Systematic Review of the Effectiveness of Continuing Dental Professional Development on Learning, Behavior, or Patient Outcomes

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Abstract: This study is based on a systematic review of studies using a randomized controlled trial or quasi-experimental design in order to synthesize existing evidence evaluating the effectiveness of continuing professional development (CPD) interventions in dentistry on learning gains, behavior change, or patient outcomes. The authors searched a range of electronic databases from 1986 to the present and screened all potentially relevant studies for inclusion, using pre-established inclusion/exclusion criteria. Following data extraction and quality appraisal of all included studies, a narrative synthesis of the studies was undertaken. Ten studies (in fourteen articles) were included. All were evaluation studies of CPD interventions targeted exclusively at dentists. The ten included studies evaluated a range of interventions: courses/workshops, written information, CAL, audit/self-reflection, face-to-face support, and black box combinations of these interventions. Two high- and moderately high-quality studies evaluated CAL CPD for dentists and found equivocal impact of CAL for dentists. A black box combination of interventions was rigorously evaluated and showed moderate impact on patient care. This finding suggests that multimethod and multiphased CPD has potential for the greatest impact. There is a need for more high-quality randomized controlled trials evaluating CPD interventions in dentistry. It is important that future evaluations of CPD interventions clarify the nature of the interventions such that they are explicit and replicable and that appropriate outcomes are selected (health of patients and change in practice or behavior as well as knowledge and understanding) in order to move the evidence base of effective practice forward in this area of dental education.

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It has long been widely accepted as good practice for health care professionals to keep up-to-date with their clinical skills and knowledge and ensure that research developments and new techniques are integrated into patient care. Increasing public expectations, an aging society (with its associated comorbidities), the increasing diversity of the health professions workforce, and the greater likelihood of refresher training following career breaks are just some of the pressures that heighten the importance of effective ongoing professional educational activity. Also, in the face of mounting cost pressures on publicly funded health systems, such as the United Kingdom’s National Health Service (NHS), finding the most effective ways to educate health care professionals is imperative.

Professionals working in dentistry are no exception to these pressures. The changing profile of dental disease is well documented. For example, an aging population brings with it the need for more complex high technology dentistry; increasing numbers of women dentists are evident in younger age groups; and, in recent years, legislative amendments have altered the skill mix in primary care dental teams, with, for example, expanded roles for dental therapists. Education and training at all levels...
program towards becoming a specialist. This breadth was to ensure an inclusive approach, with the aim of differentiating between strategies and approaches within CPD at the synthesis stage of the review. CPD can be focused on clinical or nonclinical topics in a range of ways from formal interventions, such as courses or conferences, to self-directed reading of journals. A full definition of the educational interventions included in this review is provided in Table 1.

Over a decade ago, the UK government stressed the key role CPD plays in ensuring quality and strongly encouraged the professional bodies to strengthen systems for self-regulation and promote lifelong learning. In response, the last ten years has witnessed a strengthening in the requirements for members of the dental team to participate in and record their CPD activity. All registered members of the dental team in the UK must now undertake mandatory CPD hours. This requirement was first introduced for dentists by the regulatory body, the General Dental Council (GDC), in its publication of Lifelong Learning. More recently, dental care professionals (DCPs) have followed suit with requirements to participate in CPD—though to a lesser specified amount than their dentist colleagues. Similarly, since August 2008, all DCPs (which includes dental nurses, dental technicians, clinical dental technicians, orthodontic therapists, dental therapists, and dental hygienists) are required to register with the GDC on the DCP register. In the United States, continuing professional development is required for credentialing. Arguably, such a professional requirement for all registered members of the dental team to complete mandatory hours of CPD simply stipulates participation in CPD activity, rather than implementation of any learning gained to the benefit of patient care. There is very limited prescription about what is learned and how it is learned, with the exception of

**Table 1. Definitions of terms and concepts used in the review**

**Members of the dental team:** this includes qualified clinical dental staff, which means registered (included in a register held by a dental regulatory body) dentists, dental therapists, dental hygienists, and dental nurses.

**Continuing professional development:** any education or training that takes place after initial qualification that aims to advance professional development in the field of dentistry, either clinical or nonclinical.

**Effectiveness:** any measured (quantified) impact of a continuing professional development intervention on one or more members of the dental team, including learning or knowledge and skills gain, behavior change, and patient outcomes (self-report and measured).

**Intervention:** any educational intervention (or combination of interventions), including courses, conferences, clinical audit, peer review, journal clubs, e-learning, and distance learning as well as journal reading and private study. These could be unidisciplinary and targeted at any one of the members of the dental team (e.g., dentist, dental nurse) or multidisciplinary and/or targeted at dental teams working together.
Evaluating the Effectiveness of CPD

With the evidence-based medicine movement and a shift towards clinical guidelines and clinical audit, health care has witnessed a change in the desire to find out what works and to ensure it is implemented. There is a desire to close the gap between research evidence and practice. However, in order for education to contribute towards bridging this gap, we need to better understand how education can be more or less effective in securing real change for both health professionals and patients.

As such, interest in evaluating the effectiveness of continuing education interventions for health professionals has escalated in the last twenty years, and the amount of educational evaluation research literature is significant. The framework provided by Kirkpatrick, which is focused on the evaluation of a training program or educational activity, structured our approach to this review. Kirkpatrick suggests that evaluation can take place at a number of levels, which we have modified and applied to health care settings as follows: Level 1—participation: numbers and types of participants; Level 2—reaction: participants’ reaction to the education; Level 3—learning or knowledge: principles, facts, and techniques learned; Level 4—performance: changes in practice or behavior resulting from the education; and Level 5—health care outcomes: the health of patients. As shown in Table 1, our review defined educational effectiveness in terms of Kirkpatrick’s Levels 3, 4, and 5 (learning, behavior change, or patient outcomes), and we included studies with quantified measures (including self-report) of effectiveness at any of these three levels.

Previous Systematic Reviews in Medicine and Dentistry

The professional group for whom the evaluation literature on the effectiveness of educational interventions is most rich is medical practitioners. Indeed, there have been systematic reviews in the field of medical education and reviews that focus on a mix of health professionals. However, systematic review research focused on the education of distinct health care professionals other than doctors has been slower to evolve, and there is very limited systematic literature review evidence in continuing dental education.

In medical education, Cantillon and Jones summarized the findings of a systematic review of CPD and reported that it is most effective when linked to clinical practice, interactive educational meetings, and outreach events and strategies that involve multiple educational interventions and when including reinforcement and reminders. The least effective methods were lecture format teaching and unsolicited printed material. These findings were supported by Davis et al., who found that didactic, traditional lecture-based sessions had little impact. Multimethod and multiphased CPD (more than a one-off event) has been found more likely to bring about change. Prior needs assessment was also found to be important in directing the uptake of effective educational interventions, with the additional proviso that giving doctors freedom to select which educational events to attend will not encourage them to stray outside their comfort zone. This finding supports research evidence on the effectiveness of tools used by professionals to identify their learning needs. Selection of the most effective educational intervention should therefore not be based entirely on doctors’ self-assessment of their educational needs or knowledge deficits, but should use evidence from a range of sources.

Dental professionals have unique characteristics that make them distinct from professionals working in medicine. The vast majority of registered members of the dental team work in the general dental service, i.e., a dental practice/office. These dental professionals are more isolated in their professional work and workplace learning environments than many other health professionals. In the UK, most are contracted NHS performers who undertake a mixed
profile of NHS and private treatments and have limited routine contact with neighboring dental practices.

Only two previous reviews investigating the effectiveness of continuing dental education (CDE) have been undertaken, as far as we are aware, and these were not systematic reviews. Non-systematic reviews have the potential to suffer from a range of biases, including selection bias and design bias. Bader undertook a critical review of evaluations of effectiveness in CDE published in the twenty-five years preceding 1987. He included sixteen studies, only four of which used an experimental or quasi-experimental design, and only six of which had clinical process or patient health outcomes. Bader concluded that that there was a very low evidence base for the effects of CDE at that time. Eaton et al. undertook a literature review of the impact of CPD in dentistry. Although the authors used a “systematic approach” for searching the dental literature and “specific exclusion criteria” (p. 10), they themselves state that theirs was not a systematic review. They used a strength of evidence tool to differentiate between studies of different designs (from systematic reviews of multiple randomized controlled trials [RCTs] to RCTs to expert opinion). Eaton et al. included ninety-four studies in their review, of which only six were RCTs. However, they did not quality appraise the included RCTs and, therefore, did not differentiate between trials of different quality. Rosenberg et al.’s systematic review in the effectiveness of one narrow area in the topic of CDE was published in 2003. The authors identified twelve RCTs that investigated the effectiveness of computer-aided, self-instructional programs in dental education. They concluded that the evidence of the effectiveness of such programs in dental education was equivocal.

Methods

A systematic review is a method of locating, appraising, and synthesizing evidence. The stages of a systematic review are explicit and open to scrutiny and aim to limit potential selection, publication, and other biases. Evidence is collected, screened for quality, and synthesized into an overall summary of the research in the field. We used the PRISMA statement (www.prisma-statement.org/) to guide the design, conduct, and reporting. A peer-reviewed protocol for the review was developed prior to locating any studies for inclusion to minimize any possible sources of bias in the design and conduct of the review. We sent our search strategy to an independent information specialist in the health care research field who read it and responded that she found it to be an appropriate and rigorous search strategy.

This systematic review analyzes and synthesizes the evidence from international studies using experimental and quasi-experimental design because studies employing these designs enable causal inference to be inferred regarding the effectiveness of interventions. It also appraises the quality of the empirical literature regarding continuing education’s effectiveness for the dental team using an assessment of risk of bias tool adapted from the CONSORT statement. Our risk of bias tool was developed from the five most important items on the CONSORT checklist: details of sequence generation of the randomization and whether it was independent and concealed; whether outcome ascertainment was blinded; whether sample size was adequate; whether there was significant differential attrition; and whether there was implementation fidelity. We also looked at any other potential sources of bias in the design, conduct, and reporting of the study and used judgment to rate the studies as being of high, medium, or low quality.

As far as we are aware, since the original publication of the CONSORT statement in 1996, there has been no attempt in the literature to quality appraise the studies on dental CPD using a quality assessment tool based on the CONSORT guidelines. It should be noted that our inclusion criteria included quality items such as whether quantified outcomes were available for extraction, which means that all studies that were included met minimum standards.

There is currently very limited evidence about the effectiveness of continuing professional development in dentistry and only one systematic review. This review was conducted twenty-three years ago and synthesized studies from the previous twenty-five years. Given the expansion of modes of continuing education for dentists during this time period (such as clinical audit and peer review) and its heightened prominence in health policy, it is appropriate and necessary to conduct a new systematic review of continuing professional development in dentistry that explores the evidence from the last twenty-five years. This timeframe builds directly on the date of searches conducted by Bader that reviewed the effectiveness of CPD literature from 1961 to 1986. Definitions of all key terms are provided in Table 1.

The following electronic databases were searched from 1986 to the present: Cochrane Library (Cochrane Database of Systematic Reviews, DARE and HTA Databases, and Cochrane CENTRAL Reg-
<table>
<thead>
<tr>
<th>Study</th>
<th>Setting</th>
<th>Number and Type of Participants</th>
<th>Intervention Characteristics</th>
<th>Main Results/Conclusions</th>
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</table>
| Bahrami et al. (2004)       | Primary Dental Care, General Dental Service (Scotland)                  | 51 GDPs randomly allocated at practice level into one of four groups (2x2 factorial design) | Intervention 1=audit and feedback (A&F)  
Intervention 2=CAL (laptop-based tool)  
All groups (including control) received copy of guidelines and a course.                                                                                                           | “In an environment where pre-intervention compliance was unexpectedly high, there was no evidence that CAL or A&F increased compliance with the SIGN guideline... compared with mailing GDPs and providing them with the opportunity to attend a postgraduate course alone” (p. 686). |
| Bonetti et al. (2009)       | Private Dental Care, General Dental Practice (GDPs, Australia)          | 1,471 private GDPs randomly allocated to four groups (two intervention groups, two control groups),  
Control 1 completed self-assessment manual at pre- and posttest, Control 2 at posttest only. | Intervention 1=self-assessment manual, relevant references, and feedback on scores (pretest), half-day course, written materials, and interactive workshop  
Intervention 2=self-assessment manual, relevant references, feedback on scores (pretest)                                                                                                                                 | A&F significantly increased knowledge, compared with CAL and controls, but A&F’s increased knowledge did not predict extracting behavior.  
Regardless of intervention, dentists’ attitude, perceived behavioral control, and self-efficacy were found to predict extraction behavior.  
The interventions failed to change behavior because they missed causal mechanisms of that behavior (self-efficacy, perceived behavioral control, and especially attitudes). |
| Best and Messer (2003)      | Primary Dental Care, Private Dental Practice (GDPs, Australia)          | 147 private GDPs randomly allocated to four groups (two intervention groups, two control groups),  
Control 1 completed self-assessment manual at pre- and posttest, Control 2 at posttest only. | Intervention: course (one-day educational workshop)                                                                                                                                                                        | Self-assessment instrument (manual), receipt of scores, and relevant references were effective in facilitating change in quality dental practice.  
The course/workshop intervention was not found to have had an effect, but response rate bias was apparent. High attrition from Intervention 1 group “may indicate that the topic [of quality improvement] and intensity of the intervention may not have matched their needs or learning styles... strategies and techniques for professional development of dentists should include observations of patterns of participation” (p. 132). |
| Clarkson et al. (2008)      | Primary Dental Care, General Dental Service (Scotland)                  | 149 GDPs randomly allocated to four groups (2x2 factorial design), two groups relevant for review (education; control, no education) | Intervention: course (one-day educational workshop)                                                                                                                                                                        | The educational intervention showed a positive trend (in terms of increase in sealant treatments) but did not reach statistical significance; possible clinically significant effects couldn’t be ruled out.  
Findings suggest “teaching an evidence-based approach to primary care dentists may not produce readily detectable changes in clinical practice” (p. 643). |
| Kay et al. (2001)            | Not stated, “dentists”                                                  | 95 dentists randomly allocated to three groups (Solomon 3 group design) | Intervention: CAL package                                                                                                                                                                                                   | “The CAL package had no effect on the sensitivity and specificity of dentists’ restorative treatment decision making behavior. This finding... has very important implications, given the burgeoning use of computer packages in education” (p. 557). |
Table 2. Characteristics of studies included in the systematic review

<table>
<thead>
<tr>
<th>Study</th>
<th>Participants</th>
<th>Intervention Characteristics</th>
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</thead>
<tbody>
<tr>
<td>Lang et al. (1991)</td>
<td>GDPs randomly allocated to four groups. Dentists</td>
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<tr>
<td></td>
<td>randomly allocated to control or experimental</td>
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<tr>
<td></td>
<td>group; dentists in experimental group “elected”</td>
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<tr>
<td></td>
<td>one of three groups.</td>
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<tr>
<td>Mettes et al. (2010)</td>
<td>GDPs randomly allocated by peer groups (QUALs)</td>
<td></td>
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<tr>
<td></td>
<td>into two groups (experimental, control).</td>
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</tr>
<tr>
<td>Molander et al. (2007)</td>
<td>GDPs randomly allocated by clinic (25 clinics)</td>
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<tr>
<td></td>
<td>into three groups (two intervention groups, one</td>
<td></td>
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<tr>
<td></td>
<td>control group).</td>
<td></td>
</tr>
<tr>
<td>Sadowsky and Kunzel (1991)</td>
<td>GDPs randomly assigned to six groups (four</td>
<td></td>
</tr>
<tr>
<td></td>
<td>experimental groups, two control groups)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>but not clear from article the numbers in each</td>
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</tbody>
</table>

All education groups had significantly higher knowledge scores, indicating that knowledge can be increased by means other than direct contact. Attitude values increased but not significantly and sealant use did not increase. It can be concluded that, “for sealants, continuing education is likely to increase dentists’ knowledge but have little effect upon attitudes or sealant use” (p. 169).

A multifaceted intervention “showed small to moderate effects in planned patient subgroups in levels of adherence to the . . . guidelines . . . The primary outcome most in need of improvement (i.e., recall assignment in low risk groups) showed a small but relevant improvement” (p. 75).

“Implementation of the education packages exerted influence on the quality of the dentist performance” (p. 259). Rate of good-quality root fillings increased significantly for both intervention groups, and the rate of low-quality root fillings decreased (but not significantly). When the two educational programs were compared, no significant difference was found on root canal quality.

Both interventions equally effective in improving dentists’ knowledge in most instances tested. No attenuation of the interventions’ effect over study period (9 months). The relative absence of the effect of Intervention 2 (theory) could be explained by the value of having “succinct, didactic (information) oriented toward a clinical rather than a scholarly audience” (p. 924). Overall, “it is possible to improve clinicians’ knowledge through direct mail, and the effect does not disappear rapidly” (p. 925).

(continued)
Results

A total of 2,427 potentially relevant studies were retrieved through the electronic searches. Table 5 presents the characteristics of included studies. A narrative synthesis involved grouping the studies thematically in terms of their design characteristics, and then commonalities between studies. A meta-analysis was not undertaken as there was insufficient homogeneity among the included studies to justify this approach to synthesis.

Table 2. Characteristics of included studies (continued)

<table>
<thead>
<tr>
<th>Study</th>
<th>Setting</th>
<th>Number and Type of Participants</th>
<th>Intervention Characteristics</th>
<th>Main Results/Conclusions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seager et al. (2005)</td>
<td>Primary Dental Care, GDPs (Wales)</td>
<td>9/7 dentists randomly allocated at practice level to three groups (two interventions, one control)</td>
<td>Intervention 1: written guidelines and patient information leaflets</td>
<td>The results suggest that “evidence-based guidelines alone do not improve prescribing by general dental practitioners. However, educational outreach visits by a pharmacist may be successfully employed to improve prescribing” (p. 222).</td>
</tr>
<tr>
<td>van der Sanden et al. (2005)</td>
<td>Primary Dental Care, GDPs (Netherlands)</td>
<td>92 dentists randomized into two groups (experimental, control)</td>
<td>Intervention: a multifaceted educational intervention (feedback, reminders, and an educational meeting)</td>
<td>The educational intervention employed for dissemination and implementation of a clinical practice guideline “improves dentists' knowledge and is effective in improving decision making in simulated cases; however, no clinical effect on their actual clinical practice was demonstrated” (p. 349).</td>
</tr>
</tbody>
</table>

GDP=general dental practitioner, CAL=computer-assisted learning
Note: See reference list for full citations for each article.
leading to the identification of seventeen for inclusion in the review. One article was excluded during data extraction (third stage) due to a high attrition rate; two systematic reviews were excluded from the review, leaving a final total of ten empirical studies published in fourteen articles (see Table 6). Figure 1 shows the flow in inclusion and exclusion of studies through all stages of screening.

The key characteristics of the ten studies (fourteen articles) included in the review are shown...
the ten studies, five looked simply at self-reported learning gains and/or behavior change. These five studies included one that assessed self-reported learning (knowledge) gains and participants’ views towards the intervention, two studies that reviewed dentists’ self-reported learning gains and self-reported behavior change, and two studies that reported behavior change alone. Seager et al. used self-report measures of behavior change, and Kay et al. provided simulated patients to test dentists’ intended behavior. Five studies examined patient outcomes: two were based on the dentists’ self-reported change of their patient care and three studies measured patient outcomes or change in patient care by independent scrutiny of patient records. Notably, the study by Bahrami, which looked at patient outcomes, also produced a complementary article to examine self-reported learning gains and participants’ views. Similarly, Molander et al. produced a second article, which reported self-reported learning gains and self-reported behavior change from the included study. Van der Sanden et al. was the only article that reviewed outcomes at all three levels: learning gain, behavior change, and patient outcomes. Thus, using Kirkpatrick’s three highest levels of the educational effectiveness, out of the ten studies included in this review, one study focussed on learning gains (Level 3), four studies examined behavior change (Level 4), and five studies examined patient outcome (Level 5).

Study Quality

All of the studies met a minimum standard of rigor because they all used an experimental design to evaluate a CPD intervention. This is important because only studies that use an RCT design or quasi-experimental design (QED) are able to warrant the conclusion that an intervention, control, or comparison condition is more or less effective than another condition. Having said this, the quality of the individual studies varied, particularly in terms of rigor in design, conduct, and reporting (see Table 7). Eight studies were judged to be of high to moderately high quality in terms of rigorous design, conduct, and reporting based on the results of the use of the quality assessment tool to extract data about features in the design of the trials that could have introduced bias at randomization or post-randomization. Specifically, these studies included all or most of the following: explicit statements concerning sequence generation for the random allocation and independent, concealed randomization (to minimize bias at randomization);
Titles and abstracts identified and screened  
\( n = 2827 \)

Duplicates  
\( n = 557 \)

Excluded at pre-screening stage  
\( n = 1985 \)

Excluded at first-stage screening  
\( n = 247 \)

Full copies retrieved and assessed for eligibility  
\( n = 38 \)

Excluded  
\( n = 21 \)
- Not CPD  \( n = 12 \)
- Inadequate study design  \( n = 4 \)
- No full paper  \( n = 1 \)
- Not dental focus  \( n = 4 \)

Publications meeting inclusion criteria  
\( n = 17 \)

Excluded  
\( n = 3 \)
- High Attrition Rate  \( n = 2 \)
- Systematic Reviews  \( n = 1 \)

Publications included in the review  
\( n = 14 \)

Number of studies included in the review  
\( n = 10 \)

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Figure 1. Flowchart of study selection process
Table 7. Quality assessment of studies included in systematic review

<table>
<thead>
<tr>
<th>Study</th>
<th>Random Allocation: Sequence Generation; Independent, Concealed?</th>
<th>Blinded Assessment of Outcome?</th>
<th>Sample Size; Attrition</th>
<th>Implementation Fidelity</th>
<th>Other</th>
<th>Overall Judgment of Quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bahrami et al. (2004)</td>
<td>Computer generation; independent, concealed</td>
<td>Yes</td>
<td>51 practices; attrition low (8%)</td>
<td>Not stated</td>
<td>Cluster RCT</td>
<td>High</td>
</tr>
<tr>
<td>Best and Messer (2003)</td>
<td>Computer generation; not stated</td>
<td>Not stated</td>
<td>TG1: 469 assigned randomly, 71 recruited, 38 completed pretest, reduced to 8 at posttest TG2: 334 assigned randomly, 243 recruited, 69 completed baseline pretest, reduced to 29 at posttest CG1: 334 assigned randomly, 232 recruited, 54 completed baseline pretest, reduced to 25 at posttest CG2: 334 assigned randomly, 257 recruited, 70 completed posttest</td>
<td>Not stated</td>
<td>Individual RCT; possibility of recruitment bias</td>
<td>Moderate</td>
</tr>
<tr>
<td>Clarkson et al. (2008)</td>
<td>Not stated; independent, concealed</td>
<td>Not stated</td>
<td>149 dentists allocated/randomized (73 in education arm, 76 in control [no education]); 16 lost to follow-up (8 in education arm, 8 in control); 133 in sample for analysis (63 education arm, 68 control)</td>
<td>Not stated</td>
<td>Individual RCT; use of CONSORT flow diagram</td>
<td>High</td>
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<tr>
<td>Kay et al. (2001)</td>
<td>Not stated</td>
<td>Not stated</td>
<td>n=95 randomized into 3 armed trial In Group 3, data from 1 dentist unusable reducing from 31 to 30; overall, 95 dentists randomized reduced to 94 (99%). Attrition low.</td>
<td>Not stated</td>
<td>Individual RCT</td>
<td>Moderately high</td>
</tr>
<tr>
<td>Lang et al. (1991)</td>
<td>Not stated</td>
<td>Not stated</td>
<td>1,361 allocated to experimental (n=923) or control (n=438) 1,037 returned both pre- and post-surveys. Pediatric dentists (n=23) removed from analysis “because the number of pediatric dentists completing both surveys was small” (p. 166), leaving 1,014.</td>
<td>Not stated</td>
<td>Individual RCT</td>
<td>Moderately high</td>
</tr>
<tr>
<td>Mettes et al. (2010)</td>
<td>Computer generation; independent, concealed</td>
<td>Not stated</td>
<td>GDPS: Nine peer groups of GDPs (iQuals) were recruited. Two declined further participation; seven peer groups of GDPs were then randomized (n=51 GDPs). 4 groups in the intervention group (n=27 GDPs) and 3 in the control (n=24 GDPs). All these took part in pretest. 3 GDPs in the intervention group were lost in the intervention phase, leaving 24 GDPs in the intervention group and 24 GDPs in the control group for the posttest (total n=48 GDPs). Patients: At pretest, total of 1,162 patients: 643 in the intervention group and 519 in control group. At posttest, total of 1,139 (different patients): 608 in the intervention group, and 531 in control group (6 patients were excluded because of incomplete data, not stated which arm).</td>
<td>Not stated</td>
<td>Cluster RCT</td>
<td>Moderately high</td>
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<tr>
<td>Study</td>
<td>Random Allocation</td>
<td>Blinded</td>
<td>Fidelity of Quality</td>
<td>Notes</td>
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<tr>
<td>Bahrami et al. (2004)</td>
<td>Yes</td>
<td></td>
<td>High</td>
<td>Pre- and post-intervention data obtained for only 94 dentists in total (64% of the original 148). Reasons for dropout given (insufficient molars in the study period, termination of employment, parental leave, long-term sick leave, etc.). Authors argue no bias.</td>
<td></td>
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<tr>
<td>Best and Messer (2003)</td>
<td>Not stated</td>
<td>Not stated</td>
<td>Not stated</td>
<td>Attrition at dentist level (n=54). High attrition &gt;30%. “It was possible to retrieve cases treated before and after education from only 64% of practitioners originally enrolled in the study” (pp. 257-8).</td>
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<td>Clarkson et al. (2008)</td>
<td>Not stated</td>
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<td>Moderate</td>
<td>1,361 allocated to experimental (n=923) or control (n=438); 1,037 returned both pre- and post-surveys. Pediatric dentists (n=23) re-both surveys was small” (p. 166), leaving 1,014.</td>
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<tr>
<td>Mettes et al. (2007)</td>
<td>Computer generation; independent, concealed</td>
<td>Not stated</td>
<td>Not stated</td>
<td>468 GDPs were randomly assigned. Not clear numbers allocated to each of the six groups. Article stated that “an overall response rate of 87.20% was achieved” (p. 924), leaving 598 dentists responding to questionnaires.</td>
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<tr>
<td>Seager et al. (2005)</td>
<td>Computer generation; independent, concealed</td>
<td>Not stated</td>
<td>High</td>
<td>343 dentists invited, 111 agreed to participate, 97 randomized (control=32; guideline only=32; guideline + visit=33). 93 took part in the intervention (control=32; guideline only=32; guideline + visit=29). 70 responded to post-test (control=23; guideline only=20; guideline + visit=27). From the 70 practitioners, 1,496 questionnaires were returned (control=490; guideline only=451; academic detailing=556).</td>
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<td>van der Sanden et al. (2005)</td>
<td>Random number table</td>
<td>Not stated</td>
<td>High</td>
<td>150 GDPs invited to participate, 92 were randomized (46 intervention group, 46 control). Pretest clinical data and pretest questionnaire (simulated patients) data collected from all 92 (46+46). 79 completed posttest questionnaire and were eligible for analysis (38 intervention group, 41 control). 92 were included in the posttest clinical data analysis. 13 lost from follow-up of questionnaire data. 92 at assignment and 79 at posttest analysis (8 from intervention and 5 from control). No attrition for the follow-up of the clinical data (92 at pretest and 92 at posttest).</td>
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GDP=general dental practitioner; RCT=randomized controlled trial
Note: See reference list for full citations for each article.
appropriate analysis (taking clustering into account where relevant and adopting an intention to treat analysis as the primary analytical strategy); and reporting the flow of participants through the trial, with low attrition or appropriate measures to deal with higher levels of attrition (to minimize bias post-randomization). In some studies not all features were present: there was a lack of an explicit statement about how the random allocation was done and whether assessment of outcome was blinded. Finally, two studies demonstrated some limitations in terms of design, conduct, or reporting. Sadowsky and Kunzel randomly assigned 686 general dental practitioners, but it is not clear how many were allocated to each of the six groups in the write-up. Best and Messer undertook random allocation before recruitment, which could have introduced a potential for recruitment bias. In Table 7, we show the results of the quality assessment of each of the ten studies and our overall quality judgment statement.

**Substantive Findings by Type of Intervention**

The ten included studies evaluated a range of CPD interventions against a variety of control conditions. As shown in Table 2, most (n=6) studied the impact of more than one educational intervention and used more than one experimental arm to determine differential treatment effects. Two studies evaluated a single intervention, and the remaining two studies employed a black box design in which the aim was not to interpret the distinct effect of any one active ingredient (or educational intervention) within the box but rather to evaluate the totality of components and features of the intervention.

**Courses and workshops.** Four studies were designed to determine the impact of a formally taught course/lecture or workshop program. These interventions were predominantly a half-day or day in duration, apart from the Lang et al. study, which evaluated a lecture program delivered over a twelve-month period. All interventions included an interactive element, primarily specifying a hands-on aspect.

The impact of these interventions was found to be variable; the quality of the four studies was judged to range from moderate to high. Clarkson et al. evaluated a one-day educational workshop of training in evidence-based health care and found a positive but negligible impact on dentists’ self-reported change in their patient care in terms of increased use of sealants on second permanent molars. However, the change did not reach statistical significance. This study was judged to be of overall high quality. Molander et al.’s study evaluated the impact of a lecture course on the quality of root fillings. They examined patient records by independent scrutiny and found a significant effect of the course/workshop studies. Both a four-hour lecture and a six-hour hands-on session demonstrated impact on the rate of high-quality root fillings, but there was no significant distinction between the effect of the lecture versus the hands-on component. However, the attrition rate in this study was greater than 30 percent, and this could have introduced a potential source of attrition bias. Lang et al. evaluated a sustained educational course over twelve months, with a lecture-based and hands-on aspect. Dentists’ self-reported knowledge gain and behavior change were used as outcome measures. However, an effect was only observed in terms of knowledge gain, rather than attitude or behavior change. This is possibly because attitudes towards the topic of fissure sealants were high at baseline, producing the potential for risk of a ceiling effect. Best and Messer evaluated a four-and-a-half-hour course and a one-hour workshop. Although neither was not found to have an effect, high attrition and low participant numbers were reported.

**Written information.** Three moderate and moderately high-quality studies evaluated interventions that provided written materials in some form, including guidelines/best practices, research articles, patient information, and course materials. The three studies were of variable quality. Overall, their findings suggest that written information increased participant knowledge but was not sufficient to change clinical behavior. Lang et al. reported that an increase in knowledge was observed from written materials, just as much as from the course/workshop. Similarly, Sadowsky and Kunzel reported that mailed interventions (whether basic or detailed, theory based in content) increased knowledge. Seager et al. compared two interventions: the provision of evidence-based guidelines only versus provision of guidelines with a face-to-face visit by a qualified professional. They reported that the written information alone had no discernible impact on the dentists’ self-reported patient care.

**Computer-assisted learning.** Two studies evaluated computer-assisted learning (CAL) as a form of CPD for dentists. Bahrami et al. used a high-quality factorial design (2x2) to assess the impact of two separate interventions: a CAL tool and an audit and feedback educational intervention.
Impact was measured by two independent researchers assessing participating dentists’ clinical records. Kay et al. provided a pre and post simulated test to measure dentists’ restorative decision making behavior and used a moderately high-quality Solomon three-group design to exclude the possibility of the pretest having an effect. The substantive findings of both studies reached the same conclusion: there was no evidence that either of these CAL interventions had an effect on dentists’ patient care or behavior. Moreover, Bonetti et al. who investigated knowledge and attitudes towards changing clinical behavior amongst the trial participants in the Bahrami et al. study, reported that the CAL intervention did not increase dentists’ knowledge significantly either. These findings are limited as they drew on only two studies and therefore should be treated cautiously; however, arguably our findings endorse the systematic review findings reported by Rosenberg et al. that the impact of using CAL for dentists’ CPD remains uncertain.

**Audit/self-reflection/feedback.** Interventions that involved dentists’ self-reflection on their practice formed an element of two studies in our review. As highlighted above, Bahrami et al.’s report was of a high-quality study that compared an audit and feedback intervention with a CAL tool to increase compliance with a clinical guideline. Best and Messer relied on voluntary participation and experienced high rates of attrition. We judged their evaluation to be of moderate quality. They compared participants’ self-assessment of their dental practice with a course/workshop in changing behavior. Both studies provided feedback to dentists about their audit results and their self-assessment scores against standards of best practice as a way of informing participants’ behavior change. The substantive findings demonstrated that the effect of the interventions was mixed. There was no evidence that audit and feedback increased compliance with the topic guideline, as measured by change in patient care, although Bonetti et al. reported that the intervention had increased dentists’ knowledge. In contrast, Best and Messer’s self-assessment tool was reported to be effective in facilitating change in the quality of dental practice, although the authors’ acknowledged response bias in the study emphasizes the need for more high-quality research focussed on this kind of intervention.

**Face-to-face support.** Only one study tested the impact of a face-to-face visit by an experienced health professional to influence participating dentists’ behavior in line with guidelines for antibiotic prescribing and compared this effect with distributing guidelines alone. Seager et al. measured dentists’ self-reports of behavior change and found a significant impact of the visit when compared with guidelines alone and the control. The findings of this study suggest that face-to-face support and discussion offer promise in changing dentists’ clinical behavior—albeit an intervention likely to be resource-intensive in pragmatic implementation. Further RCT studies in dental CPD are needed to evaluate this kind of intervention; so too is an evaluation of the sustainability of such potential effects.

**Black box interventions.** Two moderately high-quality studies adopted a distinct approach to investigate the effectiveness of CPD on participating dentists. Rather than distilling separate interventions for assessment, these studies adopted a black box design evaluating multifaceted educational strategies that comprised several of the interventions listed above in combination. For example, Mettes et al. evaluated an online tool, written guidelines, an interactive meeting, and reminders, while van der Sanden et al. evaluated written guidelines, an educational meeting, provision of feedback, and reminders. Both studies demonstrated moderate effects: the primary outcome most in need of improvement showed a relevant improvement in dentists’ self-assessment of patient care. Seager et al. reported improvements in knowledge and decision making as tested in simulated cases, but no clinical effect in dentists’ self-reported patient care was found.

**Discussion**

Our systematic review found only ten trials evaluating the effectiveness of continuing professional development on one of the outcomes of interest. It is important to note that the limited evidence base does not necessarily imply that CPD interventions are not effective; the fact that we were not able to draw firm conclusions from this systematic review is a reflection of the nature of the evidence base. However, several observations are warranted from the limited evidence. First, two high- and moderately high-quality studies evaluated CAL CPD for dentists, and their findings endorse a previous systematic review that demonstrated equivocal impact of CAL for dentists. Given the burgeoning use of CAL for dentists, this is an intervention that should be prioritized for further high-quality evaluation using experimental designs. Second, a black
box combination of interventions was rigorously evaluated by Mettes et al.\textsuperscript{31} and showed moderate impact on patient care. This limited finding supports the findings from medical education systematic reviews\textsuperscript{11,14} that multimethod and multiphased CPD has potential for the greatest impact. Further research using randomized controlled trial designs is required in dentistry to reach a more definitive evidence base. Given the popularity of short attendance courses for dentists, it is not surprising that the largest number of included studies (n=4) investigated the impact of courses for dentists. However, with the exception of the study by Clarkson et al.,\textsuperscript{30} these studies were insufficiently robust to draw firm conclusions. Given that the medical education literature suggests interactive, hands-on, sustained courses hold most promise, future evaluations of dental CPD studies should be clearer about distilling these features.

This review signals the limitations of the international RCT literature in dental education across all key formal CPD interventions in terms of quality and quantity. It is important for future RCT research into the effectiveness of CPD interventions for dentists to be considered in the light of other research evidence. Two studies in our review\textsuperscript{27,31} concluded that part of the reason for limited effects of the intervention evaluated could have been because the pretest results were already high (at ceiling) and the dentists were studying a topic in their comfort zone. This signals the need for future RCT studies to be mindful of the topics studied as well as the interventions targeted. Clearly, the mode of the delivery is critical, but so too is its timing and topic. Building the RCT literature to better understand dental CPD is a key priority; however, this will not be the panacea for guaranteed dental CPD effectiveness for the future. Dental professionals and educators will still need to be mindful of the most appropriate topics, be engaged in identifying the learning needs of potential learners, and plan which interventions to target for whom at the right time.

Conclusions and Recommendations

This systematic review located a moderate number of studies undertaken in the last twenty-five years. The ten included studies were judged to be of moderate or better quality in design and implementation. However, only five used an outcome measure based on patient care, and only three of these did so independently using patient records rather than relying on dentists’ self-report.

It is clear from this review that there is need for more high-quality randomized controlled trials evaluating CPD interventions in dentistry. This is especially pressing given the resources committed to supporting members of the dental team to participate in regular CPD. In the UK, the proposals to introduce revalidation may help dentists target their selection of CPD, but until the academic and professional communities understand more about the effectiveness of CPD interventions in dentistry, arguably such proposals can have limited impact. Finally, it is important that future evaluations of CPD interventions clarify the nature of the interventions so that they are explicit and replicable and that appropriate outcomes are selected based on the higher levels in Kirkpatrick’s framework\textsuperscript{12} (health of patients and change in practice or behavior as well as knowledge and understanding) in order to move the evidence base of effective practice forward in this area of dental education.

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Author Contributions

Vickie Firmstone led on background and contributed to all phases of the review. Carole Torgerson is the corresponding author; she led on design, methodology, and methods and contributed to all phases. Karen Elley provided subject expertise and contributed to all phases. Magdalena Skrybant provided administrative and research support. Anne Fry-Smith and Sue Bayliss wrote the search strategies and undertook the electronic searches. All authors contributed to and approved the final article.

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