A systematic review of interventions promoting clinical information retrieval technology (CIRT) adoption by healthcare professionals


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Purpose: This paper presents the evidence on the effectiveness of interventions promoting the use of clinical information retrieval technologies (CIRTS) by healthcare professionals.

Methods: We electronically searched articles published between January 1990 and March 2008 using following inclusion criteria: (1) participants were healthcare professionals; (2) specific intervention promoted CIRT adoption; (3) studies were randomised controlled trials, controlled clinical trials, controlled before and after studies or interrupted time series analyses; and (4) they objectively reporting measured outcomes on CIRT use.

Results: We found nine studies focusing on CIRT use. Main outcomes measured were searching skills and/or frequency of use of electronic databases by healthcare professionals. Three studies reported a positive effect of the intervention on CIRT adoption, one showed a positive impact post-intervention, and four studies failed to demonstrate significant intervention effect. The ninth study examined financial disincentives, and found a significant negative effect of introducing user fees for searching MEDLINE in clinical settings. A meta-analysis showed that educational meetings were the only type of interventions reporting consistent positive effects on CIRT adoption.

Conclusion: CIRT is an information and communication technology commonly used in healthcare settings. Interventions promoting CIRT adoption by healthcare professionals have shown some success in improving searching skills and use of electronic databases. However, the effectiveness of these interventions remains uncertain and more rigorous studies are needed.

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DOI: 10.1016/j.ijmedinf.2010.07.004
1. Introduction

Information and communication technologies (ICT) have the potential to address many of the challenges that health systems are currently confronting but remain underused by healthcare professionals. In a recent work [1], we were interested in effectiveness of interventions promoting ICT adoption by healthcare professionals. A Cochrane review has been done on this topic and found very few experimental studies, while most of the included studies focused on clinical information retrieval technology (CIRT) [1]. It is particularly relevant to assess adoption of CIRT since this type of ICT is perhaps the one that clinicians use the most in their daily practice.

Information retrieval (IR) refers to information-seeking behaviours and processes (information being actively found from a search) and CIRT refers to databases, e.g., MEDLINE, and search engines that clinicians can use to retrieve general information on disease prevention, health promotion, diagnosis, treatment and prognosis when needed to answer clinical questions at the point-of-care [2,3]. CIRT corresponds to knowledge-based information systems, and do not include patient-based systems (such as computerised patient records) [4]. In addition to provide information potentially applicable for patient care, CIRT may contribute to continuing professional education, as shown in a comprehensive study of CIRT usage [5].

Pluye et al. [5] have shown that CIRT has greatly improved access to updated medical information and research evidence over the last decades and constitutes a new means of supporting clinical decision making. A randomised controlled trial has found that librarian-mediated searches could answer clinical questions and have positive cognitive impact on decision making [6]. However, such services are not widely available, and the ability to search the literature effectively has become essential for clinicians to implement evidence-based practice. If clinicians are increasingly turning to the Internet to satisfy their information and educational needs [2,7], several barriers still block the acquisition and use of high quality research information in healthcare, as reported by Haynes et al. [8]. According to surveys, their main barriers physicians report for using CIRT are the lack of time due to busy daily routines [9,10], and the lack of skills to seek for information within databases [10,11]. Data from the 2004 National Physician Survey show that information technology is increasingly integrated by new generations of Canadian family physicians, but still varies between provinces. These tools seem to be more integrated by physicians from isolated or remote areas [12].

Optimal integration of ICT into healthcare professionals’ practices should be based upon the highest level of available scientific evidence with respect to implementation strategies [13,14]. The effectiveness of interventions aiming at ICT adoption and their integration into healthcare professionals’ practices is likely to be influenced by various factors pertaining to individual, group, organisational, and contextual characteristics and by the very nature of the intervention [15,16]. The present paper aims to review current evidence on the effectiveness of interventions promoting healthcare professionals’ CIRT adoption and optimal use. Outcomes of interest include CIRT usage, but also other dimensions related to the quality of CIRT use, as proposed by Hersh & Hickman in their framework for evaluating information retrieval systems [17].

2. Methods

2.1. Inclusion and exclusion criteria

We sought randomised controlled trials (RCTs), controlled clinical trials (CCTs), controlled before and after studies (CBAs), and interrupted time series analyses (ITS). Study participants had to be healthcare professionals providing clinical
care to patients, including professionals in training (residents, fellows, and other registered health professionals), who were exposed to an intervention aimed at promoting CIRT adoption or use (digital libraries or electronic databases). Any type of intervention described in the Effective Practice and Organisation of Care (EPOC) Review Group of the Cochrane Collaboration data collection checklist [18] was included. The intervention had to go beyond the simple provision of or access to an application; i.e., a planned strategy to promote the adoption or use of this application should have been implemented. Healthcare professionals’ performance was selected as the primary outcome of interest for this review. We sought objective measures of healthcare professionals’ CIRT adoption or use (e.g., the frequency or duration of use), but also measures of the quality of use (e.g., efficacy and relevance of searches).

Second, we considered any objective measure of general clinical performance or process outcome. Measures of healthcare practitioners’ attitudes or satisfaction were included in this review as secondary outcomes as they may provide useful complementary information. Studies with only self-reported measures were excluded following the requirements of the EPOC Review Group. Studies published from January 1, 1990 until March 3, 2008 in all languages were considered.

This review focused on CIRT which refers to databases and search engines that clinicians can use to retrieve general information on disease prevention, health promotion, diagnosis, treatment and prognosis when needed in order to answer clinical questions at the point-of-care.

2.2. Search strategy

Specific strategies defined with the help of an information specialist were used to search the EPOC register and the database of studies awaiting assessment. To cover not only the medical, but also social sciences (education, psychology mainly) and computer sciences, we conducted extensive searches across disciplines in the following databases: MEDLINE, EMBASE, Cochrane Database of Systematic Reviews, Ovid, Database of Abstracts of Reviews of Effects (DARE), Cumulative Index of Nursing and Allied Health Literature (CINAHL), Biosis Previews, Psychological Abstracts (PsycINFO), Current Content, Health Services/Technology Assessment Text (HSTAT), Dissertation Abstracts, Educational Resources Information (ERIC), Proquest, ISI Web of Knowledge, Latin American and Caribbean Health Sciences (LILACS), and Ingenta.

Search strategies for electronic databases were developed with the help of an information specialist using the methodological component of the EPOC search strategy combined with selected ICT terms and free text terms relating to ICT. This search strategy was then translated into the other databases using the appropriate controlled vocabulary as applicable.

Given the high number of irrelevant references found in the initial review, we decided, after consultation with an information specialist, to use only three databases (MEDLINE, Embase, Cochrane Database of Systematic Reviews) for the update of the review. This choice was justified because all studies included in the first systematic review were found in these three databases. All relevant references found in the included studies were also reviewed, and publications citing the selected articles were searched through the ISI Science Citation index.

2.3. Study identification

All titles and abstracts were screened and full-text copies of all potentially relevant studies were retrieved. Each study was then independently assessed for eligibility by two reviewers randomly chosen among six members of the research team (MPG/FL/ML/PP/PF/JG). Discrepancies were resolved by consensus or involvement of a third reviewer.

2.4. Data abstraction and quality assessment of included studies

Two teams of reviewers (MPG/MD and JC/CP) independently and systematically assessed characteristics of the studies and extracted data using the EPOC Data Collection Checklist. Study authors were contacted if data were missing or needed clarification; all contacted authors replied. Discrepancies in ratings were resolved by consensus and involvement of a third reviewer when necessary.

Each study included in the review was rated for its risk of bias (high, moderate or low protection against bias) by two independent reviewers based on three main criteria: concealment of allocation, blinded or objective assessment of primary outcome(s) and follow-up of participants. We assigned a rating of HIGH protection against bias when those three criteria were scored as done, and when there were no important concerns related to other risk of bias, e.g., risk of contamination; MODERATE when one or two criteria were scored as not clear or not done; and LOW when more than two criteria were scored as not clear or not done [19]. Discrepancies were resolved by consensus.

2.5. Analysis

Methods proposed by Grimshaw [13] were used to guide data analysis and presentation. Studies were analysed using the RevMan 5 software [20]. Statistical analysis considered both dichotomous process outcomes and continuous process outcomes. Relative risk differences were calculated for dichotomous variables, and standardised mean differences for continuous variables. When data were insufficient to calculate effect sizes, results are presented as reported by authors of primary studies.

First, we report the main results for each study in natural units (e.g., average number of logins on a database per physician). When baseline data are available from RCTs, pre- and post-intervention means, as well as proportion or percentage are reported for both experimental and control groups. The absolute change from baseline is calculated (change in experimental group values minus change in control group values) with the 95% confidence limits when possible. When baseline data are not available, results are expressed as the relative percentage change (the difference between post-intervention values in the experimental and control groups divided by the post-intervention values in the control group). This score allows estimating a standardised effect for each outcome,
which can be interpreted and pooled across studies regardless of the original measurement scale [21].

Second, we report meta-analysis that was conducted by pooling similar outcomes reported across studies. Since dichotomous and continuous data are used to report similar outcomes, we have to re-express standardised mean differences as odds ratios, allowing dichotomous and continuous data to be pooled together. Based on an assumption that the underlying continuous measurements in each intervention group follow a logistic distribution, and that the variability of the outcomes is the same in both intervention and control participants, the standardised mean difference can be re-expressed as log odds ratios using the formula proposed by Chinn [22]:

\[ \ln \text{OR} = \frac{\pi}{\sqrt{3}} \cdot \frac{\text{SMD}}{\text{EM}} \]

Once standardised mean differences (or log odds ratios) and their standard errors have been computed for all studies in the meta-analysis, they are combined using the generic inverse-variance method in RevMan 5.

3. Results

The search generated a total of 47,979 references. Of those, 47,916 were excluded based mainly on title and abstract. Then, 63 studies were assessed in details by two independent evaluators. Following this evaluation, 10 studies were included in the Cochrane review and eight of them [8, 23–29] were about CIRT. An update of the review was done in March 2008 and another relevant study about CIRT was found [30]. Fig. 1 presents the process of search and selection and includes the update.

3.1. Study characteristics

Study characteristics are presented in Table 1. All included studies focused on the use of electronic databases and digital libraries, often MEDLINE (in six studies). They were all RCTs involving physicians as participants (including residents, interns, clinical clerks, clinical fellows, and faculty). Only one study [25] also included other healthcare professionals. Seven studies were conducted in North America (including three in Canada), one in Hong Kong [25], and one in Australia [29]. Three studies were published before 2000 [26–28].

Frequency of CIRT use (and sometimes duration of logins) and search performance (measured by the number of citations per search, search recall, precision, and others) were the main outcome measures in four studies [24, 26–28]. One of these studies [8] measured frequency of use, use of relevant, evidence-based information, usefulness and satisfaction with the system (utility). The study by Magrabi et al. [29] considered the frequency of CIRT use as the main outcome measure, but was also interested in factors that influenced usage. The three other studies [23, 25, 30] focused on improving searching skills (including clinical question formulation), but have also measured frequency of use. One of these studies [30] also evaluated comfort in searching EBM resources.

The nine studies were RCTs included four cluster randomised controlled trials (C-RCT) [8, 23, 24, 29]. As reported in Table 1, the methodological quality of these RCTs was moderate except for one study [8] that had a low risk of bias (high quality). In three RCTs [26, 27, 30] it was not possible to determine whether the contamination between groups was totally prevented. The C-RCTs were conducted to minimise contamination between study groups, but in two of them [23, 24] authors mentioned that they could not be certain that contamination between groups was totally prevented.

Fig. 1 – Search and selection of studies for the systematic review. *Two references found on the same study.
<table>
<thead>
<tr>
<th>Study</th>
<th>Design</th>
<th>Allocation concealment</th>
<th>Follow-up of professionals</th>
<th>Blinded assessment</th>
<th>Overall protection against bias</th>
<th>Participants</th>
<th>Interventions</th>
<th>Outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bradley [23]</td>
<td>C-RCT</td>
<td>Adequate</td>
<td>Done</td>
<td>Unclear</td>
<td>Moderate</td>
<td>10 residents in a neonatal intensive care unit Country: USA</td>
<td>1. Real-time librarian instruction about EBM searching (during one month) + educational material 2. Control 1. 1-h didactic session + use of well-built clinical question cards + practical sessions in clinical question building 2. Control</td>
<td>Search strategy, perceptions, satisfaction and opinion about use of MEDLINE</td>
</tr>
<tr>
<td>Cabell [24]</td>
<td>C-RCT</td>
<td>Unclear</td>
<td>Done</td>
<td>Done</td>
<td>Moderate</td>
<td>48 residents in a university hospital-based internal medicine training program Country: USA</td>
<td>Use of library information system: number of log-ons, time spent searching, total searching volume, abstracts viewed, and full-text articles viewed</td>
<td></td>
</tr>
<tr>
<td>Cheng [25]</td>
<td>RCT</td>
<td>Adequate</td>
<td>Not done</td>
<td>Unclear</td>
<td>Moderate</td>
<td>800 hospital clinicians Country: Hong Kong (China)</td>
<td>1. 3-h training workshop (with supervised hands-on practice) 2. Control</td>
<td>Clinical question formulation, awareness, knowledge, confidence and use of databases, attitude towards the use of electronic information services, searching skills MEDLINE search frequency, duration, recall, precision and searcher satisfaction</td>
</tr>
<tr>
<td>Erickson [26]</td>
<td>RCT</td>
<td>Adequate</td>
<td>Not done</td>
<td>Done</td>
<td>Moderate</td>
<td>31 obstetrics and gynecology residents training at an academic medical centre Country: USA</td>
<td>1. 1-h individual tutorial on MEDLINE with hands-on instruction: resident performing the searches 2. 1-h individual tutorial with all searching conducted by the instructor or 3. Control</td>
<td></td>
</tr>
<tr>
<td>Haynes [28]</td>
<td>RCT</td>
<td>Unclear</td>
<td>Done (for main outcomes)</td>
<td>Done (for main outcomes)</td>
<td>Moderate</td>
<td>59 physicians and physicians-in training of a teaching hospital Country: Canada</td>
<td>1. Introducing user fees for MEDLINE searching in clinical settings (pay group) 2. Continue searching without charge (no pay group)</td>
<td>Frequency and quality (number of citations per search, search recall, precision) of MEDLINE searching; effect on decision</td>
</tr>
<tr>
<td>Study</td>
<td>Design</td>
<td>Allocation concealment</td>
<td>Follow-up of professionals</td>
<td>Blinded assessment</td>
<td>Overall protection against bias</td>
<td>Participants</td>
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<tr>
<td>Haynes [27]</td>
<td>RCT</td>
<td>Unclear</td>
<td>Unclear</td>
<td>Done (for main outcomes)</td>
<td>Moderate</td>
<td>308 physicians and physicians-in-training from six departments of a teaching hospital Country: Canada</td>
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<td></td>
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<td>Before randomisation: 2 h of basic training 1. Access to a clinical preceptor experienced in MEDLINE searching + audit and feedback about search quality from a study librarian 2. Control</td>
<td></td>
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<tr>
<td>Haynes [8]</td>
<td>C-RCT</td>
<td>Adequate</td>
<td>Done (for relevant outcomes)</td>
<td>Done (for relevant outcomes)</td>
<td>High</td>
<td>203 physicians in a sparsely populated area Country: Canada</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Magrabi [29]</td>
<td>C-RCT</td>
<td>Unclear</td>
<td>Not done (for relevant outcomes)</td>
<td>Done</td>
<td>Moderate</td>
<td>227 physicians (general practice) from across the country Country: Australia</td>
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<td></td>
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<td></td>
<td>1. Advanced online training which provided additional guidance to answer clinical questions 2. Control (standard tutorial)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stark [30]</td>
<td>RCT</td>
<td>Unclear</td>
<td>Done</td>
<td>Done (for some outcomes)</td>
<td>Moderate</td>
<td>77 residents (2nd- and 3rd-year) in internal medicine Country: USA</td>
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<tr>
<td></td>
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<td></td>
<td>1. Searching tutorials (up to six) 1-h small group sessions with card of “searching pearls” 2. Control (an usual medical conference)</td>
<td></td>
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</tr>
</tbody>
</table>

Outcomes:
- Nb of searches, search performance (nb relevant citations, precision, recall), cost and time/session, perception of searches worth and other perceptions
- Utilisation of the service, utility, use of relevant evidence-based information, clinical usefulness

**Table 1 – (Continued)**
3.2. Effects of interventions promoting healthcare professionals’ CIRT adoption or use

Eight out of nine studies evaluated interventions categorised as professionals [8,23–27,29,30] according to the EPOC Checklist [18]. The ninth study [28] evaluated a financial intervention targeted to healthcare professionals. The effects of interventions are presented in Table 2.

3.3. Professional interventions

Four types of professional interventions [18] were evaluated in the reviewed studies: (1) educational meetings; (2) distribution of educational materials; (3) educational outreach visits; and (4) audit and feedback. Three studies compared a single intervention specifically designed to improve healthcare professionals’ CIRT use or adoption, and no intervention [25] or standard practice [8,29]. The study by Erickson et al. [26] compared two interventions, but at the outset, the two intervention groups were combined and compared with a control group (no intervention). Four studies [23,24,27,30] tested a multifaceted intervention.

3.3.1. Single interventions

3.3.1.1. Educational meetings. Two studies evaluated the effects of educational meetings on CIRT use [25,26]. A basic training on information retrieval including practical sessions was used in these studies with different modes of delivery and duration. In the study by Cheng [25], the intervention consisted of a 3-h training workshop with supervised hands-on practice. The study reported that the educational intervention increased the proportion of clinicians able to provide an adequate clinical question (relative difference = 31%, 95% CI; 22% to 39%; p < 0.001). In the study by Erickson and Warner [26], the intervention consisted of individual tutoring and hands-on instruction, and a 1-h user-driven tutorial was compared with either a 1-h instructor-led tutorial or no intervention. This study [26] found no effect of the intervention on the proportion of residents performing two assigned searches (third search: relative difference = −5%; ns; fourth search: relative difference = −6%; ns). This study also reported a non-significant increase of 0.22 in the mean number of logins in the intervention group, but no post-intervention data were provided for the control group.

3.3.1.2. Educational material. Two studies [8,29] evaluated the effect of educational materials. In the study by Haynes et al. [8], the intervention consisted of access to an Internet-based addition to an existing digital library; this addition was providing alerts to new articles and a cumulative database of alerts. This study reported a proportion of physicians using the digital library service significantly higher in the intervention group (relative difference = 13%, 95% CI; 2–23%; p = 0.02). Moreover, the intervention increased the mean number of logins per month per user among those who used the digital library service (standardised mean difference (SMD) = 0.34, 95% CI; 0.03–0.65; p = 0.03). In the study by Magrabi et al. [29], the intervention group received advanced online training in CIRT use in addition to the basic training provided to all participants before randomisation. In this study, the frequency of searches in a digital database did not increase in the advanced training group compared to basic training (SMD = −0.07; ns). The mean number of searches was higher among participants who received the basic training, but this effect was not significant.

3.3.2. Multifaceted intervention

Four studies [23,24,27,30] tested the effect of a multifaceted intervention versus no intervention or standard practice. Haynes et al. [27] combined access to a clinical preceptor experienced in MEDLINE searching (educational outreach visit) and individualised feedback given by a librarian (audit and feedback). In this study, all participants were also given a 2-h basic training before randomisation. The study did not report any significant difference in the proportion of participants who conducted a successful search (defined as a search retrieving at least one relevant reference) for none of the two searches assessed (fourth search: relative difference = −5%; ns; eighth search: relative difference = 8%; ns) between intervention and control groups. Nevertheless, clinicians in both groups improved their search performance compared to baseline data (first search). According to the authors, this effect could be related to the basic introduction given to all participants before randomisation.

In the study by Stark et al. [30], residents in the intervention group participated in 1-h small group sessions (up to six) to search for answers to questions about hospitalised patients. A card with description of databases and suggested techniques in PubMed was also given to each participant. Meanwhile residents in control group attended a usual medical conference. Although residents in the intervention group used more searching techniques than control residents, the number of successful searches did not differ between groups (SMD = 0.25; ns).

Bradley et al. [23] used educational outreach visits as the main component of their intervention and reported mixed effects on residents’ searching skills. In this study, real-time librarian instruction about Evidence-Based Medicine (EBM) searching was used during one month, and a floppy disk containing EBM search hedges was also distributed. Recall, precision and quality of searches were evaluated by librarians, the quality being measured notably by formulation of good questions, use appropriate of MeSH and application of logical limits. This study used a scale to rate the quality of the search strategy with 1 representing the highest score and 5 the lowest. Thus, a negative difference should be interpreted as an increase in search quality. Post-intervention data did not show a significant effect of the intervention on the quality of the search strategy (SMD = −0.08; ns). However, complementary data was obtained from the authors regarding quality of the search strategy 6 months post-intervention, and a significant increase in quality was found (SMD = −2.75, 95% CI; −4.73 to −0.77; p = 0.007).

In the study by Cabell et al. [24], individual practical sessions in clinical question building and searching of the medical literature were used in complement with a didactic session and distribution of educational material. In this study, a significant positive effect of the multifaceted intervention on residents’ use of electronic databases was found. The median number of logins significantly increased by 2.1 fold in the intervention group. However, it was not possible to com-
<table>
<thead>
<tr>
<th>Study ID</th>
<th>Type of intervention</th>
<th>Primary outcome(s)</th>
<th>Effect size</th>
<th>Conclusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bradley [23]</td>
<td>Educational outreach visits; educational material</td>
<td>(1) Quality of the search strategy (post-intervention): mean average (1 = highest)</td>
<td>(1) Score difference: $-0.08, 95% \text{ CI } = -1.32$ to $1.16, p = 0.90$</td>
<td>No significant effect of intervention on search strategy quality immediately after intervention</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(2) Quality of the search strategy (6-month follow-up): mean average (1 = highest)</td>
<td>(2) Score difference: $-2.75, 95% \text{ CI } = -4.73$ to $-0.77, p = 0.007$</td>
<td>Intervention improved quality of the search strategy 6 months after intervention</td>
</tr>
<tr>
<td>Cabell [24]</td>
<td>Educational meeting; educational material; educational outreach visits</td>
<td>(1) Search frequency (number of log-ons)</td>
<td>No data for effect size calculations. Median: 2.1 vs 4.4, $p &lt; 0.001$</td>
<td>An educational intervention increased residents’ searching activity</td>
</tr>
<tr>
<td>Cheng [25]</td>
<td>Educational meeting (workshop)</td>
<td>(1) Proportion of professionals able to provide adequate clinical question</td>
<td>(1) Intervention effect: $31%, 95% \text{ CI } = 22%$ to $39%, p &lt; 0.00001$</td>
<td>Intervention increased the proportion of clinicians able to provide adequate clinical question</td>
</tr>
<tr>
<td>Erickson [26]</td>
<td>Educational meeting (individual tutorial)</td>
<td>(1) Proportion of professionals who performed third search</td>
<td>(1) Intervention effect: $-5%, 95% \text{ CI } = -41%$ to $30%, p = 0.76$</td>
<td>No effect of intervention on the proportion of residents performing the search</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(2) Proportion of professional who performed fourth search</td>
<td>(2) Intervention effect: $-6%, 95% \text{ CI } = -45%$ to $33%, p = 0.76$</td>
<td>No effect of intervention on the proportion of residents performing the search</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(3) Search frequency (mean number of log-ons)</td>
<td>(3) Intervention effect: $0.22, 95% \text{ CI } = -0.36$ to $0.80, p = 0.45$</td>
<td>No effect on residents search frequency</td>
</tr>
<tr>
<td>Haynes [28]</td>
<td>Financial intervention</td>
<td>(1) Proportion of professionals who searched MELDINE</td>
<td>(1) Intervention effect: $-35%, 95% \text{ CI } = -57%$ to $-13%, p = 0.002$</td>
<td>An economic intervention (introducing user fees for MELDINE searching) significantly reduced the proportion of professionals who conducted a search</td>
</tr>
<tr>
<td>Haynes [27]</td>
<td>Educational outreach visits; audit and feedback</td>
<td>(1) Proportion of professionals successful at the fourth search.</td>
<td>(1) Intervention effect: $-5%, 95% \text{ CI } = -24%$ to $14%, p = 0.62$</td>
<td>No significant effect of intervention on the proportion of participants who conducted a successful search</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(2) Proportion of professionals successful at the eighth search</td>
<td>(2) Intervention effect: $8%, 95% \text{ CI } = -11%$ to $27%, p = 0.39$</td>
<td>No significant effect of intervention on the proportion of participants who conducted a successful search</td>
</tr>
<tr>
<td>Haynes [8]</td>
<td>Educational material (Internet)</td>
<td>(1) Proportion of professionals using the digital library</td>
<td>(1) Intervention effect: $13%, 95% \text{ CI } = 2%$ to $23%, p = 0.02$</td>
<td>Significant effect of intervention on proportion of professionals using the digital library</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(2) Search frequency (mean log-ons/month/user)</td>
<td>(2) Intervention effect: $0.34, 95% \text{ CI } = 0.03$ to $0.65, p = 0.03$</td>
<td>Intervention increased search frequency among those who used the digital library service</td>
</tr>
<tr>
<td>Magrabi [29]</td>
<td>Educational material (online training)</td>
<td>(1) Frequency of use (mean number of searches)</td>
<td>(1) Intervention effect: $-0.07, 95% \text{ CI } = -0.37$ to $0.23, p = 0.64$</td>
<td>No significant effect of intervention on frequency of use</td>
</tr>
<tr>
<td>Stark [30]</td>
<td>Educational meetings; educational material</td>
<td>(1) Number of successful searches</td>
<td>(1) Intervention effect: $0.25, 95% \text{ CI } = -0.21$ to $0.71, p = 0.29$</td>
<td>No significant effect of intervention on the number of successful searches</td>
</tr>
</tbody>
</table>
pute a standardised mean difference for this outcome since only medians were reported in the article and the authors could not provide complementary data.

3.4. Financial interventions

Only one study [28] described a financial intervention. This study aimed to assess the effect of introducing user fees for MEDLINE searching in clinical settings. This intervention differed from the others since it tested the negative effect of introducing user fees on healthcare professionals' CIRT use. Introducing user fees to access MEDLINE was found to significantly reduce the proportion of participants who conducted a search (relative difference = −35%, 95% CI; −57% to −13%; \( p = 0.002 \)).

3.5. Meta-analysis

In order to allow comparisons between studies, we have computed an overall "CIRT capability" outcome, defined as the proportion of health care professionals capable of performing a search, successfully searching, or using CIRT. This outcome was based on objective measures reported in the studies. When we consider the capability outcome, the overall effect is significant (Fig. 2). As seen in Fig. 2, a small weight has been given to Bradley et al.'s study [23]. The effect estimation of this study lacks precision given its small sample size and this overestimation is penalized in the weighting of the meta-analysis.

However, there is a considerable amount of heterogeneity between studies included in the meta-analysis, as shown...
by the $I^2$ statistics. A meta-analysis was nevertheless appropriate since it allows considering the overall interventions’ effect on CIRT capability and comparing different types of interventions through subgroup analyses. We have thus performed subgroups analysis based on the type of interventions. As shown in Fig. 3, the difference between types of interventions is significant ($p = 0.0007$). Only educational meetings interventions have a significant positive effect on CIRT capability (OR $= 3.65$, 95% CI; 2.48 to 5.39; $p = 0.0001$). However, there is no strong evidence against no effect for interventions providing educational material (OR $= 1.26$, 95% CI; 0.85 to 1.87; $p = 0.24$) or multifaceted interventions (OR $= 1.84$, 95% CI; 0.85 to 3.58; $p = 0.07$).

4. Discussion

As shown in a precedent systematic review [1], there are few experimental studies on ICT adoption, and most frequently they focus on CIRT. This may reflect the fact the CIRT is one of the first applications to have penetrated the healthcare sphere, specifically with the development of MEDLINE on CD-ROMs in the 1980s.

Interventions promoting CIRT adoption and use by healthcare professional have shown some success in improving searching skills and use of electronic databases. Among the nine studies included in this review, three [8,24,25] reported significant positive effects of the intervention on search frequency [8,24] or search performance [25]. Another study [23] showed a positive impact on quality of the search strategy six months after intervention.

A meta-analysis allowed consideration of the overall effect of professional-level interventions on CIRT capability and compared different types of interventions. Educational meetings are the only type of interventions showing a significant positive effect on CIRT adoption by healthcare professionals [23,24]. However, the lack of positive effect reported for other types of interventions should not be considered as evidence against their effectiveness. The limited number of studies and their small sample sizes preclude us from drawing firm conclusions about the effectiveness of interventions such as educational material and multifaceted interventions for promoting CIRT adoption by healthcare professionals. Furthermore, the small number of included studies and their heterogeneity makes it impossible to conduct subgroups comparisons that would allow testing the effect of factors such as length of intervention, long term versus short term effects, academic versus non-academic setting, and time of the study.

Eight studies included in this review targeted physicians or postgraduate physicians.

Only one study included other healthcare professionals [25]. Moreover, six studies were conducted in academic hospitals. Other studies targeted practising physicians in rural [8], urban [25] or mixed areas [29]. This finding is in line with the conclusions of Légaré et al. [31] who found that most interventions for promoting shared decision making focused on physicians only.

It is worth noting that only one study was not conducted in an Anglo-Saxon context, the study by Cheng [23]. It differs from the others in that the intervention has a strong positive impact of CIRT usage (see Fig. 2). The work by Hofstede [32] underlines major differences between Anglo-Saxon and Asian cultures, for example in the power distances (larger in the Asian culture where subordinates acknowledge the power of others based on their formal, hierarchical positions more easily than in the Anglo-Saxon culture that is more democratic) and between individualists versus collectivists cultures. This potential effect of culture could have impacted the success of the intervention.

Only one study [28] examined the effect of a financial disincentive, finding a significant negative impact of introducing user fees for MEDLINE searching on CIRT use in clinical settings. As health systems increasingly recognise the value of CIRT for supporting evidence-based practice continuing medical education (CME) activities targeting these skills are likely to be incentivised and future experimental studies may explore the effects on CIRT use [2]. For example, US organisations developing CIRT-based CME may award CME credits with the approval of the US Accreditation Council for Continuing Medical Education (ACCCME). In Canada, educational bodies are developing such policies via MainPORT® and MiniPearls® for the members of the Royal College of Physicians and Surgeons of Canada and the College of Family Physicians of Canada, respectively.

Many of the included studies may present methodological limitations that could affect the validity of reported outcomes. For instance, some studies have used multiple comparisons for the same sample without adjusting their p-value which could affect the significance of the results. Also, some studies used a cluster RCT design in order to overcome the contamination between study groups [8,23,24,29]. The consequence of adopting this type of design is that it has lower statistical power than a RCT of equivalent sample size [33]. As reported in one of the reviewed studies [30], contamination due to the frequent contacts between control and intervention groups may minimise group differences.

It is difficult to draw clear conclusions about the effectiveness of interventions promoting healthcare professionals’ CIRT adoption. Interventions based on educational meetings appear to be more successful than other types of interventions in promoting CIRT adoption by healthcare professionals, but their effect is moderate. In addition, there is no strong evidence to suggest that interventions based on educational material or multifaceted interventions are ineffective. The small samples of most of the included studies limit the strength of the conclusions than can be drawn about the effects of those interventions. Given the lack of quality data on the topic, more rigorous research is needed to assess the effectiveness of interventions that promote CIRT adoption and use. Type of research that is needed in this area should include studies comparing different interventions, as well as those exploring how to optimise CIRT implementation in clinical practice. Our results provide some insight on strategies that can be used to promote clinicians’ adoption of CIRT, but these strategies are only relevant if we can ensure that knowledge gained through these technologies is adequately appraised and transferred into practices.
Summary points
What was already known on the topic?

- If clinicians are increasingly turning to the Internet to satisfy their information and educational needs, several barriers still block the acquisition and use of high quality research information in healthcare.
- One of the main barriers to using clinical information retrieval technology (CIRT) is the lack of skills to seek for information within databases [10,11].

What does this study add to our knowledge?

- Educational meetings are the only type of interventions showing a significant positive effect on CIRT adoption by healthcare professionals.
- The lack of positive effect reported for other types of interventions should not be considered as evidence against their effectiveness.
- Given the lack of quality data on the topic, more rigorous research is needed to assess the effectiveness of interventions that promote CIRT adoption and use.

Acknowledgements

This work was supported in part by a synthesis grant from CIHR (project number: SRR – 79141) and also by a seed grant from the CHUQ research centre to Marie-Pierre Gagnon.

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