’ perceived change in knowledge and understanding, and attitudes about education.</td>
<td>K: mainly positive. A: mainly positive, EMCRM-training was considered realistic and enjoyable.</td>
<td>1, 2B</td>
<td>I</td>
</tr>
<tr>
<td>Singh et al. 2005&lt;sup&gt;27&lt;/sup&gt;</td>
<td>Medication related error rate found by attendants at poly-pharmacy chart reviews. Number and quality of safety journal entries and safety improvement actions by attendants.</td>
<td>C: trend downwards of inappropriate use of benzodiazepine (4.0% vs 6.4%), NSAID remained the same (23% vs 24%). S: 42 journal entries (half as many as requested), 55% included system-based solutions. Several residents volunteered to solve safety problems.</td>
<td>2B, 3, 4B</td>
<td>II</td>
</tr>
</tbody>
</table>
Singh et al. 2007²⁸
Number and quality of safety journal entries of attendants.
S: 1st year 42 entries, 2nd year (with revised format) 27 entries submitted (=less than requested). Revised format more effective in improving ability to develop system-based solutions. Attendants successful in identifying situational factors and active failures, poorer in latent failures. 2B, 3 III

Singh et al. 2009³⁹
Skills for: error detection and disclosure, identifying deficiencies in charts and suggest solutions, and system analyses.
S: Trainees performed better at error detection and disclosure, and identifying deficiencies in care (p<.001) and described more appropriate means of addressing them, than controls. Trainees performed better at system analysis and identifying system-based solutions after the course than before. 2B III

Tess et al. 2009³²
Attendants’ attitudes about patient safety culture and education (including perceived acquisition of knowledge and skills. Attendants’ participation in QI projects and department-wide presentations.
K/A/S: 6 of 12 items showed improved safety culture after education (p<.05). 7 of 17 items showed improved satisfaction with education (p<.05). Acquisition of knowledge and skills positively valued before and after education (NS). S: more residents reported being involved in QI. Various QI projects initiated (outcomes ND) and presentations given. 1, 2A, 2B, 3, 4A II

Tomolo et al. 2005²²
Attendants’ changes in knowledge about patient safety concepts and case analysis. Attitudes related to education. OC return rate. System changes at institution.
K: mean scores 48.4±4.0 (potential range 12-60). A: mean scores 15.9±1.6 (potential range 4-20) for personal comfort with use of OC, 12.3±1.7 (potential range 3-15) for importance of curriculum. S: 98 (82%) OCs returned. Several system changes initiated. 1, 2B, 3, 4A I

Voss et al. 2008²³
Attendants’ changes in content knowledge, attitudes about educational processes and skills for patient safety and QI. Rate of investigations and improvement interventions.
K: improved (statistics ND). A: education met learning objectives, was interactive, enjoyable and worthwhile to most residents. S: important skills gained in all proposed topics. 27 investigations completed, 25 interventions devised by residents of which 15 implemented, 6 in progress, 4 not yet attempted. 1, 2B, 3 II

Wagner et al. 2009³¹
Attendants’ and hospital administrators attitudes about education.
A: trainees most satisfied with stations providing immediate feedback. Administrators were impressed with scope and success of OSCE. 1 I

Weingart et al. 2004³³
Attendants’ reported changes in understanding and behavior, and attitudes about education.
K: 63% had improved understanding of quality of care, 88% better understood QI in own institution. A: in general positive. S: 56% changed behavior. 67% taught others about quality of care. 1, 2B, 3 II

¹=Participation. 2A=Modification of attitudes/perceptions. 2B=Modification of knowledge/skills. 3=Behavioral change. 4A=Change in organizational practice. 4B=Benefits to patients.
¹=No clear conclusions can be drawn/Not significant. II=Results ambiguous, but there appears to be a trend. III=Conclusions can probably be based on the results. IV=Results are clear and very likely to be true. V=Results are unequivocal.

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Discussion

The need for integrating patient safety into medical education has been expressed worldwide. This article presented a systematic review of studies that evaluated patient safety education for residents. A variety of educational methods was found in seventeen identified articles, i.e. discussions, feedback, role-play, simulations and web-based. Almost all curricula used educational strategies to engage residents in active learning, i.e. discussions, practice exercises and feedback. This can be considered a positive development, as Davis’ review about effects of continuing medical education (CME) showed that interactive education leads to better learning outcomes.

Curricula mostly focused on “systems thinking and cultural change” and “learning from mistakes: error reporting and analysis (at the system level)”. These topics primarily aim at creating a sense of urgency for patient safety improvement at the system level and offer strategies to stimulate learning from errors. Most interventions described the selection of educational content in relation to the ACGME competencies, which aim at acquiring the specific knowledge, skills, behaviors and attitudes and the appropriate educational experiences required for residents to complete GME programs in the US.

The implementation of the ACGME competencies in 1999 stimulated the development of patient safety curricula for American residents, because two of the six competencies, “systems-based practice” and “practice-based learning and improvement”, are closely related to patient safety. This might explain why the US are at the front line in this field and why the studies included in this review were all conducted in the US. Six (35%) of the included studies were published last year (2009), which suggests an increase in attention to patient safety educational research.

Studies mainly described positive effects in the short term, but all study designs were strongly limited because none of the studies used validated assessment tools. Only 2 (12%) of the studies used randomization and most used uncontrolled designs, which are vulnerable to secular trends and other biases. Furthermore, the studies that reported changes in knowledge, attitudes or behavior often relied on learners’ self-assessments, and the validity of this assessment method has been questioned. The current review focused on formal educational programs addressing patient safety. However, research by Pingleton et al. (2009) revealed that residents often gain knowledge about patient safety informally through hospital initiatives and resources. They did not find a relationship between the quality performance of the teaching hospital and the residents’ curriculum or their understanding of quality or safety. However, Hoff et al. (2006) suggest that the everyday workload and the social organization associated with residency programs fulfilling their core mission of creating competent clinicians leave little room for new or alternative routines, exchanges and beliefs that would enhance resident learning about safety and error. Specifically, their findings highlight the difficulty of establishing new routines, beliefs and exchanges to improve the organizational learning capacity that are not derived from existing forms of behavior within the work environment. The present review focused on a selection of all patient safety educational initiatives. For instance, patient safety team training in cooperation with other health care workers were excluded from this study. However, these were reviewed by Chakraborti et al. (2008), who concluded that teamwork training and interventions for medical students and residents
employed some sound educational principles and appeared to be modestly effective in the short term.\textsuperscript{42} They suggested that curricula might be more effective if they addressed more teamwork principles.

Safety training programs focusing only on technical skills were also excluded from this review, but they also have been subject of research.\textsuperscript{43-46} The training of technical skills often involves simulators and the results of these simulations are promising. Quality improvement projects that did not focus on patient safety in particular were equally beyond the scope of this review, but they have also proved to be a useful contribution to patient safety improvement.\textsuperscript{47}

**Limitations**

This review has several limitations. Firstly, as in all such reviews, publication bias may generate biased samples of studies and may therefore increase the likelihood of finding a false-positive result.\textsuperscript{48} Secondly, the process of study selection, data extraction and estimation of study quality may be limited, although it was performed by two independent reviewers and carried out according to a standardized coding sheet. Besides, to make an inventory of the contents of the educational programs, we relied on descriptions in the articles and on information that was provided by the authors. As the amount of information provided varied greatly between the studies, it might be possible that descriptions of some of the curricula were not extensive enough to reveal all topics that were discussed within the education. Thirdly, the limited number of studies and the high variability within the studies made it impossible to estimate effect sizes. Finally, the small number of included studies and settings may undermine the ability to generalize the findings. However, the fact that all studies mainly described positive effects suggests that patient safety education for residents can be a useful contribution to patient safety improvement.

**Conclusion & future research**

This review demonstrates that a variety of methods to educate residents on patient safety has been published. These shared experiences might inspire the development of patient safety education elsewhere. Studies mainly described positive effects in the short term, but validity of all evaluations was doubtful. More reliable research is needed to determine the most effective method for influencing patient safety behavior of residents. Research designs should preferably include control groups, randomization to groups, long-term follow-up measurements, objective outcome measures and validated measurement tools. Future evaluations should investigate the effectiveness of specific curricular content and specific educational methods. Moreover, evaluations of patient safety education should adhere to the Standards for QUality Improvement Reporting Excellence guidelines (SQUIRE), which provide a detailed approach to reporting methods and findings.\textsuperscript{49}
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