Evidence for the Effectiveness of CME

A Review of 50 Randomized Controlled Trials

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Objective.—To assess the impact of diverse continuing medical education (CME) interventions on physician performance and health care outcomes.

Data Sources.—Using *continuing medical education* and related phrases, we performed regular searches of the indexed literature (MEDLINE, Social Science Index, the National Technical Information Service, and Educational Research Information Clearinghouse) from 1975 through 1991. In addition, for these years, we used manual searches, key informants, and requests to authors to locate other indexed articles and the nonindexed literature of adult and continuing professional education.

Study Selection.—From the resulting database we selected studies that met the following criteria: randomized controlled trials; educational programs, activities, or other interventions; studies that included 50% or more physicians; follow-up assessments of at least 75% of study subjects; and objective assessments of either physician performance or health care outcomes.

Data Extraction.—Studies were reviewed for data related to physician specialty and setting. Continuing medical education interventions were classified by their mode(s) of activity as being predisposing, enabling, or facilitating. Using the statistical tests supplied by the original investigators, physician performance outcomes and patient outcomes were classified as positive, negative, or inconclusive.

Data Synthesis.—We located 777 CME studies, of which 50 met all criteria. Thirty-two of these analyzed physician performance; seven evaluated patient outcomes; 11 examined both measures. The majority of the 43 studies of physician performance showed positive results in some important measures of resource utilization, counseling strategies, and preventive medicine. Of the 18 studies of health care outcomes, eight demonstrated positive changes in patients' health care outcomes.

Conclusion.—Broadly defined CME interventions using practice-enabling or reinforcing strategies consistently improve physician performance and, in some instances, health care outcomes.

(*JAMA* 1992;268:1111-1117)

FOR SEVERAL decades, recognition of the importance of continuing medical education (CME) has been dogged by questions regarding its effects on physician competence and performance and whether it improves health care outcomes.[1] As the body of biomedical literature grows, as the CME "industry" grows, and as regulatory bodies consider the nature of competence and its relationship to CME, the need accelerates for a careful, critical appraisal of the impact of this longest and arguably most important phase of medical education. To meet that need, we examined the strongest evidence available on the nature and impact of CME.

Critical reviews of the CME literature are not new. Over a decade ago, Stein[2] analyzed those features of CME methods that changed physician behaviors. Other reviews followed,[3,4] including one reported by two of us (R.B.H. and D.A.D.) in 1984.[5] These analyses provide strong evidence that some CME interventions effect changes in competency (the physician's ability to perform in the test situation), less strong evidence for changes in actual clinical performance, and only weak demonstration of changes in health care outcomes. Two recent reviews have provided new perspectives: McLaughlin and Donaldson's[6] categorization of the educational intervention, and Beaudry's[7] application of meta-analytic techniques in evaluating CME. The impetus for this review was the substantial increase in the number and rigor of CME studies over the past few years and the growing interest in CME as a practice-based discipline.[8]

Since 1979, we have maintained a comprehensive collection of CME literature. Initially developed in print format,[9] the project's scope has broadened, and the current computerized bibliography[10] contains over 1500 citations relevant to CME, broadly defined herein as all ways by which physician learning and clinical practice may be altered by educational or persuasive means.

In this article, we review a subset of the studies comprising that bibliography, ie, randomized controlled trials that study the effect of specific CME interventions on either physician performance or health care outcomes. Our aim was to identify attributes of such interventions that most affect physician performance and health care outcomes and

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Types of Continuing Medical Education Interventions and Their Outcomes

	Intervention Type							
	Predisposing*		Predisposing and Enabling†		Predisposing and Reinforcing‡		All Three Categories or Multipotential Interventions§	
	Physician Performance	Health Care or Patient Outcomes	Physician Performance	Health Care or Patient Outcomes	Physician Performance	Health Care or Patient Outcomes	Physician Performance	Health Care or Patient Outcomes
No. of interventions with positive results	7	1	9	2	18	6	14	5
No. of interventions with negative or inconclusive results	4	5	1	4	8	3	0	4

*Academic detail visits; computer-generated information; consultations; didactic presentations, lectures; knowledge testing; needs assessment; printed materials; traineeship; workshops; tutorials and small groups.
†Clinical policy and practice guidelines; patient education materials or instruction; information from patients; practice protocols, algorithms, and flow charts.
‡Feedback and reminders.
§Chart reviews and chart-stimulated recall; influential educational leaders and clinical opinion leaders.

to derive conclusions for further practice and research.

METHODS

Data Sources

Our search of relevant CME literature included studies published from 1977 through 1991 and comprised the following steps:

1. Monthly selective dissemination of information printouts produced by the National Library of Medicine, Bethesda, Md (MEDLINE), using relevant key words and Medical Subject Headings (MeSH) including *medical education, continuing medical education, CME, continuing education, peer review, quality assurance, chart audit, medical audit, physician competence, performance assessment, health services research, utilization review, adult education,* and *continuing professional education.* All articles using any of these terms were reviewed.

2. Biannual searches of other databases, including the Social Science Index, the National Technical Information Service, and the Educational Research Information Clearinghouse, using the above-named key words.

3. Manual searches of the reference lists of articles.

4. Requests of key informants in the supporting organizations for nonindexed articles, including the *Journal of Continuing Education in the Health Professions* and journals in the field of adult education.

5. Requests to the correspondent of each identified paper to locate additional studies that met our stated criteria.

Selection of Articles

To determine as rigorously as possible the impact of CME interventions on the performance of physicians in practice and on the status of their patients, articles were selected if they met the following criteria.

Design.—Individual physicians or functional units of physicians (eg, hospitals) randomly allocated to one or more intervention group(s) and a control group.

Intervention.—A replicable description of any educational activity or program intended to improve physician performance or patient outcomes. An intervention was considered "educational" if it primarily consisted of the transfer of information to targeted physicians and was intended to affect physician performance through persuasion; interventions that used official sanctions or rewards, such as financial incentives, or that presented already available clinical information, such as laboratory test results, in a different format without new information were excluded.

Subjects.—Administrative units in which physicians formed at least 50% of those observed. Studies of residents were included, as the residency experience is similar to the "traineeship" described in the CME literature, and many practicing physicians work in similar teaching-hospital or clinic settings.

Outcomes.—Evaluation of an intervention's effect by objectively observed physician performance (behavior) or patient outcomes.

Follow-up.—Assessment of outcomes for at least 75% of study participants.

Data Analysis.—Provision of sufficient data for statistical analysis or indication of statistical significance.

To appraise the evolution of knowledge in this field, these criteria followed the pattern of article selection in our 1984 review of the literature.[5]

Data Extraction

One of us (M.A.T.) extracted data in each of the following areas: study setting, type of physicians targeted by the study, clinical area of practice and characteristics of the CME intervention, and effects on physician performance and patient outcomes. At least one of the other authors checked the data for accuracy.

Classification of Interventions

For this review, we grouped CME interventional strategies into four types, using the classification of Green and colleagues[11] of factors relevant to behavior change in health promotion (Table). These factors, modified for our purposes, included predisposing (communicating or disseminating information), enabling (facilitating the desired change in the practice site), and reinforcing (by reminders or feedback). The four intervention types thus derived included: type 1, using predisposing factors only; type 2, predisposing plus enabling; type 3, predisposing plus reinforcing; and type 4, a single multifaceted maneuver, such as chart review with a peer physician, or a combination of interventions spanning all three types.

Analysis

Quantitative data regarding the effects of CME on physician performance and on patient outcomes were extracted and tabulated. Although many of the studies reported multiple analyses, we examined only the primary measures of physician performance and patient outcomes for each study. Since the outcomes, physicians targeted, and type of intervention differed substantially across studies, we did not calculate the "average effect" of CME. For similar reasons, only weak inferences could be based on between-study comparisons of the relative effectiveness of different interventions. This overview therefore presents a qualitative analysis of results, relying in large part on tests of statistical significance reported in the trials and the original investigators' assessments of the practical importance of observed differences.

Study results were classified as either statistically significant, no differ-

ence, or inconclusive. Statistically significant "positive" studies were those that found a statistically significant difference (at least $P<.05$) between the intervention group and a control group that received no education or a less potent CME activity. All the results classified as statistically significant were considered clinically or educationally important by the original investigators.

No-difference, or "negative" studies were those that did not find a statistically significant difference between study and control groups and possessed sufficient power to rule out what investigators defined as a practically important difference. This category included studies in which the 95% confidence interval excluded any difference in favor of the experimental CME intervention.

Inconclusive studies were those that found no difference or a trend toward a difference, but may have lacked sufficient power to demonstrate or exclude a statistically significant or practically important difference.

RESULTS

Of the 1445 CME articles in the CME literature database, 777 described interventions; of these, 86 were randomized controlled trials, of which 50 met the criteria outlined in the "Methods" section.[12-61]

Descriptive Analysis of the Studies

The majority (45) of the studies analyzed the performance of internists, general practitioners, and family physicians, or their patient outcomes. Also described were studies of obstetricians (two), emergency department physicians (one), and pediatricians (two). Several studies described only primary physicians, or "MDs." Sixteen studies observed physicians in private practice and their patients; 16 analyzed interventions in hospital outpatient clinics; four, health maintenance organizations; and one, a family practice teaching unit. Thirteen studies focused on inpatient hospital settings; 15 included residents or house staff; seven, a mixture of residents and supervising faculty; and eight, residents alone.

Thirty-two trials analyzed physician performance, seven studies evaluated patient outcomes, and 11 examined both measures. The clinical aspects of the CME methods were of several types: comprehensive clinical management of general medical conditions, including investigation, diagnosis, and treatment (22 studies); use of laboratory and radiologic investigations (11); prescribing practices (six); patient counseling (six); and primary prevention activities (five).

Physician Performance Studies

General Clinical Management.—Sixteen studies focused on physician performance in general clinical management, and 12 reported postintervention changes in physician performance.* Four of these[31,50-52] used opinion leaders or "educational influentials" to modify physician behavior; others used well-designed instructional methods[28,57] or computer-generated reminders[46] to effect changes. Despite the overall change in the desired direction reported in these studies,* not all the results measured achieved statistical significance. For example, Putnam and Curry,[43] assessing the impact of a criteria-setting workshop in family medicine, reported improvement in only two of four measures. Four studies[16,24,25,49] failed to demonstrate positive changes: two were negative,[24,49] and two were inconclusive.[16,25]

Investigations.—Eleven studies assessed the impact of CME training using computerized feedback on the use or cost of laboratory tests and roentgenograms.† Of these, only one[61] failed to show a difference between experimental and control groups, and that study may have lacked sufficient power to demonstrate any reduction. Ten studies demonstrated positive changes by using a combination of intervention measures. For example, Chassin and McCue,[14] using didactic sessions, printed material, and feedback, altered pelvimetry rates in an obstetrical setting. Similarly, Everett and colleagues[22] reported that chart review by a clinical supervisor reduced the frequency and cost of laboratory test orders. One study showed an increase in the appropriate use of roentgenograms (barium enemas) and sigmoidoscopy by workshop-trained physicians.[42]

Prescribing Practices.—Six studies analyzed the effects of a variety of interventions on physicians' prescribing habits; five were positive.[12,23,26,37,40] For example, Avorn and Soumerai[12] and McConnell et al[37] coupled visits by trained physician-educators such as pharmacists ("academic detail persons") with printed material and feedback to lower the prescribing of targeted drugs and showed that simple mailed materials were ineffective by themselves. Meyer and associates,[40] studying the effects on polypharmacy of a newsletter or extensive supervision including an opinion leader, feedback, and chart review, reported that both were equally effective in accomplishing performance objectives. Gehlbach et al,[23] using computerized feedback, reported a significant increase in generic drug prescribing in a family practice teaching unit. In contrast, Hershey et al[26] demonstrated that computerized feedback could significantly reduce prescription costs, but only at the conclusion of the study, and then only in two of five measures. A follow-up study by Hershey et al,[27] using computerized feedback plus a newsletter, produced no change compared with computerized feedback alone.

Counseling Strategies.—Interventions designed to assist physicians in patient counseling were reported in five studies,[18,19,29,33,59] four of which dealt with smoking cessation[18,19,29,59] and one with compliance-enhancing behaviors in pediatrics.[33] Each of the smoking cessation studies used complex educational interventions, such as didactic presentations, practice-oriented workshops, printed material, reminders, and patient education materials to improve physician behavior. Similarly, Maiman et al[33] demonstrated that print material, coupled with didactic and problem-based sessions, could improve pediatricians' compliance-enhancing skills.

Preventive Care.—All five studies focusing on the ability of CME to improve primary prevention practices showed improvement in at least some major outcomes. Three of the studies used computer-generated reminders to physicians to perform certain tasks: McDonald et al[38] noted improvement in 14 of 15 measures; McPhee et al,[39] adding print and patient education strategies, found improvement in eight of 11 measures; and Tierney et al[53] determined that reminders and feedback, used separately, possessed as much influence on preventive care as when both were used together. Two studies used a combination of didactic presentation, feedback, and printed materials. Palmer et al[41] found significant improvement in only two of eight measures spanning a wide variety of screening maneuvers; Winickoff and colleagues[60] effected changes in colorectal cancer screening.

Other aspects of clinical practice not assessed in these 50 randomized controlled trials include the clinical reasoning process (except in the study by Heale and associates[25]), procedural or technical skills (except in the study of sigmoidoscopy by Perera et al[42]), the referral process, and information management skills. Many clinical areas and some entire disciplines, such as surgery, were not represented in these studies.

Health Care Outcome Studies

Eighteen studies analyzed the effects of CME interventions on patient or health care outcomes; 10 had negative or inconclusive results; eight demon-

*References 28,30-32,36,43,46,48,50-52,57.
†References 13-15,20,24,35,42,54,55,61.

strated some positive changes in at least one major measure. Studies with negative results included those focusing on smoking cessation,[18,19,29] hypertension control,[21,24,44] and the functional status of patients.[47] Three studies, in general medical care,[48] asthma,[58] and arthritis,[52] generated inconclusive patient outcomes.

We found eight studies with positive patient care outcomes in at least one major measure. In smoking cessation, both Cohen and associates[17] and Wilson et al[59] increased patient quit rates after counseling by CME-trained physicians for at least 3 months postintervention. The remaining studies used a variety of CME interventions to alter patient outcomes. Lomas et al[31] found that clinical opinion leaders (local clinicians able to influence their colleagues' performance by exemplary practice, role modeling, consultation, and teaching) increased the proportion of vaginal births after cesarean sections; Maiman and associates[33] employed a mixture of workshop, didactic presentation, and printed materials to improve patient compliance; and Vinicor et al[56] reported that didactic presentations, protocols, reminders, and patient education strategies improved diabetic outcomes. Restuccia[45] determined that feedback from a coordinator, occasionally augmented by that of a staff physician, reduced inappropriate patient hospital days. Linn,[30] in an emergency department setting, demonstrated that a combination of protocols, feedback, and traditional teaching methods altered patient outcomes, but in only one of four measures in the emergency department and in one of eight measures for those patients admitted. Finally, Rogers and associates[46] used computerized medical records to prompt physician activities, resulting in some positive patient outcomes in mitigating obesity and renal disease, though not in reducing hypertension.

Methods of Intervention

The 50 studies used a total of 74 discrete CME methods, all of which, by virtue of their educational intent, contained some element of information dissemination. Of these 74, 15 were type 1 (predisposing only); 12, type 2 (predisposing and enabling); 31, type 3 (predisposing and reinforcing); and 16, type 4 (multipotential interventions or a mixture of all three methods) (Table).

Type 1 predisposing strategies produced mostly negative or inconclusive results: while seven out of eleven displayed positive physician performance changes, only one of the six attempts to change health care status accomplished this objective. Most studies using printed materials were negative[12,21,44,49] or inconclusive[16]; however, in two studies, printed materials were noted to be as effective in altering prescribing practices or use of investigations as were were chart review, feedback, and information derived from patients.[35,40] Workshops or small-group discussions in which no explicit attempt was made to facilitate physician performance by intrasession practice strategies were inconclusive.[25,58] In contrast, studies using learning experiences that incorporated knowledge testing and practice needs assessment strategies did succeed in improving some aspects of physician performance.[28,57]

Of the 12 type 2 predisposing and enabling activities, 10 attempted to change physician performance and six measured health care outcomes. Nine of the former were positive,* as were two of six in the latter studies.[33,56] Patient education techniques were effective in altering physician performance in studies that coupled these methods with academic detail visits,[12] printed materials,[29] or workshops,[29] or on health care outcomes when used alone.[12] Information about specific patients, derived from health status questionnaires or interviews, enhanced physician performance in one study,[32] but had no patient effects in another.[47] The dissemination of clinical policies or practice guidelines alone showed a negative effect.[31] However, more specific practice protocols or clinical algorithms, coupled with printed materials and workshops, changed physician performance in family practice[43] and, with feedback, in the emergency department setting.[30] Other studies using workshops reinforced by didactic presentations and "practice rehearsal" strategies improved physician performance[33] and, in one instance, patient care outcomes.[33] White and associates[58] studied a small group that generated practice guidelines, but these failed to demonstrate an effect on health care outcomes. Finally, computer-generated information used by Tierney and associates[54,55] in two studies altered physician use of laboratory investigations.

Type 3 methods consisted primarily of feedback and/or reminders in conjunction with predisposing methods. Feedback was used in 23 of the 31 interventions studied,† and effected a positive performance change in 12 instances when used alone[13,15,23,26,35,45,53,61] or in conjunction with didactic presentations, workshops, academic detail visits, or printed materials.[14,24,27,35,37,41,60] Two studies[24,31] demonstrated that performance feedback induced no change in patient outcomes, whereas one study[45] that gave physicians feedback about patients' lengths of stay improved patient outcomes. Practice reminders, also commonly used, had a positive effect on physician performance[36,38,46,53] and patient outcomes.[17,46]

Type 4 methods, using a combination of all three CME strategies, comprised the majority of this category (10 of 16 interventions described)‡ and produced positive results in all eight assessments of physician performance, and in four of seven analyses of health care status. In addition, there were two multifaceted single strategies within this category: opinion leaders and chart review. The effectiveness of educational leaders or influential persons on behavior and health care outcomes was demonstrated by Lomas and colleagues.[31] Stross and associates[50-52] established the performance-altering potential of teachers and educational leaders in the management of arthritis and respiratory disease, though one study[52] related to patients' health status provided inconclusive results. Finally, chart review, in which a faculty member or supervisor discussed patient records with a resident, improved physician performance in three studies.[22,34,40]

COMMENT

Our study located 777 articles testing CME interventions, of which 50 were randomized controlled trials assessing physician performance and/or health care outcomes. This more than sevenfold increase over the seven randomized controlled trials described by us in 1984[5] and the almost tripling of the denominator over this period illustrates a substantial increase in research by those interested in enhancing physician performance. In addition, we note a wide range of rigorously tested interventions that substantially broadens the traditional definition of *continuing medical education*. Interventions not described by us in 1984 included individualized chart reviews, computer-generated information, and complex, role-reinforcing activities in workshops.

While the randomized controlled trial is indispensable for methodological rigor, we recognize several difficulties with executing such studies.[5,62] Although generally well designed, many studies did not provide enough details about their physician populations[37,45,48] or blind their assessors to the CME group. Because randomized controlled trials are difficult and expensive to perform and usu-

*References 12,29,32,33,42,43,54,55.

†References 13-15,23,24,26,27,31,35,37,41,45,53,60,61.

‡References 18,19,30,36,39,40,48,56,59.

ally require volunteer physicians, the generalizability of our findings may be limited to physicians who are above their peers in performance and thus willing to have their performance and their patients health status scrutinized.

Although these studies eliminate many concerns about contamination and cointervention, they frequently lacked qualitative details[63] that would help in the delineation of physician management patterns, learning processes, or forces for and impediments to change.[64] In light of the variance in the types of clinicians, clinical practices, settings, outcome measures, and CME strategies, as well as other aspects of the study designs, comparing the effectiveness of different CME strategies should be viewed as hypothesis-generating rather than hypothesis-testing.[65] In addition, because of wide variations in the way outcomes were reported in these studies, we focused on tests of statistical significance rather than on the magnitude of effect. Although it appears reasonable to assume that all of the statistically significant studies found differences that were clinically important,[66] it is not possible to assume that the inconclusive studies ruled out a clinically important effect.[67] Thus, our conclusions about interventions that appear to be effective are stronger than our conclusions about those that do not.

We attempted to correct for publication bias that prevents negative or inconclusive studies from being submitted for publication, but such bias may still exist. Therefore, while the strength of inferences that can be drawn from our overview of the relative effectiveness of different CME strategies is limited, these inferences reflect the present state of knowledge in the CME field and may lead to recommendations for practice improvements and future research.

Physician Performance

If physician performance is considered a benefit of CME, these studies are encouraging with regard to short-term, post-CME interventions and lend themselves to discussion of what specific strategies and activities appear to work and in what circumstances.

These studies and the relevant literature[68] suggest that clinical management and patient counseling behaviors are relatively complex and more difficult to change. Prescribing and preventive practices and use of investigations appear easier to alter. Nearly one third of CME trials attempting to measure change in the complex behaviors of general clinical management—incorporating investigation, diagnosis, and management[69]—did not succeed; even among those trials considered "positive," not all the measures achieved statistical significance.

The reasons for failure may include attempts to change clinical phenomena such as hypertension outcomes in a relatively well-controlled population,[24] or the use of inadequate, single-factor interventions.[21,49] More potent practice-linked interventions, such as experienced clinical leaders and computer-generated reminders, were effective. Traditional workshops or didactic presentations, when augmented with objective ways of assessing individual physician's requirements (such as chart audits and knowledge testing) appear to establish baselines for affecting real outcome change.[28,57]

Health counseling appears to be altered through more complex strategies[70]; especially important were explicit instructions,[33] opportunities to rehearse such strategies with simulated patients,[59] videotapes, and role playing.[18,19] Simpler behaviors were more consistently altered in these trials; for example, all but one[61] of the 11 studies of test ordering* demonstrated positive change. Practice-linked maneuvers such as reminders, feedback, computer-available information,[54,55] and chart review by supervisors or faculty members[22,34] appeared to be effective change agents, as did the use of a "probabilities curriculum" reinforced by discussions on the ward.[20] For prescribing practices, in which five[12,23,26,37,40] of six studies[27] showed positive change, having academic detail persons giving on-site information and feedback appears to be helpful and cost-effective,[71] while printed materials appear less effective.[12]

Finally, in disease prevention, reminders and feedback, used concurrently, are effective in improving physician performance.[72]

Health Care Outcome Studies

The increase since our previous review[5] in rigorously designed CME studies that analyze health care status and patient outcomes provides a more optimistic picture of the impact of CME. Of note are the smoking cessation studies,[17-19,29,59] of which two show positive results in patients at least several months postintervention.[17,59] Additionally, studies by Lomas et al,[31] Maiman et al,[33] Restuccia,[45] and Vinicor et al[56] confirm that at least some changes in patient outcomes are possible. Explanations for "negative" studies—still the majority of the studies in this category—include lack of a direct relationship between the CME-induced change in physician performance and improved patient outcomes and such impediments to optimal outcomes as noncompliance with medication. Further, a "ceiling effect" may occur in studies such as those of hypertension,[21,24,44] in which physicians and patients have limited ability to improve their performance because they are already functioning at or near their maximum capabilities.

Successful and Unsuccessful Interventions

There appears to be a direct relationship between the intensity of the intervention and the number of studies with positive outcomes. In these studies, interventions using only predisposing elements to disseminate information were less apt to induce physician performance change and registered little or no effect on health care outcomes. Much of the criticism aimed at methods frequently used in the formal programs that are the domain of traditional CME providers would seem justified.[44,49] In contrast, those studies that used enabling and/or reinforcing elements were more effective in changing outcomes; for example, workshops that provide more opportunity for case discussion and rehearsal of practice behaviors are considerably more effective than are more didactic programs. These studies also support one of the major tenets of adult education[73]: that the objective determination of practice or learning needs is a necessary prerequisite for effective education.

Two further methods in the type 1 category merit comment. Although printed materials alone demonstrate a relatively weak effect on physician performance, they may be among the many factors affecting performance change.[64] From the results of at least two studies,[25,58] small-group learning as a single entity has failed to demonstrate its ability to change physician performance[25] or patient outcomes,[58] possibly owing to the inadequate potency of small-group learning in the CME setting, or to undirected discussion. Given the increasing use of small-group learning in medical schools and the theoretical basis of the process,[69] we urge further research in this area. Finally, activities described as "academic detail visits" appear to be effective change agents and worthy of further study, both in drug-prescribing and in other clinical domains.

From our review of type 2 CME, two strategies that appear to facilitate practice change are patient education and computerized practice-based information. Practice guidelines, when used alone, were not effective. Type 3 CME, which includes feedback and reminders, appears to overcome many of the logis-

*References 13-15,20,22,24,35,42,54,55,61.

tical and sociological barriers to facilitating optimal physician performance.[74] Finally, type 4 interventions demonstrate the ability to change outcomes with a host of strategies derived from all three categories, such as studies of smoking cessation and diabetes management[17-19,29,56,59] that used a mixture of workshops, patient education materials, printed materials, and reminders. Vinicor et al[56] demonstrated that patient education materials can alter patient outcomes either singly or, with greater impact, in conjunction with other CME strategies. Chart review or chart-stimulated recall appears to be an effective and comprehensive CME activity, incorporating elements of information transfer, competency assessment, reminders of desirable practices, feedback to the physician, and the opportunity for performance-enabling suggestions.[75-77] Similarly, the example of educational or opinion leaders—derived from research on the "educational influential" in community hospitals[78]—appears to act in a comprehensive and effective manner.

Implications for Research and Practice

This review indicates the need to address several important issues in CME. First, there are some noticeable gaps in the kinds of CME interventions studied, particularly when compared with physicians' stated CME preferences.[79,80] Journal reading, for example—clearly a popular mode of learning for most physicians[81]—to our knowledge was not studied to any extent and certainly not by controlled trials.

Second, promising interventions deserve further testing and use—particularly chart review, education leaders, academic detail visits, and multiphasic intervention activities. Third, the clinical outcomes chosen in most CME studies appear to be determined somewhat more by their ease of measurement (eg, blood pressure) or by their cost (eg, investigations) than by their clinical imperative. In this regard, we suggest that CME researchers develop a research agenda that would include studies evaluating the effects of CME interventions on major causes of morbidity and mortality. Fourth, both providers and consumers of CME need to be aware of the clear lessons derived from this review: that CME is more effective when it incorporates practice-based enabling and reinforcing strategies and that adequate assessment of physicians' needs leads to increased potential for change.

Finally, these randomized controlled trials provide new evidence supporting the effectiveness of broadly defined, complex, practice-linked CME. Based on this evidence, we urge the development of an improved evidence-based CME delivery system and further research into this last and most complex arena of physician education.

The authors acknowledge the financial support of the Research and Development Resource Base in Continuing Medical Education (McMaster University, Hamilton, Ontario, Canada) in facilitating the writing of this review; the American Medical Association (Chicago, Ill); the Canadian Medical Association (Ottawa, Ontario, Canada); the Society of Medical College Directors of Continuing Medical Education (Chicago, Ill); the Royal College of Physicians and Surgeons of Canada (Ottawa, Ontario, Canada); and the Alliance for Continuing Medical Education (Lake Bluff, Ill).

Dr Oxman is a career scientist of the Ministry of Health, Ontario, Canada. Dr Haynes is a recipient of the National Health Scientist Award, from Health and Welfare Canada.

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