Evidence-Based Health Care in Medical and Chiropractic Education
A Literature Review

Charles E. Fernandez, D.C., Los Angeles College of Chiropractic, Southern California University of Health Sciences, and **Paul M. Delaney**, Ph.D., D.C., Private Practice, Los Angeles, California

Objective: The purpose of this article is to review educational and patient outcomes of teaching and utilizing evidence-based health care (EBHC) in medical and chiropractic education, and to discuss future directions for research. **Methodology:** Literature search identified 190 EBHC studies and 21 of these were reviewed and categorized into the following areas: educational and patient outcomes after EBHC medical training, and educational outcomes of EBHC chiropractic training. **Results:** Improved knowledge, skills, and attitudes after EBHC medical education were demonstrated in single studies and systematic reviews. Six controlled trials showed improved patient outcomes after EBHC medical education. Limited evidence from three single studies of EBHC chiropractic training indicate improved self-assessed educational outcomes. **Conclusions:** EBHC developed from practical need in addressing clinical uncertainty and evolves through continuous integration of new research. Early evidence demonstrated improved educational and patient outcomes after EBHC medical education. Rigorous studies of EBHC training on patient outcomes are needed in chiropractic education. (The Journal of Chiropractic Education 18(2):103–115, 2004)

Key words: evidence-based medicine, health care education

INTRODUCTION

Directly examining evidence from clinical research to support clinical decision making, evidence-based medicine (EBM) has been proposed as a new paradigm for the practice of medicine (1–3). "Evidence-based medicine" describes a learning strategy developed at McMaster Medical School in Canada (4). It requires health care providers to have a combination of unique skills, such as articulating a focused clinical question, efficiently searching literature, applying rules of evidence to clinical studies (critical appraisal), and interpreting results for an individual patient (1).

The need for doctors to analyze, share, and use new research stimulated development of journal clubs which met regularly to discuss current medical articles (5–7). The first North American journal club was held at McGill University, Montreal, in 1875 and was organized by Sir William Osler "for the purchase and distribution of periodicals to which he could ill afford to subscribe as an individual" (7). Journal clubs evolved into forums for continuing medical education in clinical epidemiology, biostatistics, research design, and clinical decision making (8–11). A recent national survey found journal clubs active in 95% of internal medicine programs (12,13). The classical objectives of journal clubs were to remain current with the literature, have an impact on clinical practice, and teach critical reading skills (8). More recent journal clubs emphasized skills of critical appraisal—how to assess the validity and applicability of the published literature (5,12).

Use of critical appraisal as an analytic strategy arose from recognition of the variable quality of

The Journal of Chiropractic Education

Vol. 18, No. 2. Printed in U.S.A.
1042-5055/$4.00

information (14–16). It has been called "the science of trashing research," but development of checklists in the 1980s helped make critical appraisal more structured, explicit, and straightforward (17). David Sackett's 1997 textbook, *How to Practice and Teach EBM* (18), embedded critical appraisal in a wider package of evidence-based health care (EBHC) skills including question development, literature retrieval, and application of research to patients.

EBHC involves self-directed, problem-based learning (PBL) where the clinician formulates an answerable question, accesses and evaluates evidence for validity, utilizes appropriate evidence in patient decision making, and then evaluates performance. Problem-based learning is derived from adult learning theory, which assumes that adults prefer self-direction and self-responsibility for decisions, prioritize learning tasks by utility to cope effectively with real-life situations, and are more responsive to internal than external motivators (19–23). PBL is student-centered and provides information-seeking skills needed for self-directed life-long learning. PBL uses health care scenarios to provide context for learning, elaborates knowledge through critical thinking and discussion, and has been adopted by 10% of medical schools worldwide (24).

Nandi et al. (25) reviewed studies and meta-analyses comparing PBL with conventional teaching in undergraduate medical education. They concluded that the two curricula encourage different ways of learning, but there was no convincing evidence of improved learning using PBL curricula, and that a combination of conventional and newer PBL curricula may provide the most effective training.

Medical educators (26,27) and advisory groups such as the Accreditation Council for Graduate Medical Education (ACGME) (28) and Association of American Medical Colleges (AAMC) (29), have called for introduction of clinical epidemiology, biostatistics, critical appraisal, and medical informatics into undergraduate and graduate medical curricula (1) and the United States Medical Licensing Examination (USMLE, 2000) included similar educational objectives (30,31).

Barriers to practicing and teaching EBHC include increased time demands, rudimentary critical appraisal skills, lack of high-quality evidence for clinical questions, perception of EBHC as detracting from optimal patient care, and perception of dichotomy between "traditional, caring" and "research-oriented" doctors (32,33). Some difficulties are logistic, such as facilities for retrieving appropriate evidence. Searching the medical literature electronically enables clinicians at clinic or bedside to find applicable information in minutes (34–36).

Concerns exist about applicability of clinical practice guidelines to individual patients who differ from patient populations used in guideline construction, and outdated or nonvalid guidelines (37) being potentially abused by institutions, policy-making agencies, and reimbursement systems (38). These concerns and the proliferation of studies require that validity and reliability of diagnostic and therapeutic procedures be confirmed (39). The Cochrane Collaboration has developed rigorous procedures for summarizing evidence and providing systematic reviews about the effectiveness of clinical interventions (5,40), but many health care providers do not utilize this growing base of evidence because of the lack of access, skills, or acceptance (41–48).

Tsafir (4) described the developmental imperatives of EBHC arising from an expanding volume of clinical literature, increased demands for accountability, and conflicting published reports about diagnostic and therapeutic procedures. Practitioners of scientific health care had to develop new strategies for finding, appraising, and applying information to individual patient decision making, using standardized rules of evidence. Epidemiological and statistical evidence has limitations and must be integrated with personal knowledge and clinical experience of the physician dealing with a particular patient or problem-solving situation (4,49).

EBHC education is a rational approach, but does it improve educational and patient outcomes? There is moderate evidence from systematic reviews for improved educational outcomes and early evidence from controlled trials for improved patient outcomes.

METHODOLOGY

A literature review was conducted to assess studies on educational and patient outcomes from EBHC teaching strategies in medical and chiropractic education. Studies addressed aspects of EBHC, including teaching and practice of question development, literature searching, critical appraisal, and application of evidence to patients. The search terms used were evidence-based health care, evidence-based medicine, evidence-based health care and medical education, and evidence-based health care and chiropractic education.

The electronic databases MEDLINE, CINAHL, Mantis, and EBM Reviews-ACP Journal Club were searched from 1966 to 2002. Studies were retained if they contained a clear objective or focused question regarding EBHC and had a clearly defined methodology (participants, intervention, design, or outcomes assessed). Opinion articles and studies without clearly defined methodology were excluded. Out of 190 articles initially identified, 21 studies were reviewed based on the above inclusion criteria. Because of the paucity of studies in the area of EBHC and chiropractic education, the above criteria were suspended and qualitative descriptive survey studies were included. The studies were then categorized into the following areas: educational outcomes of EBHC in medical education, patient outcomes of EBHC medical education, and educational outcomes of EBHC in chiropractic education.

REVIEW

Single Studies of Evidence-Based Health Care in Medical Education

One randomized controlled trial with before and after design (7), three nonrandomized pretest-posttest controlled trials (1,11,30) one crossover trial (50), and one nonrandomized noncontrolled trial (13) were identified. No quality scoring was performed because variables such as participants, interventions, outcomes assessed, and outcome measures varied significantly between studies and there was only one randomized controlled trial identified. Articles are summarized in Table 1 for comparison purposes. The following are brief descriptions of the educational interventions and limitations of each study.

One randomized controlled trial with pretest-posttest design (7) studied journal clubs in postgraduate education in a U.S.-based hospital. Reading behavior, clinical epidemiology knowledge, and critical appraisal skills were measured in 44 internal medicine interns. The control group attended standard conferences in ambulatory care while the intervention group attended weekly 1-hour journal clubs emphasizing critical appraisal. Interns chose an article (not necessarily related to a real case) to appraise and present to the journal club, and a tutor facilitated discussion of clinical utility. Participants completed a pretest and posttest following an average of five journal clubs. The authors noted their study was limited by small sample size, lack of validation of self-reported reading, and incomplete internal validation of the test instrument. This study appropriately addressed its objective but did not evaluate patient outcomes.

Green and Ellis (1) reported a controlled pretest-posttest study of internal medicine residents (postgraduate year, PGY 2–3) showing improved critical appraisal skills after an educational intervention that included a 7-week EBM curriculum including: a resident-directed tutorial format, real clinical encounters, and EBM facilitating techniques for faculty. Outcomes included a self-assessed behavior and competencies questionnaire, a 17-point skills test based on clinical vignette, and a test article. Their assessment demonstrated good reliability and content validity, but external validity remained untested. Sample size was small and there was no randomization.

Seelig (13) conducted a one-group (noncontrolled) pretest-posttest study of 14 residents (PGY 1–3), which demonstrated improved mean scores on multiple-choice exams in critical appraisal knowledge after a seminar, patient-based assignments, and journal clubs. This study had a small sample size and lacked a control group and external validation of the test instruments.

Kitchens and Pfeifer (50) assessed change in epidemiology knowledge in a within-group and between-group crossover study of 83 internal medicine residents (PGY 1–3) following critical appraisal seminars in a university training program. They reported a statistically significant improvement over crossover controls based on true-false and multiple-choice exams. The authors did not describe validity of the assessment instrument and noted that the amount of educational improvement was small.

Langkamp et al. (11) evaluated effectiveness of two didactic sessions and eight monthly journal clubs for improving clinical epidemiology and biostatistics knowledge in a controlled pretest-posttest study of 27 pediatric residents. Mean test scores of multiple-choice exams decreased nonsignificantly in the intervention group. The study had a low sample size and lacked external validation of the test instrument.

Srinivasan et al. (30) performed a nonrandomized within-group pretest-posttest study of 139 1st-year medical students assessing effectiveness of a 1-month problem-based EBM course which used Internet-based components, a practice exam, and a multiple-choice final exam to improve EBM knowledge. One hundred twelve of 139

Table 1. Educational Outcomes From EBHC in Medical Education, Single Studies

Author, year, design	Participants, intervention	Outcome(s) assessed	Outcome measure(s)	Results
Linzer et al. (1988) randomized controlled trial	$N = 87$, residents PGY1, journal club	a) Reading habits; b) clinical epidemiology knowledge; c) critical appraisal skills	a) Self-report survey; b) multiple-choice exam; c) free-text appraisal	a) Improved, $p < .001$; b) improved, $p = .02$; c) improved but not significant, $p = .09$
Green and Ellis (1997), nonrandomized pretest-posttest controlled trial	$N = 34$, residents PGY2-3, 7 week EBHC curriculum including tutorial format, use of real clinical encounters	a) Literature reading behaviors; b) EBM behaviors (decision-making frequency); c) critical appraisal skills integration with patent care	a) Self-report survey; b) self-report survey; c) free-text responses to questions on clinical vignette/journal article	a) Increased frequency reading methods and results sections, no increase in hours reading; b) increased use of original studies when faced with clinical questions; c) improved significantly over controls, $p = .001$
Seelig (1991), nonrandomized pretest-posttest trial	$N = 14$, residents PGY1-2-3, 1-hour seminar followed by written assignments, journal clubs with active feedback	a) Literature reading behaviors; b) critical appraisal ''self-efficacy''; c) critical appraisal skills	a) Self-report survey (Likert); b) test (format unspecified); c) multiple-choice exam	a) No change in sources or reasons for ''keeping-up'' or hours reading; b) self-reported improvement; c) mean score improved pre-post 42%–67%; $p = .02$
Kitchens et al. (1989), nonrandomized crossover trial	$N = 83$, residents PGY1-2-3, reading seminar: 1st phase 17 weeks, 2nd phase 12 weeks of weekly sessions	Clinical epidemiology knowledge	True/false and multiple-choice exam	Cases improved significantly over controls (63%–69% vs. 66%–65%; $p = .019$
Langkamp et al. (1992), nonrandomized pretest-posttest controlled trial	$N = 27$, residents, 2 hours of didactic instruction followed by eight monthly journal club meetings	Clinical epidemiology and biostatistics knowledge	Multiple-choice exam	Mean test scores decreased in the intervention group, but no statistically significant difference between two groups
Srinivasan et al. (2002), pretest-posttest noncontrolled study	$N = 139$, 1st-year medical students, a 1-month problem-based EBM course	a) Small group preparation and participation; b) EBM knowledge acquisition, use of Web-based curriculum; c) student satisfaction	a) Student on-line questionnaire; b) formative and summative multiple-choice testing; c) student satisfaction survey	a) On-line questionnaire completed by 59%; b) Improved significantly, $p < .05$; c) >92% of students agree or strongly agree to satisfaction survey items

PGY, postgraduate year.

students completing both exams showed significant improvement between the practice exam and the final exam. Mean scores for individual exam items were provided but overall scores were not. Assessment was performed immediately after course instruction, so long-term outcomes were not measured, and no control group was used.

In summary, three studies evaluated a change in critical appraisal skills following an educational intervention. Two of these showed statistically significant increases but had smaller sample sizes and less rigorous methodology (1,13). One randomized controlled trial reported a nonstatistically significant increase in appraisal skills (7). Differences in study outcomes may be due to variable research methodology or type of educational interventions used.

Four studies assessed a change in knowledge in critical appraisal, clinical epidemiology and biostatistics, and/or evidence-based health care. Three of these reported a statistically significant improvement in knowledge (7,30,50) with one study reporting a nonstatistically significant decrease (11). Teaching interventions included journal clubs and didactic teaching methods.

Three studies evaluated change in reading habits and behaviors following journal clubs or EBHC curriculum (1,7,13). All reported no increase in the number of articles read or hours reading, but had statistically significant increases in reading quality in all three groups. Quality characteristics included improved self-assessed ability to critique methods of articles read, increased frequency of reading methods and results sections, increased use of original research studies when faced with a clinical question, and more useful reading time.

Systematic Reviews of Evidence-Based Health Care in Medical Education

Four systematic reviews addressed the effectiveness of teaching EBHC or components of EBHC in medical education. Research questions or objectives, article selection criteria, data analysis, and main results are provided in Table 2. The research questions, objectives, and areas assessed in these reviews differed, so the studies may not be directly comparable.

A review by Parkes et al. (14) addressed whether teaching critical appraisal to health professionals improved practice or patient outcomes or critical appraisal knowledge. Cochrane Collaboration criteria and methods were used to identify valid studies and independently extract data for study of quality. One U.S. hospital-based randomized controlled trial was identified (7) which assessed critical appraisal knowledge but did not assess practice or patient outcomes. Critical appraisal teaching in the intervention group resulted in a significant ($p = .02$) 25% improvement in critical appraisal knowledge compared to a control group.

Ebbert et al. (5) used Cochrane Collaboration criteria for systematic reviews to assess effectiveness of using journal clubs for students and residents to improve patient care, critical appraisal skills, reading habits, and knowledge of clinical epidemiology and biostatistics. Independent assessment of inclusion criteria, data abstraction, and methodologic quality was performed. One randomized controlled trial (7) reviewed showed statistically significant improvement in knowledge of clinical epidemiology and biostatistics ($p = .04$), reading habits ($p < .001$), and use of medical literature in practice ($p = .02$), but no statistically significant improvement in critical appraisal skills ($p = .09$). Six less methodologically rigorous studies found possible improvement in critical appraisal skills. Limitations to their review of journal club interventions include lack of methodologic rigor in studies, variability of outcomes measured, and applicability to other training levels and types. No studies reviewed assessed patient care outcomes.

Norman and Shannon's et al. (51) systematic review focused on whether teaching critical appraisal skills to undergraduate medical students or residents increased gains in knowledge and use of literature in clinical decision making. Research articles were included if the study included a control group and a measurement of performance beyond student satisfaction, following the teaching intervention. Authors analyzed data by combining scores across all outcome measures and calculated mean difference and standard deviation over all studies. There was no mention of independent data analysis. They reported that undergraduate interventions resulted in significant gains in knowledge (17%), while resident interventions showed a small change (1.3%), though statistically significant in two of three studies. Two studies that examined residents' use of the literature were unable to demonstrate any positive change. The key limitation of this review was the mixing of data and outcomes from studies of differing methodology.

Green's (12) systematic review identified characteristics and effectiveness of graduate medical

Table 2. Educational Outcomes From EBHC in Medical Education, Systematic Reviews

Author, year, design	Research question or objective	Selection criteria	Data collection analysis	Main results
Parkes et al. (2001), systematic review	Does teaching critical appraisal to health professionals improve critical appraisal knowledge or skills and practice or patient outcomes?	RCTs, CCTs, CBAs, ITSs; at minimum a comparison group with intervention group, no previous critical appraisal teaching in either group	Two reviewers independently extracted data and three reviewers independently assessed study quality utilizing methods suggested by Cochrane Collaboration.	One RCT (Linzer, 1988) was included. Process of care/patient outcomes was not assessed. Critical appraisal teaching (journal club) resulted in a 25% improvement (adjusted figure) in critical appraisal knowledge compared to control 6%, $p = .02$.
Ebbert et al. (2001), systematic review	Are journal clubs for physicians in training effective for improving patient care, critical appraisal skills, reading habits, and knowledge of clinical epidemiology and biostatistics?	Intervention - Journal Club; Study design - RCTs, cohort, CBAs, cross-sectional trials; outcomes assessed; critical appraisal skills, reading habits, knowledge of clinical epidemiology and biostatistics, use of literature in practice, or improved patient care	Two reviewers independently assessed articles and included if all criteria were met. Independent data abstraction was completed using a data extraction form developed and tested by the authors. Independently assessed quality utilizing methods suggested by Cochrane Collaboration.	One RCT (Linzer, 1988) found an improvement in knowledge of clinical epidemiology and biostatistics, reading habits, and the use of medical literature in practice, but no improvement in critical appraisal skills. Six less methodologically rigorous studies found possible improvement in critical appraisal skills.
Norman et al. (1998), systematic review	Do teaching critical appraisal skills to undergraduate medical students or residents result in significant gains in knowledge and increased use of the literature in clinical decision making?	Articles were selected if the study involved some form of control group, although strict randomization was not required, and a measure of performance (beyond student satisfaction) followed the intervention.	Studies' data were combined when authors combined mean change in score across all the outcome measures and then the mean difference and standard deviation over all studies. No mention of independent analysis.	Interventions implemented in undergraduate programs resulted in significant gains in knowledge as assessed by written test (mean gain 17%; standard deviation 4%). Conversely, studies at the residency level consistently showed a small change in knowledge (mean gain 1.3%; standard deviation 1.7%). Two studies that examined residents' use of the literature were unable to demonstrate any positive changes.
Green (1999), systematic review	To identify and review graduate medical education (GME) training in: clinical epidemiology, critical appraisal, EBM, and evaluate effectiveness where appropriate	All peer-reviewed reports of GME curricula, with or without effectiveness studies. Those with effectiveness studies minimum standard of a pretest-posttest controlled trial.	Author identified studies to include. Author and independent rater extracted characteristics data from curricula. Kappa .91, $p = .001$, indicating good interrater reliability.	18 reports included. Most common curricular objective was improving critical skills; most common format was resident-directed small group seminar. Most common outcome measure was multiple-choice exam. Only seven reports assessed effectiveness with only four meeting inclusion criteria. Impact of curricula on critical skills ranged from no effect to a 23% net absolute increase in test scores.

RCTs, randomized controlled trials; CCTs, controlled clinical trials; CBAs, controlled before/after; ITSs, interrupted time series.

training in clinical epidemiology, critical appraisal, and evidence-based medicine. Studies were included if they met a minimum standard of a pretest-posttest controlled trial. Author and independent raters extracted characteristics data from 18 studies, which used objective criteria but not independent assessment, and had good inter-rater reliability. The most common curricular objective was improving critical appraisal skills, the most common teaching format was resident-directed small group seminars, and multiple-choice exams were the most common outcome measure. Seven studies assessed effectiveness and four met inclusion criteria. Curricular impact on critical appraisal skills ranged from "no effect" to 23% net absolute increase in test scores. Limitations of this study include the lack of nonbiased blinded independent review.

Patient Outcomes From Evidence-Based Medical Education

Six randomized controlled trials and one controlled educational trial of the effect of evidence-based (EB) medical education on patient outcomes were identified and are discussed below (Table 3). Participants, interventions, and outcome measures assessed varied greatly. These provide early evidence that EB training may increase positive outcomes for patients.

Goldberg et al. (23) delivered a package of educational interventions to spine surgeons, primary care physicians, surgical candidates, and hospital administrators in 10 communities over 30 months. A statistically significant reduction of surgical rates (8.9%, $p = .01$) was seen in the intervention groups.

Balas and colleagues (52) studied 152 patients with end-stage renal disease managed by 10 physicians. The intervention group of physicians received direct clinical reports encouraging consideration of peritoneal dialysis, resulting in a statistically significant increase in patients allocated to dialysis (15.3% vs. 2.4%, $p = .041$).

Sanci et al. (53) provided 108 self-selected general practitioners with a 6-week educational program about adolescent health care. The intervention group had significantly greater improvement in all outcomes including objective ratings of videotaped consultations with standardized adolescent patients, doctor questionnaires measuring skills, knowledge, self-perceived competency, program satisfaction, and self-reported practice changes.

Searle et al. (54) trained 62 gynecologists or residents in six public gynecology units in evidence-based guidelines using a problem-based interactive workshop facilitated by a leader who provided laminated clinical algorithm and guidelines. An increase in evidence-based clinician behavior was demonstrated, but there was no significant effect on the number of hysteroscopies or dilation and curettage procedures performed for dysfunctional uterine bleeding in women <40 years old.

Bernal-Delgado and colleagues (55) taught 158 general practitioners at 24 primary care centers about recommended nonsteroidal anti-inflammatory medications, using evidence-based educational sessions reinforced with printed material. This resulted in statistically significant reductions in prescriptions of nonrecommended drugs and decreased costs per prescription in the intervention group.

D'Onofrio et al. (56) provided 36 emergency medicine residents with a 4-hour didactic, video, and structured skills-based workshop about screening and intervening in patients presenting with alcohol problems. The intervention group had statistically significant increases in knowledge scores and medical records with evidence of review and intervention.

Freemantle et al. (57) provided educational sessions on practice guidelines by pharmacists to general medicine practices in 12 districts. The intervention group had statistically significant improvement in prescribing practices and in numbers of patients treated within practice guidelines. Small groups of practitioners (two or fewer) improved performance more than larger groups did.

In summary, five randomized controlled trials and one controlled educational trial indicated improved patient outcomes after EB medical education.

Studies of Evidence-Based Health Care in Chiropractic Education

A limited number of studies addressed outcomes of EBHC in chiropractic education (Table 4). These studies were not methodologically rigorous and consisted of qualitative survey designs. No studies of EB chiropractic education on patient outcomes were identified.

In a cross-sectional survey study of chiropractic college clinics, Rose and Adams (58) reported on the teaching and use of EBHC in chiropractic education. Chiropractic college clinical administrators and directors were surveyed worldwide with a response

Table 3. Patient Outcomes From Evidence-Based Medical Education, Single Studies

Author, year, design	Participants, intervention	Outcome(s) assessed	Outcome measure(s)	Results
Goldberg et al. (2001), randomized controlled trial	Spine surgeons, primary care physicians, surgical candidates & hospital administrators in 10 communities; package of 6 educational activities over 30 months	Surgical rates	Quarterly observation of surgical rates	Reduction of 8.9% ($p = .01$) in surgical rates in intervention groups, compared to control groups
Balas et al. (1998), randomized controlled trial	$N = 10$ physicians, $N = 152$ patients with end-stage renal disease; intervention group received clinical direct reports encouraging consideration of peritoneal dialysis	Dialysis modality selection	Number of patients allocated to peritoneal dialysis	Increased percentage of patients allocated to dialysis in intervention group (15.3% vs. 2.4%, $p = .041$)
Sanci et al. (2000), randomized controlled trial	108 self-selected general practitioners; educational program 2.5 hours/week for 6 weeks followed by final 2-hour session of case discussion & debriefing	Adolescent health care	Objective ratings of consultations with standardized adolescent patients on videotape; doctor questionnaires measuring skill, knowledge, self-perceived competency, program satisfaction, self-reported practice changes	95% (103/108) doctors completed intervention & evaluation; intervention group had significantly greater improvement in all outcomes and sustained improvement in most outcomes at 13-month follow-up
Searle et al. (2002), randomized controlled trial	62 gynecologists or trainees in 6 public gynecology units; evidence-based guidelines via problem-based interactive workshop facilitated by leader, & laminated algorithm and guidelines	Hysteroscopies, and D & C performed for dysfunctional uterine bleeding on women <40 years old	Number of procedures performed, physician behavior change, perceived booking rates of procedures	Increase in evidence-based clinician behavior, but no significant effect on number procedures performed at 6 months
Bernal-Delgado et al. (2002), randomized controlled simple blind trial	158 general practitioners at 24 primary care centers, evidence-based educational session based on systematic review reinforced with printed material	Effect on prescriptions of nonsteroidal anti-inflammatory drugs	Change in numbers of packages prescribed for each drug; changes in drug costs during 6-month pre- and postintervention	Reduced prescription of nonrecommended drug (22.5%)(95% CI: 34.42 to −10.76) and decreased cost per prescription (1.91%)(95%CI: −0.33% to −3.49%)
D'Onofrio et al. (2002), controlled educational trial	$N = 36$ emergency medicine residents, 4-hour didactic, video, and structured skills-based workshop ($n = 17$ intervention group and $n = 19$ control group)	Screening and Intervening with patients presenting with alcohol problems	Medical records with evidence of review and intervention; self-reported change in knowledge, current practice, self-efficacy, role responsibility, attitudes & beliefs, provider readiness to change at 1 year	Significant increase in knowledge scores ($p < .001$) and medical records with evidence of review and intervention (95% CI: 31–50, $p < .001$); no significant between-group differences in other self-reported outcomes

(*continued*)

Table 3. *(continued)*

Author, year, design	Participants, intervention	Outcome(s) assessed	Outcome measure(s)	Results
Freemantle et al. (2002), randomized controlled trial	General medicine practices in 12 districts, educational sessions by pharmacists on practice guidelines	Prescribing practices	Numbers of patients treated within practice guidelines	Significant improvement in prescribing practices (OR = 1.24)(95% CI: 1.07–1.42), increased number of patients treated within guidelines (5.2%)(95% CI: 1.7%–8.7%); smaller groups of practitioners (2 or fewer) improved performance more than larger groups

rate of 78% (18/23). A majority of respondents required their interns to participate in oral case presentations (67%) and write case reports (65%), but only a small number required interns to routinely generate clinical/research questions or conduct literature searches (18%). The study also reported that no respondents required their interns to participate in journal clubs and that interns were likely to rely on clinical faculty, preclinic course instruction, and textbooks for clinical decision making.

Green (59) described an innovative teaching strategy, which included student-written letters about recently published articles to journal editors, to develop critical thinking and professional communication skills in chiropractic students. Prior to the assignment, students were taught elements of basic research designs commonly published in chiropractic literature and were provided instruction and practice, in critical appraisal. Results demonstrated a large percentage of students who felt they were more likely to write editorial letters to journals when in practice and felt the assignment and course helped to develop critical appraisal and professional communication skills.

Green and Johnson (60) described their clinical epidemiology course requiring integration of critical thinking skills with ability to acquire data and apply it. Student evaluations indicated that they learned most from self-directed, active learning situations, but were frustrated if insufficient individualized instructor contact was provided.

Fernandez and Delaney (61) conducted a one-group pretest-posttest design (simple panel design) with investigator-blinded survey administration to measure effectiveness of EB educational activities using adult learning theory with chiropractic interns ($n = 31$) at a college teaching clinic. Activities included two workshops on constructing clinical questions and critical appraisal of published research, and independent patient-based EBHC assignments. A qualitative self-assessment survey was administered before and after a 6-week period of EBHC activities to measure their effectiveness. Eighty-one percent (81%) of subjects completed pretest-posttest surveys, which showed statistically significant differences in interns' self-assessed ability to construct an answerable clinical question and appraise research articles and apply them to patient management, as well as their rating of importance of EB patient decision making. The authors concluded that having chiropractic interns apply EBHC to actual patients and attend critical appraisal workshops increased their perceived ability to practice EBHC.

DISCUSSION

We reviewed 21 research studies addressing areas of evidence-based health care in medical and chiropractic education, including the teaching and practice of question development, literature searching, critical appraisal, and application of evidence to patients. These suggest that educational interventions may improve critical appraisal skills, reading effectiveness, knowledge of critical appraisal, clinical epidemiology and biostatistics, and patient outcomes. Studies comparing efficacy of teaching methods are needed.

Table 4. Educational Outcomes From EBHC in Chiropractic Education, Single Studies

Author, year, design	Participants, intervention	Outcome(s) assessed	Outcome measure(s)	Results
Rose and Adams (2000), cross-sectional survey study	Clinical administrator or director of chiropractic college clinics worldwide	To what degree are EBHC methods being taught and utilized in chiropractic college outpatient clinics?	Survey developed by review of literature identifying the domains of EBHC	67% of respondents indicated that their interns participated in oral case rounds with 50% of these required to support with literature. Only 11% required interns to generate research questions for investigation about their clinical cases. Procedures utilized in clinics based on evidence: 6% routinely, 41% moderate degree, 41% small degree, 12% not at all.
Green (2001), survey study	First-year chiropractic students; teaching strategy including instruction in basic research design, critical appraisal, and assignment of student-written letters to editors of peer-reviewed journals	Critical appraisal and professional communication skills	Survey of student self-reported skills	Large percentage of students felt that they would be more likely to write to the editor of a journal when in practice and felt their critical appraisal and professional communication skills were better developed.
Green and Johnson (1999), survey study	First-year chiropractic students in clinical epidemiology course requiring the integration of critical thinking skills	Critical thinking skills with the ability to acquire information and apply or use it	Survey of student self-reported skills	Course evaluations (survey) indicated that students enjoy and learn most from active learning opportunities and that self-directed projects provide much learning but can be a source of frustration if not enough individualized instructor contact is provided.
Fernandez and Delaney (2004 in press), a one-group pretest-posttest design (simple panel design)	First-trimester chiropractic Interns in University Teaching Health Center. Activities included two workshops on constructing clinical questions and critical appraisal of published research, and independent patient-based EBHC assignments.	Self-assessed ability to construct an answerable clinical question, conduct a literature search, appraise research articles and apply them to patient management, as well as their rating of importance of EBHC in patient decision making.	Survey instrument based on previous study (Green and Ellis) where similar survey instrument was compared to actual skills testing and found to be valid.	There were statistically significant differences in interns' self-assessed ability to construct an answerable clinical question, appraise research articles and apply them to patient management, as well as their rating of importance of EBHC in patient decision making.

Most single studies in medical education were limited in research design, but developed strategies for teaching evidence-based health care. Limitations of some include a lack of randomization of participants, low numbers of subjects, short follow-up periods, and possible "test-training effect" when investigators used identical pretests and posttests.

Four systematic reviews were identified that assessed various questions and objectives regarding teaching critical appraisal skills or knowledge, clinical epidemiology and biostatistics knowledge, and use of literature in clinical decision making. No reviews of undergraduate education assessed patient care outcomes. Three reviews assessed critical appraisal skills, and two cited a study (7) reporting nonstatistically significant improvement in critical appraisal skills following a journal club intervention. One systematic review excluded trials where critical appraisal was provided as only one component in an educational package, such as in an evidence-based program, or where effects of critical appraisal training could not be separated from other interventional components (14). Another review with broader objectives and inclusion criteria found six studies of less rigorous methodology reporting improved critical appraisal skills following various teaching interventions (5). The systematic review by Green (12) reported a range of "no-effect" to 23% net absolute increase in test scores following training in critical appraisal.

Three systematic reviews reported statistically significant improvement in critical appraisal knowledge following teaching interventions. Parkes et al. (14) reported 25% improvement compared to controls 6% ($p = .02$) in a study of medical residents. Norman and Shannon (50) found significant mean gains in critical appraisal knowledge among 1st-year medical students (17%), but only small gains in residents (1.3%), but their review may be weakened by its design, which combined data from studies of varying interventions and outcome measures. Green's review evaluated comparative teaching methods of clinical epidemiology, critical appraisal, and EBHC (15). The most common curricular objective was improved critical appraisal skills, the most common format was resident-directed small group seminars, and multiple-choice exams were the most common outcome measure.

Six randomized controlled trials and one controlled educational trial of the effect of EB medical education on patient outcomes were identified. Participants, interventions, and outcome measures assessed varied greatly. Overall, these provide early evidence that EB training may increase positive outcomes for patients.

Two descriptive studies (59,60) in chiropractic education reported positive student responses to a clinical epidemiology course which focused on critical appraisal and professional communication, and a third survey study found improved self-assessed critical appraisal skills after didactic seminars with patient-related assignments (61). Another survey study found that EBHC curricula are not widely used in chiropractic college clinics (58). These limited studies show potential strategies for other chiropractic curricula and the need for chiropractic curricula focused on critical appraisal and evidence-based health care.

Our review found few studies evaluating EBHC in chiropractic curricula and no studies evaluating patient outcomes after such training. Rigorous research studies of educational and patient outcomes are needed in light of the chiropractic profession's historically philosophical approach (62) and early evidence that EB medical education improves patient outcomes.

CONCLUSIONS

EBHC developed from practical need in addressing clinical uncertainty and expanding information and evolves through continuous integration of research. Improved knowledge, skills, and attitudes after EB medical education were demonstrated in six single studies and four systematic reviews. Teaching methods included journal clubs, didactic classroom instruction, and training in critical appraisal and epidemiology. Six controlled trials showed improved patient outcomes after EB medical education, using didactic training in guidelines or critical reviews, structured skills workshop, video and printed material, and direct clinical reports.

Limited evidence from three single studies (no controlled trials) indicated EB chiropractic training improved educational outcomes. Teaching methods included primarily didactic sessions in critical appraisal, journal clubs and interactive case-based group sessions, and patient-based clinical assignments. No studies were found on the comparative effectiveness of various teaching methods or chiropractic patient outcomes. Educational resources should be allocated based on evidence of type/combination of teaching methods

producing the best outcomes. Rigorous research using randomized controlled trials is needed to determine whether EBHC teaching is a cost-effective strategy to improve educational and patient care outcomes.

Received, August 23, 2003
Accepted, August 21, 2004
Address correspondence to: Charles E. Fernandez, LACC/SCUHS, P.O. Box 1160, Whittier, CA 90609-1166; e-mail: charlesfernandez@scuhs.edu.

REFERENCES

1. Green ML, Ellis PJ. Impact of an evidence-based medicine curriculum based on adult learning theory. J Gen Intern Med 1997;12:742–50.
2. Evidence-Based Medicine Working Group. Evidence-based medicine: a new approach to teaching the practice of medicine. JAMA 1992:268:2420–2425.
3. Sackett DL, Rosenberg WMC. The need for evidence-based medicine. J: R Soc Med 1995:88:620–624.
4. Tsafir J. Who needs evidence-based health care? Bull Med Libr Assoc 1998;86(1):40–45.
5. Ebbert JO, Monitori VM, Schultz HJ. The journal club in postgraduate medical education: a systematic review. Med Teacher 2001;23:5.
6. Sleeman W. Dr. Osler and the Book and Journal Club of the Medical and Chirurgical Faculty of Maryland. Maryland Med J 1990;39:1111.
7. Linser M, Brown JT, Frazier LM, DeLong ER, Siegel WC. Impact of a medical journal club on house-staff reading habits, knowledge, and critical appraisal skills: a randomized controlled trial. JAMA 1988;260:2537–2541.
8. Linzer M. The journal club and medical education: over one hundred years of unrecorded history. Postgrad Med J 1987;63:475.
9. Markert RJ. A research methods and statistics journal club for residents. Acad Med 1989;64:233.
10. Kitching AD, Ross Jr. Resuscitating the cardiology journal club. Can J Cardiol 1992;8:520.
11. Langkamp DL, Pascoe JM, Nelson DB. The effect of a medical journal club on residents' knowledge of clinical epidemiology and biostatistics. Fam Med 1992;24:528.
12. Green ML. Graduate medical education training in clinical epidemiology. Critical appraisal, and evidence-based medicine: A critical review of curricula. Acad Med 1999;74:686–694.
13. Seelig CB. Affecting residents' literature reading attitudes, behaviors, and knowledge through a journal club intervention. J Gen Intern Med 1991;6:330–334.
14. Parkes J, Hyde C, Deeks J, Milne R. Teaching critical appraisal skills in health care settings. Cochrane Database of Systematic Reviews, Issue 2, 2002.
15. Seltzer CC. Critical appraisal of the Royal College of Physicians' report on smoking and health. Lancet 1972;1(7744):243–248.
16. Fisher B. Cooperative clinical trials in primary breast cancer: a critical appraisal. Cancer 1973;31(5):1271–1286.
17. Department of Clinical Epidemiology and Biostatistics, McMaster University Health Sciences Centre. How to read clinical journals. I. Why to read them and how to start reading them critically. CMAJ 1981;124(5): 555–558.
18. Sackett DL, Richardson S, Rosenberg W, Haynes B. Evidence-Based Medicine: How to Practice and Teach EBM, 1st and 2nd eds. Oxford: Churchill-Livingstone, 1997:1–252.
19. Leung W. Why is evidence from ethnographic and discourse research needed in medicine the case of problem-based learning. Med Teach 2002; March (2): 169–172.
20. Knowles M. The adult learner: a neglected species. Houston, Tx: Gulf Publishing Co., 1984.
21. Barrows HS. Problem-based, self-directed learning. JAMA 1983;250:3077–3080.
22. Neame RLB, Powis DA. Toward independent learning: curricular design for assisting students to learn how to learn. J Med Educ 1981;56:886–893.
23. Goldberg HI, Deyo RA, Taylor VM, Cheadle AD, Conrad DA, Loeser JD, Heagerty PJ, Diehr P. Can evidence change the rate of back surgery? A randomized trial of community-based education. Effect Clin Pract 2001;4(3):95–104.
24. Chalon P, Delvenne C, Pasleau F. Problem-based learning, description of a pedagological method leading to evidence-based medicine. [Article in French.] Rev Med Liege 2000;55(4):233–238.
25. Nandi PL, Chan JN, Chan CP, Chan P, Chan LP. Undergraduate medical education: comparison of problem-based learning and conventional teaching. Hong Kong Med J 2000;6(3):301–306.
26. Barondess JA. The future physician: realistic expectations and curricular needs. J Med Educ 1981;56:381–389.
27. Rafuse J. Evidence-based medicine means MDs must develop new skills, attitudes: CMA conference told. Can Med Assoc J 1994;150:1479–1480.
28. Accreditation Council for Graduate Medical Education. Program requirements for residency education in internal medicine: special educational requirements. In: The Graduate Medical Education Directory, 1996–7. Chicago, IL: American Medical Association, 1996:79.
29. Physicians for the twenty-first century: report of the project panel on the general professional education of the physician and college preparation for medicine. J Med Educ 1984;59(pt 2):127–128, 155–167.
30. Srinivasan M, Weiner M, Breitfeld PP, Brahmi F, Dickerson KL, Weiner G. Early introduction of an evidence-based medicine course to preclinical medical students. J Gen Intern Med 2002;17:58–65.
31. United States Medical Licensing Examination. Step 1: Content Description and Sample Test Materials. Philadelphia, PA: Federation of State Medical Boards, Inc. and National Board of Medical Examiners 2000:13.
32. Delaney P, Fernandez C. Toward an evidence-based model for chiropractic education. J Manipulative Physiol Ther 1999;22:114–118.
33. Evidence-Based Medicine Working Group. Evidence-based medicine. A new approach to teaching the practice of medicine. JAMA 1992;268(17):2420–2425.
34. Haynes RB, McKibbon KA, Walker CJ, Ryan N, Fitzgerald D, Ramsden MF. Online access to MEDLINE in clinical settings. a study of use and usefulness. Ann Intern Med 1990;112:78–84.
35. Haynes RB, McKibbon KA, Fitzgerald D, Guyatt GH, Walker CJ, Sackett DL. How to keep up with the medical literature. IV. Using the literature to solve clinical problems. Ann Intern Med 1986;105:636–640.
36. Haynes RB, McKibbon KA, Fitzgerald D, Guyatt GH, Walker CJ, Sackett DL. How to keep up with the medical

literature. IV. Access by personal computer to the medical literature. Ann Intern Med 1986;105:810–816.
37. Medeiros JM. Barriers to compliance with evidence-based guidelines. J Man Manipulative Ther. 2002;10:7–9.
38. Rosen A, Teesson M. Does case management work? The evidence and the abuse of evidence-based medicine. Aust NZ J Psychiatry 2001;35:731–746.
39. Ellis J, Mulligan I, Rowe J, Sackett DL. Inpatient medicine is evidence-based. Lancet 1995;346:407–410.
40. Clarke M, Oxman A. Formulating the problem. Cochrane reviewers' handbook 4.0- (updated July 1999); Section 4. In: Review Manager (RevMan) [Computer program]. Version 4.0, Oxford, UK: the Cochrane Collaboration.
41. Ayanian JZ, Hauptman PJ, Guadagnoli E, Antman EM, Pachos CL, McNeil BJ. Knowledge and practices of generalist and specialist physicians regarding drug therapy for acute myocardial infarction. N Engl J Med 1994; 331:1136–1142.
42. Brand DA, Newcomber LN, Freiburger A, Tian H. Cardiologists' practices compared with practice guidelines: use of beta-blockade after acute myocardial infarction. J Am Coll Cardiol 1995;26:1432–1436.
43. Soumeral SB, McLaughlin TJ, Spiegelman D, Hertzmark E, Thibault G, Goldman L. Adverse outcomes of under use of beta-blockers in elderly survivors of acute myocardial infarction. JAMA 1997;277:115–121.
44. Covel DG, Uman GC, Manning PR. Information needs in office practice: are they being met? Ann Intern Med 1985;103:596–599.
45. Osiobe SA. Use of information resources by health professionals: a review of the literature. Soc Sci Med 1985;21:965–973.
46. McKibbon KA, Haynes RB, Walker-Dilks CJ, et al. How good are clinical MEDLINE searches? A comparative study of clinical end user and librarian searches. Comput Biomed Res 1990;23:583–593.
47. Weiss St, Samet JM. An assessment of physician knowledge of epidemiology and biostatistics. J Med Educ 1980;55:692–697.
48. Berwick DM, Fineberg HV, Weinstein MC. When doctors meet numbers. Am J Med 1981;71:991–998.
49. Sackett DL, Rosenberg WC, Gray JA, Haynes RB, et al. Evidence-based medicine: what it is and what it isn't. BMJ 1996;312(7023):71–72.
50. Kitchens JM, Pfeifer MP. Teaching residents to read the medical literature: a controlled trial of a curriculum in critical appraisal/clinical epidemiology. J Gen Intern Med 1989;4(5):384–387.
51. Norman GR, Shannon SI. Effectiveness of instruction in critical appraisal (evidence-based medicine) skills: a critical appraisal. CMAJ 1998;158(2):177–181.
52. Balas EA, Boren SA, Hicks LL, Chonko AM, Stephenson K. Effect of linking practice data to published evidence. A randomized controlled trial of clinical direct reports. Med Care 1998;36(1):79–87.
53. Sanci LA, Coffey CM, Veit FC, Carr-Gregg M, Patton GC, Day N, Bowes G. Evaluation of the effectiveness of an educational intervention for general practitioners in adolescent health care: randomized controlled trial. BMJ 2000;320(7229):224–230.
54. Searle J, Grover S, Santin A, Weideman P. Randomized trial of an integrated educational strategy to reduce investigation rates in young women with dysfunctional uterine bleeding. Aust NZ J Obstet Gynaecol 2002;42(4): 395–400.
55. Bernal-Delgado E, Galeote-Mayor M, Pradas-Arnal F, Peiro-Moreno S. Evidence based educational outreach visits: effects on prescriptions of non-steroidal anti-inflammatory drugs. J Epidemiol Commun Health 2002; 56(9):653–658.
56. D'Onofrio G, Nadel ES, Deglutis LC, Sullivan LM, Casper K, Bernstein E, Samet JH. Improving emergency medicine residents' approach to patients with alcohol problems: a controlled educational trial. Ann Emerg Med 2002;40(1):50–62.
57. Freemantle N, Nazareth I, Eccles M, Wood J, Haines A. Evidence-based outreach trialists. A randomized controlled trial of the effect of educational outreach by community pharmacists on prescribing in UK general practices. Br J Gen Pract 2002;52(482):767.
58. Rose KA, Adams A. A survey of the use of evidence-based health care in chiropractic college clinics. J Chiropr Educ 2000;14:71–77.
59. Green B. Letters to the Editor for Teaching Critical Thinking and Professional Communication. J Chiropr Ed 2001;15(1):8–9.
60. Green B, Johnson C. Teaching clinical epidemiology in chiropractic: a first-year course in evidence-based healthcare. J Chiropr Ed 1999;13(1):18–19.
61. Fernandez C, Delaney P. Applying evidence-based health care to musculoskeletal patients as an educational strategy for chiropractic interns (a one-group pretest-posttest study). J Manipulative Physiol Ther 2004; in press.
62. Johnson C, Green B. Chiropractic education and critical thinking. Top Clin Chiropr 1998;5(2):34–40.