

# Electronic Continuing Education in the Health Professions: An Update on Evidence from RCTs

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**Introduction:** Demonstrating the effectiveness of the rapidly expanding field of electronic continuing education (e-CE) has important implications for CE in the health professions. This study provides an update on evidence from randomized controlled trials (RCTs) assessing the effectiveness of e-CE in the health professions.

**Methods:** A literature search of RCTs was performed in MEDLINE, EMBASE, and CINAHL from 2004 to 2007. Papers were reviewed separately by 2 of the authors and results were categorized and reviewed according to study comparisons.

**Results:** Fifteen studies met our inclusion criteria. Six compared e-CE to no intervention or placebo. Of these 6 studies, 4 showed a statistically significant advantage of the e-CE intervention and 2 showed no significant effect. Two studies compared e-CE to a lecture. Of these, 1 showed an advantage of e-CE and 1 showed no difference. Two studies compared e-CE to a small-group interactive intervention. In both studies, the e-CE group outperformed the control. Two studies compared a multicomponent e-CE intervention to one based on flat text, and both showed the multicomponent intervention to be more effective. Two of the 15 studies demonstrated a statistically significant effect on practice patterns. Positive effects of e-CE on knowledge were shown to persist for up to 12 months and effects on practice up to 5 months.

**Discussion:** Overall, these studies suggest that multicomponent e-CE interventions can be effective in changing health professionals' practice patterns, and improve their knowledge. E-CE interventions based purely on flat text appear to be of limited effectiveness in changing either knowledge or practice. These results support the use of multicomponent e-CE as a method of CE delivery.

**Key Words:** electronic continuing education, education, medical, continuing, computer-based education, Internet, CD-ROM

## Introduction

The number of continuing education initiatives in the health professions that are offered in electronic form has grown

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exponentially in the past decade. E-CE<sup>a</sup> (electronic continuing education) programs offer many advantages including easy access, flexible timing, the possibility of adaptation to individual learning styles, and low cost. E-CE has the potential to provide many of the elements that have been found to be effective in traditional continuing medical education such as interactivity,<sup>1</sup> multiple sequenced sessions,<sup>1,2</sup> and reinforcing materials.<sup>1</sup> Interactivity can take many forms such as e-mail, asynchronous or synchronous discussion boards, video Web-conferencing, cases with scripted interactivity, and others.

Several literature reviews on electronic learning in the health professions have been published in recent years. Wutoh et al<sup>3</sup> reviewed randomized controlled trials (RCTs) and retrospective studies of e-CE interventions published

<sup>a</sup>E-CE is used here to indicate any form of continuing education that is delivered with the use of either (1) the Internet, ie, Web, or e-mail, or (2) a computer interface, ie, CD-ROM. Studies involving computer-controlled mannequins as virtual patients were not included in this review.

before January 2004, concluding that Internet-based CE programs were equivalent to traditional methods in effecting knowledge change. Little information, however, was available to address whether this extended to effects on practice patterns. Curran et al also conducted a review of evaluation outcomes of Web-based CE programs based on publications between 1966 and 2003.<sup>4</sup> This revealed that the majority of the literature was based on participant satisfaction ratings. There was limited data showing change in clinical practice and no data regarding changes in patient outcomes. Our search dates did not overlap with these two studies. Most recently Cook et al conducted a meta-analysis of studies published between 1990 and 2007 comparing Internet-based CE interventions to either no intervention or a non-Internet intervention.<sup>5</sup> Seven of the 15 studies in our review were included in Cook's meta-analysis. The meta-analysis revealed a large positive effect for Internet interventions compared to no intervention in terms of knowledge and skill acquisition as well as changes in behavior and patient care. The comparison of Internet interventions to non-Internet interventions revealed inconsistencies across studies with small nonsignificant pooled effect sizes suggesting no significant advantage of one over the other.

Within the context of the current literature as outlined above, our study addresses the questions of (1) general e-CE efficacy, (2) the relative efficacy of various e-CE formats, and (3) the duration of e-CE effects, all through the specific lens of the randomized controlled trial. Our study is a review of RCTs published between 2004 and 2007 involving both Internet-based and non-Internet based (CD ROM) e-CE interventions. We chose to limit our review to RCTs with the objective of focusing on the best-quality data available.

## Methods

A literature search was undertaken using the MEDLINE, EMBASE, and CINAHL databases as detailed below. In addition, the reference lists of all selected papers were hand-searched for missed studies.

### MEDLINE

This search was conducted in the OVID version of the MEDLINE database (Ovid MEDLINE® (1950 to November Week 2 2007)). The following search terms and combinations were used: (1) education, distance/ or patient simulation/ or computer-assisted instruction/ or internet/ or exp computers/ AND (2) exp education, continuing/ AND (3) limit to the following publication types: clinical trial, all or controlled clinical trial or evaluation studies or meta-analysis or multicenter study or randomized controlled trial or validation studies, limit to publication year 2004–2007.

### CINAHL

This search was conducted in the OVID version of the CINAHL database (Cumulative Index to Nursing and Allied Health Literature (1982 to December Week 1 2007)). The following search terms and combinations were used: (1) education, nontraditional/ or programmed instruction/ or computer assisted instruction/ or simulations/ or computer simulation/ or patient simulation/ or internet/ or internet connections/ or exp world wide web/ or intranet/ or computer systems/ or computer hardware/ or exp computer types/ or exp user-computer interface/) AND (2) exp education, continuing/ or “education, continuing (credit)”/ AND (3) exp clinical trials/. CINAHL does not have study designs indexed as publication types. Results were limited to publication year 2004–2007.

### EMBASE

This search was conducted in the OVID version of the EMBASE database (EMBASE (1980 to 2007 Week 50)). The following search terms and combinations were used: (1) simulation/ or computer simulation/ or internet/ or intranet/ or exp computer/ AND (2) continuing education/ AND (3) ct.fs. or crossover procedure/ or double-blind procedure/ or single-blind procedure/ or triple-blind procedure/ or exp clinical trial/ or exp controlled clinical trial/ or randomization/ or (clin: adj5 trial:).ti.ab. or (rct or rcts).ti.ab. EMBASE does not have study designs indexed as publication types. The subheading “ct” (clinical trial) is used to index all types of trials from phase 1 to RCTs. The fs (floating subhead) function was used to quickly retrieve all of these references. Results were limited to publication year 2004–2007.

Studies were included in the final analysis if:

1. They evaluated a CE intervention for any group of health professionals, including physicians, nurses, nursing aides, pharmacists, paramedics, and nursing home managers. Studies with subjects restricted to students were not included, since it was felt that this group may differ significantly from the population of practicing health professionals with regards to their use of electronic devices.
2. The intervention involved a computer interface (Internet or CD-ROM).
3. The study was an RCT.
4. The study was published between 2004 and 2007.

The MEDLINE search produced zero meta-analyses and 22 RCTs. Of these, 12 met the inclusion criteria and were included in the final analysis. The EMBASE search produced 18 studies, of which 6 met the inclusion criteria. Four of these were identical to studies found in the MEDLINE search. The CINAHL search produced 31 studies. Of these, only 4 met the inclusion criteria. Three of these were identical to studies found in the MEDLINE search. In total, the 3 searches produced 15 studies.

TABLE 1. Summary of Study Comparisons and Findings

Study	Participants	Subject	Comparison Groups	Outcome Evaluation	Follow-up	Sig. Diff.	Level
e-CE versus no intervention or placebo Harrington and Walker <sup>9</sup>	45 Nursing facility managers	Ergonomics	CD-ROM multicomponent (text, graphics, photographs, animation, sound, interactivity) vs no intervention	Pre/post test	0 mo 2 mo	Yes Yes	1,2
Irvine et al <sup>10</sup>	72 Nurse Aides	Aggressive behavior management	Web-based multicomponent (images, video vignettes, narrator video, interactivity) vs no intervention	Pre/post test	0 mo	Yes	1,2
Short et al <sup>11</sup>	52 MDs (Primary care)	Intimate partner violence	Web-based multicomponent (interactive cases, audio, video, link to practice tools) vs no intervention	Pre/post test	6 mo, 12 mo	Yes Yes	2
Frush et al <sup>12</sup>	89 MDs, RNs, paramedics	Correct use of Broselow tape	Web-based text with still images Noninteractive vs no intervention	Pre/post test	0 mo	Yes	2
Mukohara and Schwartz <sup>13</sup>	107 MDs (internists)	Critical appraisal	E-mail flat text (summaries of critically appraised articles) vs e-mail link to commercial health news Web site	Pre/post test	0 mo	No	1,2
Butzlaff et al <sup>14</sup>	62 MDs (general practitioners)	Clinical guideline implementation	CD-ROM flat text vs no intervention	Pre/post test	0 mo	No	2
e-CE versus lecture Tsai et al <sup>15</sup>	81 Nurses	IV insertion	CD-ROM multicomponent (text, graph, picture, film, sound) vs lecture	Pre/post test	0 mo 2 weeks	Yes Yes	1,2
Chung et al <sup>16</sup>	58 MDs (Pediatric ER), fellows and senior residents	Bi terrorism education	Web access, e-mailed flat-text clinical scenarios and lecture vs lecture alone	Pre/post test	1 mo 6 mo	No No	1,2
e-CE versus small group interactive Fordis et al <sup>17</sup>	93 MDs (Primary care)	Hyperlipidemia	Web-based multicomponent (audio, video, interactive cases, e-mail access to experts, Web-conference) vs single interactive small group	Pre/post knowledge test, chart review	0 mo and 3 mo 5 mo	Knowledge: similar increase from baseline in both groups Screening: no increase from baseline in either group	

Electronic Continuing Education: Recent RCT Evidence

Sanddall et al <sup>18</sup>	77 EMS workers	Pre-hospital pediatric emergency training	“Interactive CD-ROM” (no further details given) vs in-class workshop vs no intervention	Pre/post knowledge test, videotaped standardized patient interaction	12 mo	Knowledge—No Performance in simulated patient interaction—Yes	Appropriate pharmacotherapy in high risk patients: significant increase in e-CME group but not small group	1,3
e-CE multicomponent versus e-CE flat text								
Allison et al <sup>19</sup>	209 MDs (Primary care)	Chlamydia screening	Web-based multicomponent modules (not described) vs Web-based flat-text modules	Screening rates	0 mo	Yes		3
MacRae et al <sup>7</sup>	55 MDs (General surgeons)	Critical appraisal	Flat text + e-mail reminders + list-serve discussion vs Flat-text + Internet access to major journals	Pre/post test	0 mo	Yes		1,2
Timing of e-CE delivery								
Kemper et al <sup>20</sup>	780 MDs, RNs, RDs, Pharm.	Dietary supplements	Multicomponent (moderated list-serve, case-based self-instructional modules with links to online resources) delivered by: e-mail over 1 week vs e-mail over 10 weeks vs Web access over 1 week vs Web access over 10 weeks	Pre/post test	0 mo after intervention	Yes—for all groups compared to baseline No differences between groups		1,2
Beal et al <sup>21</sup> (follow-up of Kemper et al study)	385 MDs, RNs, RDs, Pharm.	Dietary supplements	Same as Kemper et al above Web, e-mail, multicomponent	Pre/post test	6–10 mo	Yes—for all groups compared to baseline No differences between groups		2
Virtual patient vs real standardized patient								
Triola et al <sup>8</sup>	52 RNs MDs, psychologists	Psychological aspects of bioterrorism and disasters	Live workshop + 2 live standardized patients + computer-based virtual patient (video responses to a selection of questions) vs workshop + 4 live standardized patients	Pre/post test	0 mo 2 weeks	No difference between 2 groups No significant increase in knowledge or diagnostic ability in either group		1,2

Note: Studies grouped by comparison question.

MD = physicians, RN = nurses, PM = paramedics, EMS = emergency medical services workers, Pharm = pharmacists

Sig. Diff: = Significant difference between groups favoring e-CE or e-CE multicomponent

Level indicates the Kirkpatrick<sup>22</sup> level of evaluation: 1 = Reactions; How participants liked the program, 2 = Learning: Advancement in knowledge, 3 = Transfer: Change in participants' behavior, 4 = Results: Improvement in patient outcomes

## Results

Of the 15 studies reviewed, 12 had statistically significant results supporting the effectiveness of an e-CE intervention and 3 failed to demonstrate an effect. The studies have been summarized in TABLE 1.

### Study Quality

Methodologic quality was assessed for each study. The Cochrane Collaboration's tool for assessing risk of bias<sup>6</sup> was used to identify potential sources of bias. The results have been summarized in TABLE 2. Overall the methodological quality of the studies was fair, with considerable uncertainty regarding sources of bias due to incomplete descriptions. Several studies had large attrition rates. Nine studies used nonvalidated tools to assess knowledge gains.

In 2 studies it was impossible to separate the effect of the electronic intervention. In the MacRae study<sup>7</sup> the intervention group received other materials (in addition to the electronic component) that were not received by the control group. In the Triola study<sup>8</sup> the results are difficult to interpret, as the minimum amount of exposure to a live standardized patient needed to produce an adequate performance is not known.

### E-CE Versus No Intervention or Placebo

Six studies compared some form of e-CE to no intervention or a form of placebo.<sup>9–14</sup> Of these, four<sup>9–12</sup> showed a statistically significant advantage of the e-CE intervention and two<sup>13,14</sup> showed no significant effect. In both negative studies the medium used to deliver the information was flat text.

### E-CE Versus Lecture

Two studies looked at an e-CE intervention versus a lecture.<sup>15,16</sup> One showed an advantage of e-CE over lecture<sup>15</sup> and the other<sup>16</sup> showed no difference and no improvement over baseline.

### E-CE Versus Small-Group Interactive

Two studies compared e-CE to small-group, interactive learning.<sup>17,18</sup> In both studies the e-CE group slightly outperformed the control.

### Virtual Patient Versus Real Standardized Patient

Triola et al<sup>8</sup> compared a workshop with 4 live standardized patients to a workshop with 2 standardized patients and 2 virtual patients. No difference in performance was found between the two groups.

### E-CE Flat Text Versus e-CE Multicomponent

Two studies<sup>7,19</sup> compared a purely flat-text-based intervention to an e-CE multicomponent intervention. Both showed a significant advantage of the multicomponent intervention over flat text.

### Timing of e-CE Delivery

Kemper et al<sup>20</sup> and Beal et al<sup>21</sup> (the 6–10 month follow up) compared knowledge, confidence, and communication gains in 4 groups receiving a series of case-based modules by e-mail or Web access over 1 or 10 weeks. Sustained improvements were shown in all 3 areas regardless of method of delivery. This was true both immediately postintervention and at 6–10 months postintervention.

### Outcome Evaluation

None of the 15 trials in this study assessed outcomes at Kirkpatrick's<sup>22</sup> level 4, ie, none looked at effects on patient outcomes.

Two studies assessing level 3 outcomes<sup>17,19</sup> showed objective effects of e-CE on practice patterns. Allison et al<sup>19</sup> showed a significant difference in screening rates between groups receiving a multicomponent e-CE module and a module based on flat text, favoring the multicomponent module. Fordis et al<sup>17</sup> used a chart review up to 5 months postintervention, and showed a significant increase in prescriptions for high-risk patients but no change in screening rates following an interactive e-CE program.

The majority of studies used pre- and post-knowledge scales to test for a change in knowledge (level 2). Of 11 studies, 9 demonstrated an effect on knowledge and 2 failed to do so. Two studies used an acted-out clinical scenario to assess participants' assimilation of material taught.<sup>12,18</sup> Both were positive. One study used reported practice change and assessed attitude and confidence via questionnaire<sup>13</sup> and did not show a significant effect.

Nine studies assessed satisfaction at level 1 via open-ended questions or Likert scale. For the studies with positive results, satisfaction ratings were generally very high with the majority of participants being interested in participating in similar programs in the future. Only 1 of the positive studies<sup>7</sup> had a low rating of the listserv discussion of 3.4 on a 5-point scale (1 = strongly disagree to 5 = strongly agree). Two of the negative studies had less favorable ratings, possibly providing part of the etiology for a lack of effect. In the study by Chung et al<sup>16</sup> only 50% rated the Web site as helpful, and in Mukohara and Schwartz's study<sup>13</sup> only 69% felt the intervention was useful.

### Duration of Effects

Effects on knowledge were demonstrated at 2 months,<sup>9</sup> 3 months,<sup>17</sup> 6–12 months,<sup>21</sup> and 12 months.<sup>11</sup> Effects on

TABLE 2. An Application of the Cochrane Collaboration's Tool<sup>a</sup> for Assessing Risk of Bias to the Studies in This Review

Study	Adequate Sequence Generation?	Allocation Concealment? <sup>d</sup>	Blinding? <sup>e</sup>	Incomplete Outcome Data Addressed? <sup>f</sup>	Free of Selective Reporting?	Free of Other Obvious Source of Bias?
e-CE versus no intervention						
Harrington and Walker <sup>9</sup>	U <sup>b</sup>	U	No: Participants U: evaluators	U 21/17 <sup>g</sup>	Yes	Yes
Irvine et al <sup>10</sup>	U <sup>b</sup>	U	No: participants U: evaluators	U 8/22 <sup>h</sup>	Yes	Yes
Short et al <sup>11</sup>	U <sup>b</sup>	U	No: participants U: evaluators	U: 11/30 <sup>h</sup>	Yes	Yes
Frush et al <sup>12</sup>	U <sup>b</sup>	U	No: participants No: evaluators	Yes 2/2 <sup>g</sup>	Yes	Yes
Mukohara and Schwartz <sup>13</sup>	Yes	No	Yes: evaluator No: participants	U: 5/15 <sup>g</sup>	Yes	Yes
Butzlaff et al <sup>14</sup>	Yes <sup>c</sup>	U	No: participants U: evaluators	U: 8/0 <sup>g</sup>	Yes	Yes
Tsai et al <sup>15</sup>	U <sup>b</sup>	U	No: participant U: evaluators	Yes 0/0	Yes	Yes
Chung et al <sup>16</sup>	U <sup>b</sup>	Yes	U	U: 29/28 <sup>g</sup>	Yes	Yes
Fordis et al <sup>17</sup>	U <sup>b</sup>	U	No	Yes 15/4 <sup>h</sup>	Yes	Yes
Sandaal et al <sup>18</sup>	U <sup>b</sup>	U	No: participants Yes: evaluators	U 38/51/38	Yes	? tool not validated
Allison et al <sup>19</sup>	Yes <sup>c</sup>	U	No : participants U: evaluators	Yes 0/0	Yes	Yes
MacRae et al <sup>7</sup>	U <sup>b</sup>	U	No: participants Yes: evaluators	U 41/21	Yes	Yes
Kemper et al <sup>20</sup>	Yes	U	No: Participants U: evaluators	No 35/38/36/43 <sup>i</sup>	Yes	Yes
Beal et al <sup>21</sup>	Yes	U	No: participants U: evaluators	U 45/52/46/60 <sup>h</sup>	Yes	Yes
Triola et al <sup>8</sup>	Yes	U	No: participants U: evaluators	U 8/2 <sup>g</sup>	Yes	Yes

Note: U = Unclear.

<sup>a</sup>A full description of the tool can be found at [http://www.ohg.cochrane.org/forms/RoB\\_form.pdf](http://www.ohg.cochrane.org/forms/RoB_form.pdf)

<sup>b</sup>Sequence generation described as “randomized” but no specific method given.

<sup>c</sup>Block randomization by office.

<sup>d</sup>Although allocation concealment was not described in most studies, 13 of the 15 studies compared intervention and control groups with respect to their baseline characteristics and found them to be similar.

<sup>e</sup>Blinding of participants in the majority of these studies was challenging due to the nature of the intervention. Participants not being blinded is not likely to have a significant effect on outcome in this type of study. Since assessment in most cases was by knowledge questionnaire, it is also unlikely that evaluators not being blinded would have a great impact on final outcome.

<sup>f</sup>X/Y refers to attrition rate (%) in intervention group(s)/attrition rate (%) in control group

<sup>g</sup>Information for participants who did not complete the study was not available.

<sup>h</sup>Baseline characteristics of dropouts were similar to those who completed the study.

<sup>i</sup>Statistically significant differences between dropouts and those who completed the study.

performance in a simulated patient encounter were demonstrated at 12 months.<sup>18</sup> A change in practice based on chart audit was demonstrated at 5 months.<sup>17</sup>

## Discussion

Overall these results suggest a positive effect of multi-component e-CE interventions on health care provider

knowledge and health care provider behavior, which is consistent with the findings of other reviews.<sup>3,5</sup> E-CE interventions based on flat text appear to be of limited effectiveness in improving knowledge. Two of the 3 studies in which flat text was the only mechanism of information delivery showed no significant benefit compared to no intervention or placebo. In addition, 2 studies comparing flat text vs multicomponent e-CE interventions showed the latter to be significantly more effective.

Interactive, multicomponent e-CE interventions appear to be at least as effective as and possibly more effective than small-group interactive sessions. In the 1 negative study involving such an intervention the lack of effect may be partly accounted for by a poor quality of materials, as suggested by poor ratings by participants.<sup>16</sup>

These findings are consistent with research on traditional CE methods indicating that passive CE methods are relatively ineffective and that interactivity is a significant contributor to change in professional practice.<sup>1,23,24</sup> They are also consistent with the finding that multifaceted activities are more effective than simple ones.<sup>25</sup>

The positive effects on knowledge persisted for up to 12 months and in the 1 study of physician practice, up to 5 months. All of the studies with long-term follow-up used multicomponent interventions. This suggests that the effects of multicomponent e-CE can be long-lasting.

None of the studies attempt to identify which components of the multifaceted interventions are responsible for the effects. Several authors have commented that media-comparative research (which juxtaposes a computer-based program with a non-computer-based program) is problematic since multicomponent interventions make it impossible to know which component is producing the effect.<sup>26,27</sup> Only 2 of the 15 studies had a simple intervention.<sup>13,14</sup> Both were text based and both had negative results. Only 1 study by Kemper et al<sup>20</sup> and its 6-month follow-up by Beal et al<sup>21</sup> studied the effect of simple variables (timeline and method of information delivery: Web vs e-mail) within a computer-based intervention. Their finding of lack of effect of timing is in contrast with Davis's review of traditional CE activities, which concluded that multiple sequenced or longitudinal interventions were more effective than single ones.<sup>1</sup> In their meta-analysis Cook et al also found inconsistent results with regard to the effects of instructional design on learning and behavior outcomes.<sup>5</sup> These findings highlight the need to focus future research on identifying the relative efficacy of various instructional methods within e-CE. There is also a need to clarify whether there are significant differences in e-CE efficacy depending on individual learning styles.

## Limitations

This is a review of recent RCTs published between 2004 and 2007 and does not constitute a review of all existing literature on this topic. There could be an element of publication bias in the studies found, resulting in an overrepresentation of positive studies. The risk of publication bias in education literature is not as critical as in the pharmaceutical literature as the effect of this bias would simply be overestimation of effectiveness, with limited risk to recipients.

## Conclusion

This review of randomized controlled trials published between 2004 and 2007 on the effectiveness of e-CE confirms

## Lessons for Practice

- Electronic continuing education can be an effective tool for advancing knowledge and changing practice patterns among health practitioners.
- E-CE interventions consisting of purely flat-text information are of limited value and should be avoided if possible.
- Multicomponent e-CE interventions including interactivity have the strongest evidence to support them and therefore should be the preferred option for e-CE delivery.

the conclusion of previous reviews, that multicomponent e-CE interventions can contribute to health care provider knowledge acquisition and can also effect change in health care provider practice patterns. Flat-text interventions are found to be of limited effectiveness. The impact of e-CE is shown to persist for up to 12 months. Further research is needed to clarify which components of these complex interventions are creating the positive effects, so as to maximize their usage. With its diverse capabilities and a growing body of evidence to support its effectiveness, e-CE has the potential to become a leading method of CE delivery in the future.

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