

Comparison of the Instructional Efficacy of Internet-Based CME With Live Interactive CME Workshops

A Randomized Controlled Trial

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THE QUALITY OF US HEALTH CARE has come under scrutiny following a series of Institute of Medicine reports that addressed the linkage between quality and professional education.¹⁻⁴ They included recommendations for improvements spanning the health professional education continuum. The continuing challenges for physicians to maintain care quality was further emphasized in a recent report positing an inverse relationship between physicians' years in practice and the quality of care provided.⁵ While educational intervention is not a panacea for all problems with health care quality,⁶ there is a need to improve the effectiveness of continuing medical education (CME),^{7,8} the longest and arguably the most important component of the medical education continuum.⁷

Continuing medical education has been criticized for being episodic, delivered in isolation from patient care and the health care team, and produced in "one-size-fits-all" formats relying heavily on didactic presenta-

Context Despite evidence that a variety of continuing medical education (CME) techniques can foster physician behavioral change, there have been no randomized trials comparing performance outcomes for physicians participating in Internet-based CME with physicians participating in a live CME intervention using approaches documented to be effective.

Objective To determine if Internet-based CME can produce changes comparable to those produced via live, small-group, interactive CME with respect to physician knowledge and behaviors that have an impact on patient care.

Design, Setting, and Participants Randomized controlled trial conducted from August 2001 to July 2002. Participants were 97 primary care physicians drawn from 21 practice sites in Houston, Tex, including 7 community health centers and 14 private group practices. A control group of 18 physicians from these same sites received no intervention.

Interventions Physicians were randomly assigned to an Internet-based CME intervention that could be completed in multiple sessions over 2 weeks, or to a single live, small-group, interactive CME workshop. Both incorporated similar multifaceted instructional approaches demonstrated to be effective in live settings. Content was based on the National Institutes of Health National Cholesterol Education Program—Adult Treatment Panel III guidelines.

Main Outcome Measures Knowledge was assessed immediately before the intervention, immediately after the intervention, and 12 weeks later. The percentage of high-risk patients who had appropriate lipid panel screening and pharmacotherapeutic treatment according to guidelines was documented with chart audits conducted over a 5-month period before intervention and a 5-month period after intervention.

Results Both interventions produced similar and significant immediate and 12-week knowledge gains, representing large increases in percentage of items correct (pretest to posttest: 31.0% [95% confidence interval {CI}, 27.0%-35.0%]; pretest to 12 weeks: 36.4% [95% CI, 32.2%-40.6%]; $P < .001$ for all comparisons). Chart audits revealed high baseline screening rates in all study groups ($\geq 93\%$) with no significant postintervention change. However, the Internet-based intervention was associated with a significant increase in the percentage of high-risk patients treated with pharmacotherapeutics according to guidelines (preintervention, 85.3%; postintervention, 90.3%; $P = .04$).

Conclusions Appropriately designed, evidence-based online CME can produce objectively measured changes in behavior as well as sustained gains in knowledge that are comparable or superior to those realized from effective live activities.

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tions.⁷ However, meta-analyses indicate that CME can influence physician behavior and health care quality when appropriate methods are used.⁹⁻¹²

As an educational trend, use of the Web by physicians is growing rapidly. Between 78% and 85% of physicians use the Web,^{13,14} with the fastest growth among those aged 60 years and older.¹³ In 2003, Internet-based formats accounted for 12.5% of all CME,¹⁵ with an estimated 45% to 64% of physicians participating in such offerings.^{13,14} Between 1998 and 2003, the number of Internet-based CME activities increased over 700%, compared with a 38% growth in total CME activities.^{15,16} The number of physicians receiving credit for Internet-based CME increased 1400%, compared with a 64% increase for all CME programs.^{15,16}

Internet-based CME is attractive for both practical and theoretical reasons. Compared with traditional live programs, online CME may offer greater flexibility in training times and sequencing, improved access by geographically dispersed learners, reduced travel expenses and time, and greater adaptability to individual learner styles.¹⁷ Educational resources can be delivered at or near the point of care or “just-in-time.”¹⁸ The Web’s interactive and multimedia capabilities provide opportunities for realistic problem solving, performing tasks in the context of clinical problems, engaging in case studies with exposure to authentic clinical learning settings, linking to other resources, and participating in social dialogue. These approaches are emphasized in adult learning theories such as constructivism,¹⁹ derived cognitive flexibility theory,²⁰ andragogy,²¹ and situated learning,²² which are relevant to online CME design.^{23,24}

Despite a growing body of literature on Web-based health professional education,²⁵⁻²⁷ few rigorous studies of Web-based CME have been reported. These have included self-controlled trials,²⁸⁻³⁰ controlled trials,³¹⁻³³ and randomized controlled trials (RCTs).^{23,34-39} Eighty percent of controlled studies reported positive

change in 1 or more of the nonbehavioral measures—knowledge, attitudes, confidence, and satisfaction.^{23,28-32,35-39} With the exception of 2 RCTs, these studies compared online CME with no intervention,^{28-33,35-37,39} potentially confounding learning gains due to educational method with those due solely to content exposure. The other 2 RCTs (with mixed results³⁸ and negative results³⁴) compared an Internet-based intervention with a control group receiving Web-based content as text, an educational approach that has not been shown to change physician behavior.

Two RCTs have examined objective measures of physician behavior.^{38,39} However, both trials involved randomization of physician offices rather than individual physicians, which may dilute observable behaviors by mixing results for participating and nonparticipating physicians. Only one of these studies³⁸ compared Internet-based education with a control intervention, which was Web-based content as text.

No investigations have simultaneously randomized the participants and compared performance outcomes for physicians participating in Internet-based CME with physicians participating in a live CME intervention using approaches documented to be effective. Thus, the purposes of this study were to determine if online CME can produce (1) changes in physician knowledge comparable to those achievable with appropriately designed live interventions, and (2) changes in behavior that have an impact on patient care. The multifaceted CME approaches we used have been shown to enhance knowledge, attitudes, and other nonbehavioral measures, and, in some cases, to contribute to physician behavioral change.^{9,11,25,40}

METHODS

Experimental Design

An RCT was designed to compare live, small-group, interactive CME workshops with online CME related to cholesterol management. To control for

external effects (such as the impact of site activities apart from the educational study), a control group with no educational intervention was included in assessing behaviors. The hypotheses tested were (1) phase 1: whether there is a difference between the online CME group and the live CME group in knowledge gains related to National Institutes of Health (NIH) cholesterol management guidelines; and (2) phase 2: whether there is a difference between the online CME group and the live CME and control groups in gains in objectively measured practice behaviors associated with implementing the NIH cholesterol management guidelines.

In phase 1, lipid management-related knowledge was measured over time to detect any changes between physicians randomly assigned to the live CME and online CME groups. In phase 2, behavioral impact related to lipid management was assessed via 5-month preintervention and postintervention patient chart reviews, including a control group of physicians who did not participate in either educational program. The study protocol was approved by the Baylor College of Medicine institutional review board. Physicians in the intervention groups provided written consent.

Study Participants

To be eligible for the study, physicians were required to work full-time or part-time in a primary care setting and have privileges at a community health center or private practice primary care clinic. Physicians were excluded if they were unwilling or unable to participate in either randomly assigned educational program. Comfort in using the Internet was not required for participation, and each physician in the online CME group was offered a computer with Internet access if needed.

To assess knowledge change, a recruitment goal of 42 physicians in each of the 2 intervention arms was determined based on power analyses assuming an effect size of $\delta=0.75$, typical of moderate to large effect sizes observed

in educational studies,⁴¹ and a correlation between measures of $r=0.3$. For purposes of oversampling, 103 physicians were assigned to an intervention (51 live CME and 52 online CME) (FIGURE 1). Recruitment took place between November 2001 and January 2002 using letters, presentations, and conferences at the practice sites. The educational interventions were conducted in January and February 2002. Continuing medical education credit was offered to those who completed either educational program, with a \$750 honorarium for those who completed all data collection instruments. Randomization of participants to the live CME or online CME group, stratified by clinic type (public or private), was done using a pseudo random number generator. The data analyst was blinded to the identification of participants.

Physicians represented 21 practice sites broadly distributed around the Houston area. Participating practices included 7 community health centers affiliated with Baylor College of Medicine (47 study physicians) and 14 clinics in a private multispecialty group practice not affiliated with Baylor College of Medicine (50 study physicians). Physician specialties included internal medicine (47), family practice (47), family practice and internal medicine (1), family practice and obstetrics and gynecology (1), and obstetrics and gynecology (1).

Forty physicians (20 from each intervention arm) were randomly selected for chart reviews from among the 49 live CME and 44 online CME participants who completed all coursework and follow-up activities. A non-intervention control group included 20 physicians randomly selected from the pool of primary care physicians who elected not to participate in the study. This sample size provided sufficient power to detect medium to large effect sizes ($\delta=0.75$) under the assumption of a high correlation between preintervention and postintervention measures ($r=0.75$).⁴² A higher correlation was expected of the chart data because, being tied directly to behaviors,

these assessments are less likely than knowledge tests to be influenced by measurement error. At least 25 patient charts per physician for the preintervention period and 25 per physician for the postintervention period had to meet inclusion criteria described below. Of 60 physicians selected, 54 (19 live CME, 17 online CME, 18 control) provided a sufficient number of patient charts.

Educational Design and Content

Physicians in both the live CME and the online CME groups received identical evidence-based content and participated in similar but not identical instructional activities (TABLE 1). All were exposed to a didactic component (a live lecture for the live CME group and a choice of multimedia presentations for the online CME group), interactive cases with feedback, enabling tools and

supporting resources (a risk assessment calculator, step-by-step clinical practice guides, a guidelines summary), and access to expert advice throughout the postintervention period (via telephone or e-mail for live CME participants and via e-mail and live Web conferencing for online CME participants). The live CME sessions were completed as the online CME intervention began, with 1-day overlap. Program content was drawn from the NIH National Cholesterol Education Program (NCEP) Guidelines—Third Report of the Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults (Adult Treatment Panel III—ATP III).⁴³ In addition to focusing on primary prevention as in the original ATP guidelines⁴⁴ and intensive treatment of patients with coronary heart disease (CHD) as in the ATP II guidelines,⁴⁵ the

Figure 1. Randomization Scheme and Participation Flow of the Continuing Medical Education (CME) Study Groups

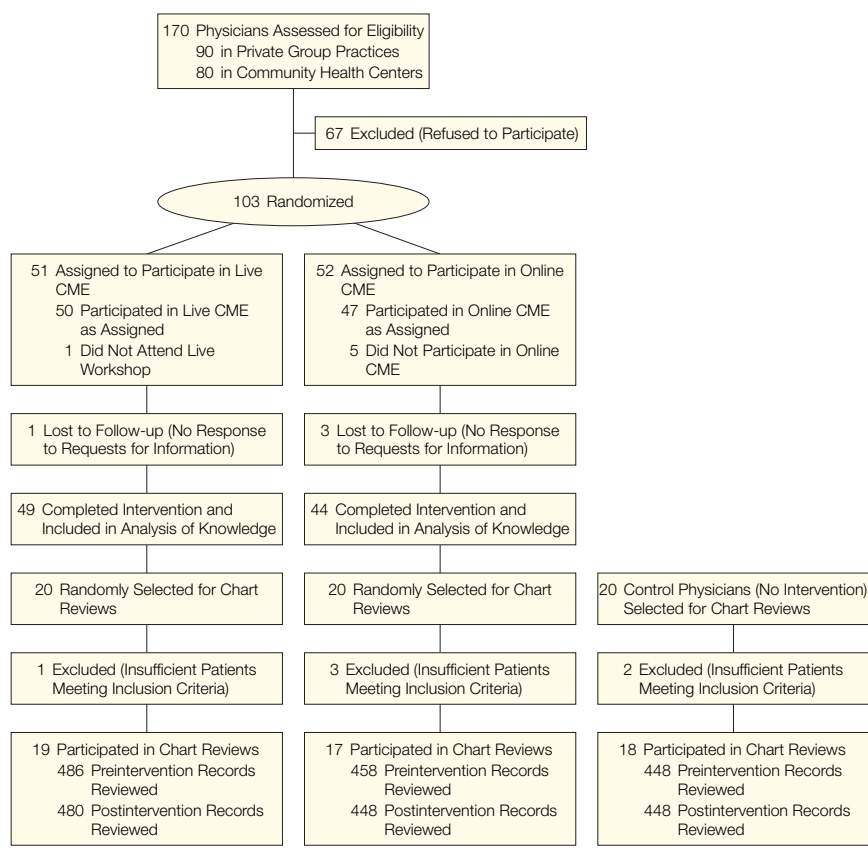


Table 1. Instructional Elements of Live CME and Online CME Interventions

Instructional Elements	Live CME Group	Online CME Group
Predisposing approaches	Live didactic presentations with question and answer session and discussion	Online multiformat didactic presentations
Application exercises	Interactive case discussions with faculty	Cases with scripted interactivity
Enabling tools	Guideline summary, quick desk reference, risk calculator	Guideline summary, quick desk reference, risk calculator
Reinforcement	Access to experts by phone and e-mail	Access to experts by e-mail; interactive case discussions with faculty via live Web conferencing

Abbreviation: CME, continuing medical education.

ATP III guidelines emphasize intensive lipid-modifying pharmacotherapy in conjunction with lifestyle modification for persons having multiple risk factors, including diabetes.⁴³

Interventions

Physicians in the live CME group attended 1 of 5 identical 1½- to 2-hour small-group, interactive workshops with a mean attendance of 10 participants over a 10-day period. On arrival at the workshop, participants completed survey forms and preintervention assessments. A faculty member, a cardiologist with expertise in lipid management, gave a lecture that included opportunities for questions and answers. Following this presentation, the participants used enabling tools to work through cases with the faculty member as facilitator. At the end of the workshop, participants completed postintervention survey forms and knowledge assessments.

During a 2-week period, online CME participants completed, at their convenience, an online program that incorporated educational elements similar to those provided in the live CME workshops. Before beginning any educational activity, participants completed an online survey and preintervention assessment form that included the same items as the paper form completed by live CME participants. The online offering provided access to didactic presentations, interactive cases, and enabling tools. Participants could also send questions to faculty members via e-mail. The educational sections were presented in a fixed sequence analogous to

that used in the live CME workshops. However, online CME users were free to revisit program sections as desired.

Multiple viewing options for the content accommodated different connectivity speeds and learning styles. Didactic presentations could be viewed with streaming media using video, audio, scrolling text, and synchronized slides; with audio and synchronized slides; or with text and slides alone. The online cases featured clinical data summaries sequentially updated as cases progressed, interactive clinical problem-solving tools (eg, an online risk-assessment calculator that mirrored the paper-based version), a step-by-step management reference guide, feedback on case management, and opportunities to forward questions to faculty at any time. Following completion of the learning activity, users completed the postintervention survey and knowledge assessment. Administration tools allowed monitoring of participant progress, including survey and test completion.

Access to faculty was provided to both groups throughout the postintervention study period. The live CME group could use e-mail (asynchronous interactivity) and telephone contacts (real-time interactivity) to reach faculty. The online CME group was also provided access through e-mail (asynchronous interactivity) and optional participation in a single 45-minute, live Web conference (real-time interactivity) that was offered several times approximately 1 month after the program. In addition to having 2-way communication with the online audience and being able to

show slides, the Web instructor could pose a multiple-choice question, poll the audience, and share the distribution of responses with the learners.

Technical assistance was provided to online CME participants by e-mail, telephone, or in person if required. Twenty-nine requests involving software, audio difficulties, firewall problems, and forgotten passwords were received from 19 online CME participants. All were satisfactorily resolved through online or telephone support.

Data Collection

Data were collected from the live CME participants using paper instruments, while the online CME participants completed most instruments online. Both groups completed a preactivity demographic survey, knowledge tests, activity evaluation, and outcomes survey. The demographic survey assessed sex, age, and years of practice; practice characteristics; preferred CME format; computer capabilities; comfort in using the Internet; familiarity with and readiness to use the NCEP guidelines; and preferred intervention group assignment. Both groups completed and returned by mail a paper-based final survey and test 12 weeks after the intervention.

The knowledge test was developed and validated by content experts and pilot tested. The test, reduced through item analysis to 39 items, assessed guideline knowledge and use in areas including risk factors, risk category assessment, screening tests, CHD risk equivalents, therapeutic goals, therapeutic agents, and the metabolic syndrome. The test consisted of multiple-choice questions and case vignettes with fixed-choice responses and produced a Cronbach α measure of internal reliability of 0.79 when averaged across testing occasions. The instrument was administered before (pretest), immediately after (posttest 1), and 12 weeks after the intervention (posttest 2); while the content was the same each time, the item order varied. Both groups also rated their satisfaction with the course and its perceived value for their clinical practice.

Chart review data were gathered by personnel trained in review procedures and condition coding. At the community health centers, personnel affiliated with Baylor College of Medicine were responsible for chart reviews. At the private multispecialty clinics, individuals engaged in the organization's quality improvement reviews and research studies were responsible for chart reviews. Charts were reviewed at 5-month intervals before (August 1, 2001–December 31, 2001) and after (March 1, 2002–July 31, 2002) the interventions. For each selected physician, at least 25 patients meeting study criteria were randomly selected for review during each study period. Inclusion criteria were 2 visits with the physician, with the second visit occurring during the 5-month study window; and a diagnosis (*International Classification of Diseases, Ninth Revision [ICD-9]* code) consistent with CHD or diabetes mellitus, newly ranked in ATP III as a CHD risk-equivalent. While patients could have been randomly selected for inclusion in both study periods if they met criteria, this only occurred for 9% to 12% of all patients per group, and the percentage did not differ significantly among groups.

Data were collected on patient sex, birth year, date of most recent lipid panel, ICD-9 code, and cholesterol-lowering drugs used in therapy. Data analyses were completed for 2768 charts (Figure 1). The percentages of patients screened and treated with pharmacotherapeutics according to guidelines were calculated for each physician in each review period. The use of screening percentage as an outcome was based on a large-scale chart audit for patients at high risk of CHD in which only 52% of patients had a lipid profile reported.⁴⁶

To estimate interrater reliability, all reviewers were asked to rate a subset of charts. Generalized κ values⁴⁷ were averaged across the dichotomously scored outcomes of primary interest (lipid screening, drug treatment) to yield mean $\kappa=0.83$. Other outcomes were assessed along varying scales of measurement and summarized with the

percent agreement index. When averaged across all outcomes, 94.7% agreement was found. A 10% sample of all charts was examined for accuracy. A total of 19 errors out of 5200 fields yielded an error rate less than 0.4%.

Analysis

Knowledge test (phase 1) and chart review (phase 2) data were analyzed using repeated-measures analysis of variance (ANOVA), reporting the partial omega squared (ω^2) effect size. For the knowledge test, scale scores were subjected to a 2×3 repeated-measures ANOVA having 1 between-subjects factor (live CME and online CME) and 1 within-subject factor (pretest, posttest 1, and posttest 2). Tests of Sidak-adjusted simple main effects were used for post hoc mean comparisons as needed. Orthogonal planned contrasts^{48,49} were formulated for the chart data to test the hypothesis about behaviors. Both data sets approximated assumptions closely but not perfectly. Nonparametric and robust analyses applied to the data yielded similar conclusions. Because of this and our intent of estimating and comparing means rather than medians or distributional shapes, we focused interpretation on the parametric results.

Additional analyses included examination of relationships between knowledge test outcomes and potential moderator variables including type of clinic, sex, year graduated from medical school, and other background characteristics; Web conference participation; study dropout; and satisfaction with the learning experience. Also considered were measures obtained at preintervention such as familiarity with prior and current guidelines, comfort with using the Internet, hesitancy in implementing the new guidelines, and frequency of attending live CME activities. For these analyses, relevant parametric methods (regression, repeated-measures ANOVA, analysis of covariance [ANCOVA]) and nonparametric methods (Wilcoxon-Mann-Whitney test, χ^2 test of independence, γ measure of association) were used as needed based on data consider-

ations. Holm's modified Bonferroni correction was applied to control experiment-wise error (eg, in exploratory analyses).^{50,51} Analysis was based on intention to treat. Statistical significance was assessed at $P<.05$ throughout, and all analyses were conducted using SAS version 9.1 (SAS Institute, Cary, NC) and SPSS version 12.0 (SPSS Inc, Chicago, Ill).

RESULTS

Randomization and Dropout Comparisons

Of 97 physicians (50 live CME, 47 online CME) who began an educational activity, 93 (49 live CME, 44 online CME) completed all learning activities, tests, and follow-up measures (Figure 1). The 4% attrition rate was well within accepted guidelines for instructional RCTs.⁵² Dropouts from the online CME group ($n=3$) did not indicate less Internet comfort than non-dropouts, suggesting that failure to complete the study was unrelated to computer skills.

Participant Characteristics

Participants randomized to the live CME and online CME groups in phase 1 of the study did not differ significantly with regard to practice characteristics, years in practice, self-rated knowledge, preferred CME formats, or prior use of or readiness/reluctance to use the NCEP guidelines (TABLE 2). The control group added in phase 2 was drawn from the same practice sites as participants in the interventions, with 16 (89%) of 18 practicing in sites with 1 or more live CME or online CME physicians and 2 (11%) practicing in sites with no other participating physicians. Control physicians were in primary care specialties (5 internal medicine, 13 family practice) and did not significantly differ from the intervention groups with respect to specialty, sex, or years since graduation from medical school.

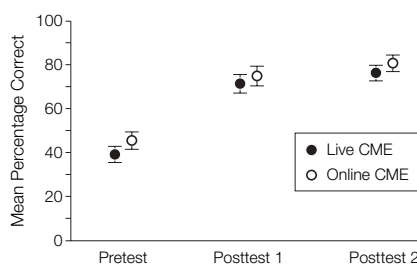
Use of Online Program

The online CME participants spent a mean (SD) of 3.8 (2.0) hours in access-

Table 2. Baseline Characteristics of Participants in Live CME and Online CME Groups

Physician Characteristics	Live CME Group (n = 49)	Online CME Group (n = 44)	P Value*
Year graduated medical school, median (interquartile range)	1989 (1978-1996)	1985 (1979-1991)	.28
Sex, No. (%)			
Female	20 (41)	22 (50)	.41
Male	29 (59)	22 (50)	
Practice, No. (%)			
Community health center	25 (51)	22 (50)	.92
Private	24 (49)	22 (50)	
No. of patients seen per day, mean (SD)	22.5 (3.7)	22.3 (4.8)	.82
Total No. of patients seen per day with lipid disorders, diabetes, or atherosclerosis, mean (SD)	10.3 (4.8)	10.0 (4.8)	.73
Availability of personnel to assist in patient follow-up, No. (%)			
Yes	14 (29)	11 (25)	.82
No	35 (71)	33 (75)	
Ever lectured to professionals about lipid disorders			
Yes	7 (14)	5 (11)	.76
No	42 (86)	39 (89)	

Abbreviation: CME, continuing medical education.

*Independent t test for continuous data, Wilcoxon-Mann-Whitney test for ordinal data, and Pearson χ^2 test for discrete data. Statistical significance determined by modified Bonferroni correction.**Figure 2.** Knowledge Test Mean Estimates

Error bars represent the 95% confidence interval (CI) for mean percentage correct on a 39-item knowledge test. A repeated-measures analysis of variance revealed a significant increase in percentage correct between groups ($P=.03$) and across time ($P<.001$), but no interaction between group and performance across time ($P=.70$). CME indicates continuing medical education.

ing all components of the online program, including tests and surveys. The mean (SD) time spent accessing the educational components was 2.2 (0.8) hours. Though comparable to total time spent by live CME participants (range: 1.5-2 hours), the online CME physicians spread their involvement over a median of 3 sessions (range: 1-9), each lasting a mean (SD) of 1.4 (0.9) hours. An effort was made to exclude time periods in which physicians were logged

on but not actively engaged. However, since participants were not visually monitored, active viewing time may have been overestimated.

Use of Reinforcing Options

Live CME participants made very little use of either e-mail or telephone to contact faculty, with inquiries made by only 2 (4%) of the physicians. The online CME participants submitted no questions by e-mail. However, 85% signed on at some point in time during a Web conference.

Knowledge Test

Knowledge test score means for both study arms are shown in FIGURE 2. No interaction effect between group membership and test performance across time emerged, indicating similar pre-intervention to postintervention improvements for both groups. Regarding the group main effect, the online CME group scored slightly higher than the live CME group when averaged across all 3 testing occasions (4.8% additional items correct, 95% confidence interval [CI], 0.6%-9.0%; partial $\omega^2=0.01$; $P=.03$). Knowledge retention at 12 weeks was comparable

across both groups. There was also a statistically significant and large time main effect (partial $\omega^2=0.70$, $P<.001$). For both groups combined, posttest 1 scores surpassed pretest levels, and posttest 2 scores surpassed both pretest and posttest 1 levels ($P<.001$). The sizes of the differences from pretest to posttest 1 and pretest to posttest 2 were large, representing increases in percentage of items correct of 31.0% (95% CI, 27.0%-35.0%) and 36.4% (95% CI, 32.2%-40.6%), respectively. Although the increase from posttest 1 to posttest 2 was statistically significant ($P<.001$), the percentage increase was only 5.4% (95% CI, 2.6%-8.2%).

Potential Moderator Variables

Physicians assigned to the online CME group were actually less comfortable in using the Internet than physicians assigned to the live CME group ("very comfortable" indicated in 40% vs 66% of participants, respectively; Wilcoxon-Mann-Whitney test, $P=.009$). Participants indicating less familiarity with the new guidelines at pretest achieved slightly greater learning gains. The increase in number of items correct for those indicating being very familiar was 19%; moderately familiar, 33%; slightly familiar, 34%; and not familiar, 43% (χ^2 test of independence, $P=.03$). Women registered greater pretest to posttest gains than men (35% increase vs 27% increase; repeated-measures ANOVA, $P=.01$). No other strong relationships between test scores and background variables emerged.

Participant Satisfaction

All live CME participants and 94% of online CME participants rated the learning experience as "good" or "excellent." Nonparametric correlations revealed no significant associations between course satisfaction and test performance. Nearly all of the 40 online CME participants (95%) who attended the live Web conference rated it as "useful" or "very useful" and indicated that it provided an opportunity to solidify guideline knowledge and obtain answers to questions.

Chart Review

For appropriate screening for lipid abnormalities, the online CME group did not differ significantly from the live CME and control groups ($P = .24$) (TABLE 3). The live CME group did not differ from the control group ($P = .16$).

Regarding drug treatment for patients at high risk (TABLE 4), there was a statistically significant though relatively small increase (5.0% [95% CI, 1.0%-9.1%]) in the percentage of patients appropriately treated by the online CME group when compared with the live CME and control groups (partial $\omega^2 = 0.16$, $P = .04$). The live CME and control groups did not differ significantly in treatment of patients.

COMMENT

To our knowledge, this study provides the first evidence at the individual physician level that Internet-based CME can produce objectively measured changes in behavior as well as gains in knowledge sustained over 12 weeks that are comparable or superior to those realized from effective live activities. Several factors indicate that these results may be generalized to other physician populations. The participants were diverse and represented varying levels of experience and content knowledge. Similar numbers of men and women participated, and they were drawn from a range of practice settings in urban/suburban environments including community health centers and a private, multispecialty group. The randomization process avoided the self-selection bias based on Internet comfort that is typically observed in studies of Internet use. Indeed, those randomized to the Internet-based intervention were significantly less comfortable with the Internet than those randomized to the live CME intervention.

While changes in knowledge and attitudes were comparable across both groups, only the online CME participants demonstrated behavioral change. Several factors could have contributed to this. First, online CME participants often completed the learning activity over several sessions, in contrast

to a single, live interactive workshop. Repeated visits to the Web site may have provided additional reinforcement of learning. Second, performance may have been enhanced because the online CME participants were able to move about the Web site and structure their own learning—allocating time to each educational piece as desired—in keeping with current theories of adult learning.⁵³

Third, whereas both study groups were given access to experts throughout the postintervention period, few participants in either group made use of learner-initiated modes of access (e-mail or telephone). However, 85% of the online CME participants signed on at some time during the scheduled option of the Web conference. This later exposure to an educational activity combined with the multisession use of the online materials may indicate an advantage of sequential reinforcement with Internet-based education, an option more challenging to achieve when using live education.

Several potential limitations of this study need to be considered. Because gains in knowledge were similar for both groups over time, it is reasonable to consider the possibility that cross-contamination occurred within those

practices housing physicians in both study arms. However, because the live CME workshops primarily occurred before the beginning of the online CME interventions, and the pretest and posttest 1 measures for the live CME group were collected during the workshop, cross-contamination could not have affected the preintervention to postintervention gains for the live CME group. While the possibility of cross-contamination effects on the online CME group's learning gains cannot be completely excluded, it is unlikely for 2 reasons. First, the knowledge assessment instrument was designed to be challenging and addressed a variety of domains relevant to the guidelines; any exchange of information between learners would need to address the complexity and comprehensiveness of the material covered. Second, 10 online CME physicians practicing at sites where there were no live CME participants achieved learning gains from pretest to posttest 1 (35.9% increase in percentage of correctly answered items) and from pretest to posttest 2 (38.7%) that were at least as great as those for 34 online CME physicians at mixed sites (27.8% and 34.5%, respectively).

Cross-contamination is also an unlikely explanation for the behavioral re-

Table 3. Patients Appropriately Screened for Dyslipidemia (Lipid Panel on Chart)*

	Live CME Group (n = 19)†	Online CME Group (n = 17)†	Control Group (n = 18)†
Preintervention, mean (SD), %	95.3 (6.6)	94.5 (3.8)	93.0 (5.0)
Postintervention, mean (SD), %	92.0 (7.5)	94.3 (5.2)	92.2 (5.3)
Difference, mean (95% CI), %	-3.3 (-5.9 to -0.7)	-0.1 (-2.9 to 2.6)	-0.8 (-3.5 to 1.8)

Abbreviations: CI, confidence interval; CME, continuing medical education.

*Orthogonal planned contrasts from a repeated-measures analysis of variance yielded no significant differences between the online CME and the live CME and control groups ($P = .24$), or between the live CME and control groups ($P = .16$). For each group, between 448 and 486 charts were reviewed in each time period.

†Number of physicians with chart reviews.

Table 4. Patients Appropriately Treated for Dyslipidemia (Lipid-Lowering Drug on Chart)*

	Live CME Group (n = 19)†	Online CME Group (n = 17)†	Control Group (n = 18)†
Preintervention, mean (SD), %	87.0 (8.4)	85.3 (9.2)	83.6 (7.9)
Postintervention, mean (SD), %	85.9 (10.3)	90.3 (5.7)	84.8 (9.1)
Difference, mean (95% CI), %	-1.1 (-4.9 to 2.7)	5.0 (1.0 to 9.1)	1.2 (-2.8 to 5.1)

Abbreviations: CI, confidence interval; CME, continuing medical education.

*An orthogonal planned contrast from a repeated measures analysis of variance indicated a significant increase in the number of patients appropriately treated by the online CME group when compared with the live CME and control groups ($P = .04$). The live CME and control groups did not differ significantly ($P = .44$). For each group, between 448 and 486 charts were reviewed in each time period.

†Number of physicians with chart reviews.

sults. Although physicians in all 3 arms demonstrated similar lipid screening behavior, no change from baseline screening levels was observed following the intervention. While the absence of change cannot completely exclude the possibility of cross-contamination, improbable coincidental effects (decreases, increases, or both) of similar magnitudes in 2 or more groups would have been required to maintain the observed baselines. With respect to the use of appropriate drug therapy, improvement in treatment was observed only for the online CME group, but not for the live CME and control groups, which did not differ significantly from each other.

Payment of honoraria for completing data collection instruments could potentially have influenced study results, giving individuals a greater incentive to participate. However, since the same honorarium was provided to participants in both intervention arms, this should have affected the groups in the same manner.

There were high baseline levels of screening and compliance in these practices, and it is reasonable to ask how this might occur prior to the knowledge gains demonstrated by the knowledge test. There are several possible explanations. During this time period there were separate but analogous quality improvement initiatives in the public and private clinics that might have contributed to the high levels. In the community health centers, these included incentives that focused on blood pressure, glycosylated hemoglobin levels, lipid levels, and other screening measures. The private multispecialty group practices had launched an initiative to inform physicians about abnormal low-density lipoprotein cholesterol levels in patients with diabetes mellitus. Also, the test, while validated for content, examined a much larger knowledge base regarding ATP III guidelines than could be investigated in the behavioral component. In particular, while the guidelines categorize patients as low risk, moderate risk, high risk, and the metabolic syndrome, we only studied the im-

pact on high-risk patients with CHD and diabetes mellitus. The measured behavioral performance (screening and treatment) for high-risk patients may differ from that for the general population of patients at risk for CHD. It is possible that these results would not hold for other risk groups. Had it been possible to study all risk categories, we might have observed a tighter linkage between preintervention knowledge levels and baseline performance.

While the objective of the study was to determine equivalence of the 2 approaches to CME, rather than superiority, we did find a 5% increase in compliance with treatment guidelines in high-risk patients among physicians in the online CME group, and no increase in the live CME group. The clinical significance of this magnitude of change needs to be considered. The change is modest, and it is not clear what impact it would have on patient health outcomes. At baseline, 84% to 87% of these physicians' high-risk patients were receiving drug therapy as specified in the guidelines, and among those not on treatment may have been patients who declined to use medications or were intolerant of all lipid-lowering medications. On the other hand, the 5% change represents about a third of the maximum possible improvement that could have occurred. With the high baseline rate, there may have been a ceiling effect, and it is possible that the absolute increase could be greater in a population in which the baseline treatment rate is lower. Additional research among populations with lower baseline screening and treatment rates is required to define more precisely the magnitude and clinical significance of the observed improvement and to explore approaches to optimize behavioral gain.

Arguments supporting the advantages of Internet-based education have typically emphasized the convenience, interactivity, flexible scheduling, widespread availability, and potentially low cost per learner from an educational perspective.¹⁷ Studies are needed to provide additional esti-

mates of physician behavioral change—and ultimately of health care outcomes—before we can fully understand the relative costs and benefits of these technologies in education.

The landmark report *Crossing the Quality Chasm* noted the challenge of identifying ways to foster ongoing skill development for professionals already in practice.² The results of our study provide evidence for additional value that can be realized from the expanded use of appropriately designed Internet-based CME in promoting health care quality.

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