Assessing the impact of clinical information-retrieval technology in a family practice residency

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Abstract

Rationale and objective Evidence-based sources of information do not integrate self-assessment tools to assess the impact of a users' search for clinical information. We present a method to evaluate evidence-based sources of information, by systematically assessing the impact of searches for clinical information in everyday practice. **Methods** We integrated an information management tool (*InfoRetriever* 2003) with an educational intervention in a cohort of 26 family medicine residents. An electronic impact assessment scale was used by these doctors to report the perceived impact of each item of information (each hit) retrieved on hand-held computer. We compared the types of impact associated with hits in two distinct categories: clinical decision support systems (CDSS) vs. clinical information-retrieval technology (CIRT). Information hits in CDSS were defined as any hit in the following *InfoRetriever* databases: Clinical Prediction Rules, History and Physical Exam diagnostic calculator and Diagnostic Test calculator. CIRT information hits were defined as any hit in: Abstracts of Cochrane Reviews, InfoPOEMs, evidence-based practice guideline summaries and the Griffith's 5 Minute Clinical Consult. **Results** The impact assessment questionnaire was linked to 5160 information hits. 4946 impact assessment questionnaires were answered (95.9%), and 2495 contained reports of impact (48.4%). Reports of positive impact on doctors were most frequently in the areas of learning and practice improvement. In comparison to CDSS, CIRT hits were more frequently associated with learning and recall. CDSS hits were more frequently associated with reports of practice improvement. **Conclusions** Our new method permits systematic and comparative assessment of impact associated with distinct categories of information.

Introduction

The development of valid, efficient methods to document the impact of information technology on doctors and their patients is a challenge (Croasdale 2003). Although information technology eases access to evidence-based sources of information, these sources do not integrate self-assessment tools to systematically assess the impact of a users' search for information. A method to systematically assess the impact of searches for clinical information would help to evaluate the utility of databases that seek to enhance practice-based learning and improvement (Manning 2003; Moore & Pennington 2003). Previously, we proposed an impact assessment scale to evaluate the perceived impact of information retrieval on doctor practice (Pluye & Grad 2004). In the present study, we assessed whether we could systematically link the retrieval of diverse clinical information with its impact on the doctor.

Background

Information technology promises benefit for clinicians and their patients. We have termed databases that are mostly text (e.g. electronic textbooks) clinical information-retrieval technology (CIRT) (Fig. 1, left screen shot). CIRT provides reference information about diseases, therapies, and interpretation of lab tests, and is potentially applicable to decisions about multiple patients, unlike patient data (Wyatt & Liu 2002). While the printed word predominates, CIRT may include images, sound and movies, as well as multimedia (Kagolovsky & Moehr 2003). CIRT is distinct from clinical decision support systems (CDSS) such as clinical prediction rules and calculators, which require the user to enter patient-specific data to obtain information on risk, diagnosis, therapy or prognosis (Fig. 1, right screen shot). Clinical decision support systems match reference information with patient-related data to provide patient-specific recommendations (Wyatt & Liu 2002). Information management tools can provide health professionals with CIRT and CDSS. For example, *InfoRetriever* allows simultaneous searching of seven databases, including guideline summaries and abstracts of all Cochrane Reviews (Ebell *et al*. 2002). These databases are examples of CIRT, while the *InfoRetriever* collection of clinical decision and prediction rules are examples of CDSS.

Literature review

We reviewed the literature on the impact of CIRT on doctors. Given the paucity of experiments in this field, all research designs were sought (quantitative, qualitative and mixed methods studies). In line with the Cochrane reviewers' handbook, the world literature was reviewed up to February 2004 (Pluye *et al*. 2004a). Using inclusion/exclusion criteria, two reviewers

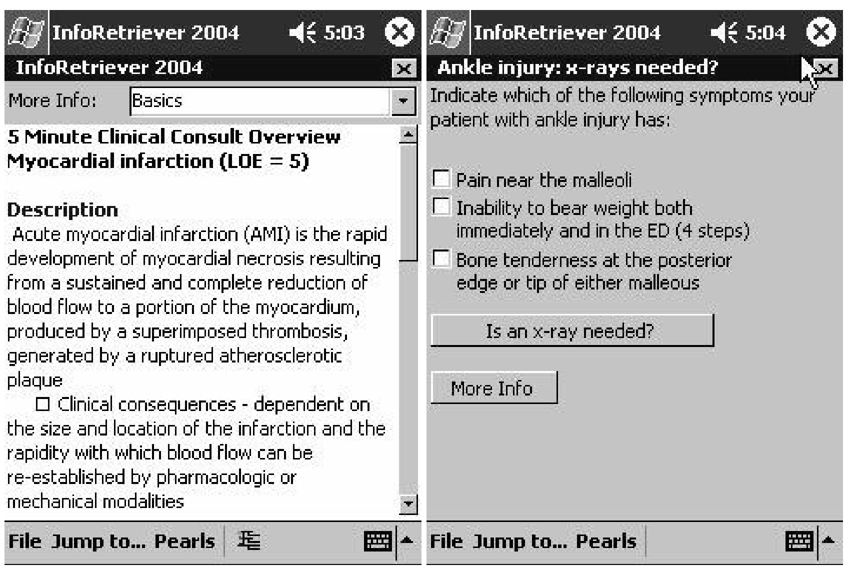

Figure 1 Examples of clinical information-retrieval technology (left screen) and a clinical decision support system (right screen).

Table 1 Literature review: methods to assess the impact of CIRT on doctors

		Design		*Impact assess(measure)ment**		
First author (year)	*Experimental*	*Observational*	*Laboratory*	*Nominal scale*†	*Interval scale*‡	*Comparison*§
Pluye & Grad (2004)		X		SR		
Sintchenko *et al*. (2004)			X (experimental)		IA	X
Westbrook *et al*. (2004)		X		SR		X
Crowley *et al*. (2003)		X		SR		
Leung *et al*. (2003)	X				SR	X
Schwartz *et al*. (2003)		X		SR		
Cullen (2002)		X		SR		
Jousimaa *et al*. (2002)	X			IA		X
Rothschild *et al*. (2002)		X		SR		
Baker *et al*. (2001)		X		IA		X
Brassey *et al*. (2001)		X		SR		
Del Mar *et al*. (2001)		X		SR		
Lapinsky *et al*. (2001)			X (experimental)		IA	X
Swinglehurst *et al*. (2001)		X		SR		
Eberhart-Phillips *et al*. (2000)		X		SR		
Wildemuth *et al*. (2000)			X (observational)		IA	X
Abraham *et al*. (1999)			X (experimental)	IA		X
Hayward *et al*. (1999)		X		SR		
Jousimaa *et al*. (1998)		X		SR		
Gorman *et al*. (1994)		X		SR		X
Klein *et al*. (1994)		X			IA	X
Lindberg *et al*. (1993)		X		SR		
Veenstra (1992)		X		SR		
Haynes *et al*. (1991)	X			SR		X
Angier *et al*. (1990)		X		SR		
Haynes *et al*. (1990)		X		SR		

CIRT, clinical information-retrieval technology.
*Impact self-reported by participants (SR) vs. independently assessed (IA).
†Impact assessed using nominal scale (e.g. does information-retrieval technology change practice? yes/no).
‡Impact measured using an interval scale (e.g. test score or cost of hospitalization and length of stay).
§Impact of CIRT vs. another source of information (e.g. printed educational material or clinical decision support systems).

independently identified studies by scrutinizing 3368 and 3249 references (author, title, source and abstract) from multiple bibliographic databases: LISA, OVID (All Evidence-based Databases, CINAHL, EMBASE, HealthSTAR, Medline) and PubMed. Additional studies were retrieved by hand searches in journals, proceedings, textbooks, literature reviews, personal files, selected publications, and by searching ISI Web of Science for citations of relevant articles. With respect to the impact of CIRT on doctors, 605 articles on paper were assessed for relevance. Of those, 565 were excluded as there was no mention of quantitative results or qualitative findings of impact, while 40 (6.6%) were independently appraised by two reviewers for relevance and methodological quality by type of study (quantitative, qualitative or mixed methods). Disagreements between reviewers were resolved by consensus, and 26 (4.3%) articles were retained for further analysis (Table 1). For each retained article, content analysis was performed on extracted textual material, namely impact-related quantitative results and qualitative findings.

We found some evidence that use of CIRT may have a positive impact on doctors and health care services. However, there are no reports of a longitudinal field study to systematically measure the impact of searches for information outside of a lab setting. No studies have used an ordinal scale to assess the impact of information retrieval.

Two randomized controlled trials (Jousimaa *et al*. 2002; Leung *et al*. 2003) and four laboratory studies (Abraham *et al*. 1999; Wildemuth *et al*. 2000; Lapinsky *et al*. 2001; Sintchenko *et al*. 2004) show contradictory results regarding the impact of CIRT compared with that of printed educational material or CDSS. One cohort study and one case-control study indicate that use of CIRT may improve quality of care for persons with diabetes (Baker *et al*. 2001) and reduce cost or duration of hospitalization (Klein *et al*. 1994). Moreover, nine observational studies suggest that one third of searches for information may have a positive impact on doctors. Results of five observational studies are subject to recall and selection bias and probably overestimate impact. The time between the search for information and reported impact is eight months or more in three studies (Haynes *et al*. 1990; Veenstra 1992; Gorman *et al*. 1994). The problem of selection bias is important in two other studies. Crowley *et al*. (2003) report the impact of residents' monthly obligatory searches. Schwartz *et al*. (2003) examine the potential impact of successful searches on future patients. Four observational studies report more plausible results: 20%, 35%, 36% and 39% (on average 32.5% of searches with impact) (Lindberg *et al*. 1993; Jousimaa *et al*. 1998; Hayward *et al*. 1999; Swinglehurst *et al*. 2001). In addition, qualitative evidence that the use of CIRT impacts doctor practice has been established by two studies using the critical incident technique (Lindberg *et al*. 1993; Pluye & Grad 2004). Furthermore, Table 1 shows which studies have used nominal scales to evaluate the impact of information (e.g. impact? yes/no), and which have used interval measures to globally assess the impact of databases (e.g. knowledge tests).

Methods

We conducted a prospective study in a cohort of family medicine residents at McGill University. All 44 incoming first-year residents at four training sites received two letters to solicit their participation in this study, which offered a new hand-held computer with training in software tools. In exchange for participation, hand-held computers were considered to be residents' personal property and could be taken home. Residents were allocated to one of two groups on pragmatic grounds, as the principal investigator runs an evidence-based medicine (EBM) course at only two of the four training sites. An evaluation of this course, and a description of course curriculum, has been published separately (Grad *et al*. 2001).

Intervention

Residents at training sites A and B were allocated to the *InfoRetriever* group. They received a pocket PC hand-held computer with training in three software tools in the context of an EBM course; *InfoRetriever* (2003) (updated to *InfoRetriever* 2004) (Ebell *et al*. 2002), *Praxis* 2.3 for procedure tracking (Topps & Hall 2002) and *Lexidrugs* Comprehensive Edition for drug information (Enders *et al*. 2002). These residents attended three hours of training in two sessions; the second provided instruction on use of *InfoRetriever* and the impact assessment questionnaire. Residents in the control group (training sites C and D) were trained to use their new hand-held computer for procedure tracking and drug information in a single 1.5 h session. These residents formed a comparison group for a study of the effects of *InfoRetriever* use on knowledge of common clinical problems. They did not attend the EBM course nor did they receive *InfoRetriever*. The time period for this study was from September 2003 to May 2004.

Information hits

InfoRetriever's built-in function was used to record data on information-seeking behaviour derived from the user's tap pattern. This function tracked all the information accessed by participants in a log file on their hand-held computer. Log files provided specific characteristics on the item of information viewed by the doctor, such as item title, unique ID number and when the item of information was opened (date and time stamp). These characteristics defined an 'information hit'.

Impact assessment

We used an impact assessment scale to evaluate the perceived impact of information retrieval on doctor practice (Pluye & Grad 2004). The scale contains six types of impact, at four levels ranging from positive to negative.

To reduce bias arising from human memory of searches conducted over a period of several months, we developed a technique inspired by Computerized Ecological Momentary Assessment (Shiffman 2000). In psychological research, studies using Computerized Ecological Momentary Assessment examine real time data. These studies have demonstrated a benefit in that the technique reduces bias related to memory of events that place a high cognitive demand on the subject (Stone & Shiffman 1994). In our study, *InfoRetriever* usage data on each hand-held computer was linked to an electronic version of the impact assessment questionnaire to measure impact types as listed in Box 1. In so doing, this questionnaire assessed the perceived impact of information hits (Fig. 2). Responses were added to an *InfoRetriever* usage log file on each hand-held computer. Subsequently, the user transferred their log file to our server via the Internet. Because the questionnaire popped up daily for all hits, this computerized method also reminded participants to complete unanswered questionnaires. Participants were instructed to answer questionnaires only if they remembered the information hit in question. If they forgot the search, or if an item of information was opened in error, they were told to dismiss the questionnaire by tapping 'not applicable'. For each participant, questionnaire data on the use and impact of information hits were systematically reviewed just prior to an interview (Pluye *et al.* 2004b). Interviews were semi-structured and conducted about 8 weeks after the doctor began to use *InfoRetriever*, to increase understanding of usage patterns and to substantiate reports of impact.

We compared the significance of observed differences in impact patterns of hits in CDSS databases vs. hits in CIRT databases. Information hits in CDSS were defined as any hit in the following *InfoRetriever* databases: Clinical Prediction Rules, History and Physical Exam diagnostic calculator and Diagnostic Test calculator. CIRT information hits were defined as any hit in: Abstracts of Cochrane Reviews, InfoPOEMs, evidence-based practice guideline summaries and the Griffith's 5 Minute Clinical Consult (an electronic textbook). Descriptive statistical analyses were conducted using Microsoft Excel, while the significance of observed differences between CIRT and CDSS for each impact type was assessed via chi-square tests using SPSS version 12 for Windows. The study protocol was reviewed and approved by the Faculty of Medicine Institutional Review Board of McGill University.

Box 1 An ordinal scale to evaluate the perceived impact of clinical information-retrieval technology on doctor-practice

High level of positive impact (++): a search for information has a high level of positive impact when a doctor reports practice improvement, learning or recall. There is a change regarding care for the current patient or a potential change regarding future patient care.

Moderate level of positive impact (+): a search for information has a moderate level of positive impact when doctors report reassurance or confirmation. There is no change regarding patient care but there is a positive impact on the doctor, namely an effect or an influence on doctor practice.

No impact (0): a search for information has no impact on doctor practice and does not change patient care.

Negative impact (–): a search for information has a negative impact when doctors feel frustrated after finding no information. The literature suggests this type of frustration discourages the use of CIRT, and therefore has a negative effect or influence on professional practice.

Results

Twenty of 23 first-year residents consented to participate at sites A and B, while 17 of 21 residents consented at sites C and D. Six second-year residents were subsequently recruited into the *InfoRetriever* group ($n = 26$). Among consenting first-year residents in the *InfoRetriever* group, 70% (14/20) owned a hand-held computer at study entry.

Use

We received data on 5758 information hits during the study period. Use was highest during the two EBM course periods, a trend that was not unexpected. Eighteen participants experienced some loss of usage and impact data, related to depleted batteries and other types of hardware failure. On average, these technical issues resulted in loss of 21 days (11.2%) of usage data per participant over 190 days of usage tracking. In addition, an error in the *InfoRetriever* tracking function affected eight participants for an average of 55 days. This error failed to track one specific type of search for information in the Clinical Prediction Rules database.

Among first-year residents, the mean frequency of use was 0.98 hits per day (95% CI 0.78–1.18 hits per day). There was substantial variation in use between participants (range 0.4–1.5 hits per day). The guideline summaries and the 5-Minute Clinical Consult were viewed most often, followed closely by the InfoPOEMs. Defining the lowest quartile of use as 'low-volume usage', there were 13 high volume and four low volume users. Interview transcripts provided different explanations for the low use of *InfoRetriever*. (1) Book preference: one resident said, 'I would prefer to just go straight to the book.' (2) Technical problems: another resident said 'I did lose data. The battery died on me. This might have been my own fault, because I don't charge. Twice it ran out of power.' (3) Trust: a third resident stated 'I went to the original literature to look at the basis for a [POEM] and when I did that, I found out, well wait a second here! The (claims) were not anywhere close to what they were in the original article and in the POEM they were very much more, almost embellished. So it really brought up the question how much I could trust the information. I don't know whether or not that coloured my use afterwards. It probably did to some extent.' (4) Lack of time: to our question 'did the questionnaire discourage your use of *InfoRetriever*?', a fourth participant answered: 'Yes, it's time commitment. And I know when I come up to my hand-held computer the next time, I'm going to have . . . even if it's only 3 or 4 min, it's like hitting the buttons without any benefit.'

Impact

The impact assessment questionnaire was linked to 5160 information hits. Among these hits, 4946 (95.9%) impact assessment questionnaires were answered; 2,495[1] contained reports of impact (48.4%) while 2451 questionnaires (47.5%) were judged by participants as 'not applicable'. Interviews confirmed that participants answered 'not applicable' as instructed. For example, information hits that were forgotten, opened in error (tapping mistake), or redundant (the same hit opened twice to read and re-read recommendations on a specific issue) were answered 'not applicable'. Most questionnaires (79.5%) were answered within 3 days of the doctor's search for information, and only 214 (4.1%) were never answered.

Reports of positive impact on doctor practice were most frequently in the areas of learning and practice improvement (Table 2). Among all information hits with impact, high positive impact types were reported most frequently (62.2%), followed by moderately positive impact types (16.2%), no impact (14.6%) and negative impact (5.1%).

[1] This number includes 27 bugged hits and 21 'Other' types of impact that are not interpretable.

Table 2 Reported patterns of impact

Impact Pattern	*Number of hits (%)*
Learning	512 (20.5)
No impact	363 (14.6)
Practice improvement	356 (14.3)
Confirmation	277 (11.1)
Recall	251 (10.1)
Frustration	127 (5.1)
Reassurance	109 (4.4)
Learning and practice improvement	101 (4.1)
Learning and recall	76 (3.1)
Learning, recall and practice improvement	37 (1.5)
Learning and confirmation	31 (1.2)
Recall and practice improvement	30 (1.2)
Practice improvement and confirmation	24 (1.0)
Confirmation and reassurance	18 (0.7)
Recall and confirmation	18 (0.7)
Learning, practice improvement and confirmation	14 (0.6)
Learning, recall and confirmation	14 (0.6)
Recall and reassurance	13 (0.5)
Learning, confirmation and reassurance	12 (0.5)
Learning, recall, practice improvement, confirmation and reassurance	11 (0.4)
Hits not related to the above patterns	74 (3.0)
Total*	2468 (98.9)

*Of 2495 hits that contained a report of impact, 27 included bugged hits.

Table 3 Comparison of impact types: clinical information-retrieval technology (CIRT) vs. clinical decision support systems (CDSS)

	Learning	*Practice improvement*	*No impact*	*Recall*	*Confirmation*	*Reassurance*	*Learning and practice improvement*
CIRT: % of hits (number of hits)	22.3 (460)	12.2 (252)	14.1 (290)	10.9 (224)	11.0 (227)	4.2 (87)	3.9 (81)
CDSS: % of hits (number of hits)	12.7 (52)	25.4 (104)	11.7 (48)	6.6 (27)	12.2 (50)	5.4 (22)	4.9 (20)
P-value*	<0.0001	<0.0001	0.190	0.008	0.514	0.315	0.389

*Chi-square test of differences between CIRT and CDSS for each impact type.

Table 4 Comparison of impact types: three clinical information-retrieval technology databases vs. clinical decision support systems (CDSS)

	Learning	*Practice Improvement*
Cochrane abstracts,% of hits ($n = 189$)	39.2	15.9
Guidelines,% of hits ($n = 538$)	17.5	11.2
InfoPOEMs,% of hits ($n = 518$)	29.2	18.0
CDSS,% of hits ($n = 409$)	12.7	25.4
P-value*	<0.0001	<0.0001

*Chi-square test of differences between databases for each impact type.

About 83% of all information hits were made in CIRT databases. Overall, there was no significant difference in the probability of reporting any type of impact with hits in CIRT databases as compared to hits in the CDSS databases (odds ratio 1.17, 95% CI 0.86–1.56, $P = 0.310$). However, there were significant differences in the impact patterns associated with CDSS and CIRT databases (Table 3). In comparison to CDSS, CIRT hits were more frequently associated with *learning* and *recall*. CDSS hits were more frequently associated with reports of *practice improvement*. These associations were also seen when we compared the distribution of reports of 'Learning' and 'Practice Improvement' among individual CIRT databases (Cochrane Abstracts, InfoPOEMs and guideline summaries) with the CDSS databases (Table 4).

Discussion

Our results show the feasibility of measuring the impact of clinical information-retrieval technology on the doctor. The tremendous volume of clinical information makes it difficult for doctors to rapidly access what they need (Shaughnessy *et al.* 1994; Sullivan *et al.* 1999). Information management tools (e.g. *InfoRetriever*) have been developed and deployed as one potential solution to this problem. Although there are methods to globally assess the impact of databases, there has been limited evaluation of their specific impact in everyday clinical practice (Pluye *et al.* 2004a). Our method of coupling impact assessment with the use of EBM databases systematically establishes a chain of evidence between information hits and their self-reported impact on doctor practice. Therefore, the main message of our study is that an impact assessment scale can be coupled with EBM databases for evaluation and comparative research.

Moreover, our results suggest that the impact of CIRT may be qualitatively different to that of CDSS. CIRT seems to enable learning and recall, while CDSS appears to have a greater perceived impact on practice improvement. Although the differences in types of impact we observed may be rooted in the teaching context of the study, our results may stimulate further research and debate on the impact of CIRT vs. CDSS. As previously mentioned, 'little is known regarding the impact of the former (CIRT), as opposed to convincing evidence about the impact of the latter (CDSS)' (Pluye & Grad 2004, p. 413).

There are nonetheless three limitations to the present work. As this study involves residents, it is not yet known if our method can be adapted to capture the benefits of information retrieval by clinicians outside of a teaching context. Furthermore, self-report bias may contribute to overestimating the perceived impact of information (Adams *et al*. 1999). In addition, we have no evidence of better patient outcome or reduction of adverse events associated with our reported patterns of positive impact.

There are three important strengths of our work. First, the observed patterns of questionnaire responses demonstrate that residents can make rela-

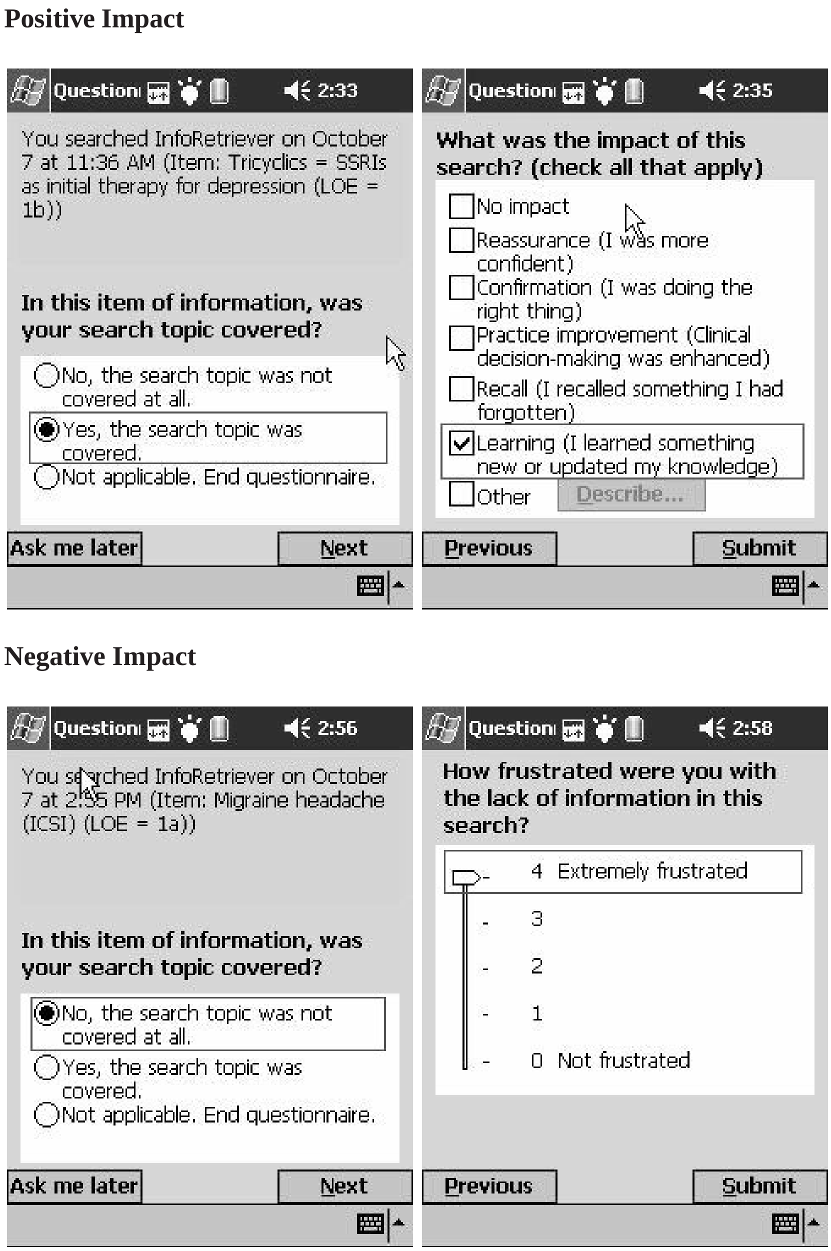

Figure 2 Examples of impact assessment.

Figure 3 The impact (in bold) of pursued information needs in clinical practice.

tively simple judgements about the impact of information hits. In addition, no redundant or unusual response patterns appeared to threaten the validity of the measure.

Second, the method of coupling an impact assessment questionnaire with information management tools minimizes the problem of recall bias arising from the passage of time between use and assessment of impact. Recall bias can be an important problem. For example, doctors have been directly observed to make six times as many inquiries as they had previously estimated in completing a questionnaire about their information seeking (Covell *et al*. 1985).

Finally, the types of impact in our assessment questionnaire fit with a conceptual framework of the information needs of clinicians (Ebell & Shaughnessy 2003). According to Ebell and Shaughnessy, an information need is recognized when a doctor reflects on their practice, and asks a question. For example, 'does the patient have acute sinusitis?' The framework proposes that doctors may recognize their information needs, pursue and satisfy them (e.g. using CIRT), and subsequently implement information in their decision making. Figure 3 suggests that learning, recall of knowledge, reassurance and confirmation are positive types of doctor impact that may arise from a satisfied information need. Practice improvement can result from the application of new information in patient care. Finally, a negative type of doctor impact, such as frustration, may be experienced when information needs are pursued, but not satisfied.

In conclusion, this study describes a new method that permits systematic and comparative assessment of impact associated with distinct categories of information (CDSS vs. CIRT) in everyday clinical practice. Our impact assessment questionnaire needs refinement in future research to permit testing of its acceptability outside of graduate training programs.

Acknowledgements

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