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How information retrieval technology may impact on physician practice: an organizational case study in family medicine

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Abstract

Rationale Information retrieval technology tends to become nothing less than crucial in physician daily practice, notably in family medicine. Nevertheless, few studies examine impacts of this technology and their results appear controversial. **Aims and objectives** Our article aims to explore these impacts using the medical literature, an organizational case study and the literature on organizations. **Methods** The case study was embedded in an evaluation of the implementation of medical and pharmaceutical databases on handheld computers in a Canadian family medicine centre. Six physicians were interviewed on specific events relative to the use of these databases and on their general perception of impacts of this use on clinical decision making and the doctor–patient relationship. A thematic data analysis was performed concomitantly by both authors. **Results and conclusion** Findings indicate six types of impact: practice improvement, reassurance, learning, confirmation, recall and frustration. These findings are interpreted in accordance with both a medical and organizational perspective. The fit with the literature on inter-organizational memory supports the transferability of the findings. In turn, this fit suggests how information retrieval technology may change physician routine. This study suggests a new basis for evaluating the impact of information retrieval technology in daily clinical practice. In conclusion, our paper encourages policy-makers to develop, and physicians to use, this technology.

Computers may reduce health care costs, increase homogeneity of physician practice and improve patient health, particularly in two ways. First, information retrieval technology is grounded in the professional literature and provides abundant knowledge (Rambo & Beahler 2003), notably practice guidelines (Sanders *et al*. 2001; International Guideline Library 2003). Second, clinical decision support systems match information retrieval technology with patient-related data and provide patient-specific recommendations (Wyatt 2000a). However, little is known regarding the impact of the former, as opposed to convincing evidence about the impact of the latter (Kaplan 2001). This lack of knowledge is problematic for two reasons: substantial resources are invested in the development of information retrieval technology, and this technology complements decision support systems. The present article aims to explore the impact of information retrieval technology on physician practice by examining successively the medical literature, an organizational case study in family practice and the literature on organizations.

Medical information can assist physicians in decision making, notably for diagnosis or prognosis and in preventive interventions or treatments. For example,

guidelines aim to improve medical practice and to control health care costs (Wensing *et al*. 1998; Woolf *et al*. 1999; Long 2001; Morris 2001). Guidelines are practice standards (Herman 1999), that is, a basis of value for the measure of quality of care (National Library of Medicine 2003), interpreted and negotiated in a clinical context (Sullivan & MacNaughton 1996; Berg 1997) the last 50 years; information retrieval technology has improved access to information (Griffith & King 2002). It thus contributes to continuing medical education and may help keep physicians up to date on scientific developments and the development of practice standards (Hersh 2003). Physicians sometimes feel overwhelmed with information, particularly in family medicine (Hibble *et al*. 1998; Salisbury *et al*. 1998). Computer-based solutions may decrease this feeling and provide clinicians with useful summaries of quickly retrievable, valid and relevant information. For example, scientific results may be filtered by level of evidence and relevance to family practice (Shaughnessy *et al*. 1994; Bero & Rennie 1995; Lohr *et al*. 1998; Shekelle *et al*. 1999).

Background

Computers are memory (Lemoigne & Sibley 1986; Simon 1969). Human memory is the faculty by which things are recalled or kept in the mind (*Canadian Oxford Dictionary* 1998). Memory brings tacit or explicit knowledge into decision making. Considering that information consists of items of explicit knowledge, computers constitute an external storage of information that supplements physicians' memory (Elson *et al*. 1997). 'Clinicians memorise some of the reference information with which they come into contact. During the consultation, through a process of recall, the clinician attempts to bring to bear that part of the information they have memorised that is relevant to the task at hand', and via computers, information may be retrieved and used at-the-point-of-care and at-the-moment-of-need (Sullivan *et al*. 1999, p. 1003).

Simon (1980) proposed a continuum between two types of decision making: programmed and non-programmed. Programmed decision making refers to 'specific procedures' for solving problems and is concerned with well-known situations, while non-programmed decision making involves 'general means' and is concerned with new or complex situations (p. 42). The former may be represented by unambiguous algorithms and then computerized, while computerization of the latter is too expansive or may be impossible. These two types of decision making form the basis of a conceptual distinction between clinical decision support systems and information retrieval technology that is not widely acknowledged in the medical literature. Systems for programmed decision making coexist with information for non-programmed decision making. The latter will remain important and complement the former for a simple economic reason: human labour is cheap and flexible for complex heuristic decision making compared to the development and testing of computerized algorithms (Simon 1980). For example, 'translation of computerised medical guidelines into computer algorithms from their published formats, which are typically not computer interpretable, is not an easy task' (Wang *et al*. 2002, p. 60).

This conceptualization is original and fits with previous work. Rousseau *et al*. (2003) distinguish 'on-demand' information sources from clinical decision support systems (p. 314). A recent handbook distinguishes knowledge-based information (Rambo & Beahler 2003), defined as primary, secondary and tertiary databases, from decision support systems (Yasnoff & Miller 2003). As Wyatt states, medical search engines on the internet 'will interpret your free-text question and find the answer for you' (Wyatt 2000a, p. 565), while decision support systems use 'patient data to drive a reasoner program that searches a knowledge base to assemble a tailored report' (Wyatt 2000b, p. 629). Others distinguish computerized information sources from clinical decision support systems and indicate that the former facilitate access to medical knowledge (Elson & Connelly 1995; McColl *et al*. 1998; Westberg & Miller 1999; Van Bemmel & Musen 2000). In the literature, information retrieval technology refers to numerous terms (e.g. computerized guidelines, computerized reference desk or guide, electronic information access in support of medical decision making, electronic medical databases, electronic resources, health care support systems, medical information retrieval and information systems). This profusion of terminology testifies to the significant desire for better comprehension of the phenomenon.

In turn, our conceptualization suggests three types of medical informatics applications, schematized in Fig. 1, that take into account the complex and non-hierarchical relationship between knowledge, information and data (Georgiou 2002). *Information retrieval technology* provides 'information about diseases, therapies, interpretation of lab tests, etc., which is potentially applicable to decisions about multiple patients and public health policies, unlike patient data' (Wyatt & Liu 2002, p. 810). This general information may include 'text documents, images, sound and movies, as well as multimedia and combinations of the above' (Kagolovsky & Moehr 2003a, p. 403), and derives from professional databases that merge or link digital libraries, computerized practice guidelines or synopses, electronic journals or textbooks and medical websites. For example, there is general pharmaceutical information on drug therapy, adverse effects of drugs, and drug interactions. *Patient-related databases* contain patient-specific data, notably those entered in electronic medical records. *Clinical decision support systems* match the former and the latter. Such systems use 'two or more items of patient data to generate case specific or encounter specific advice' (Wyatt & Liu 2002, p. 809). In daily practice, physicians may use computers that combine all applications.

Numerous applications of information retrieval technology exist and have the potential to change physicians' routines, which are usually based on seeking information from colleagues, pocket notes, paper-based textbooks and journals (Laine & Weinberg 1999; Tomlin *et al*. 1999; Dawes & Sampson 2003). However, as previously mentioned, little is known about the impact of computerized information retrieval technology on medical practice (Hersh 2003; Kagolovsky & Moehr 2003b). This impact is potentially greater than that of paper-based information while there is little evidence, for example, that the passive dissemination of paper-based practice guidelines impacts physician practice (Cabana *et al*. 1999; Grimshaw *et al*. 2001; Freemantle *et al*. 2001). Elson & Connelly (1995) suggest that there is no evidence concerning the impact of information retrieval technology, as the topic has thus far failed to attract the attention of researchers. In the same vein, Kaplan (2001) indicates that the literature is equivocal about the impact of information retrieval technology, although it 'indicates a general consensus that clinical decision support systems have the potential to improve [the quality of] health care, or at least to change physicians' behaviour' (p. 17). Moreover, these systems are 'the most frequently studied and the most successful interventions' (Balas *et al*. 1996, p. 275). For example, Mitchell & Sullivan (2001) reviewed the literature and found a positive impact of computerization in primary care, especially in studies examining decision support systems.

Our literature review updates that of Hersh & Hickam (1998). The first author searched multiple databases with a medical librarian (OVID. All Evidence-based Databases, CINAHL, Embase, HealthSTAR, LISA Medline). Additional articles were identified from Hersh (2003), specialized

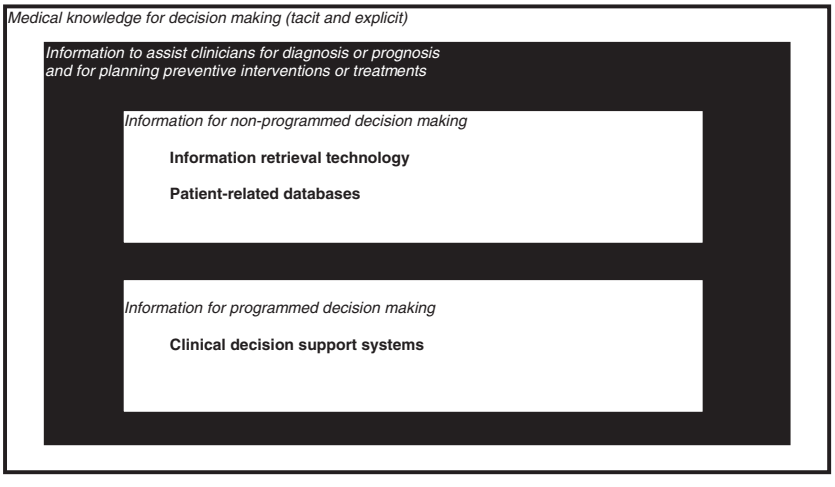

Figure 1 Information retrieval technology, patient-related databases and clinical decision support systems (the surface area of boxes does not represent the relative importance of knowledge type).

journals or proceedings and personal files. Studies included in this review examined the impact of information retrieval technology on physician practice or patient health. In accordance with Kagolovsky & Moehr (2003b), we excluded technological studies (e.g. evaluation of performance of databases outside a clinical context), studies of users' information needs, studies of users' ability to find specific information and studies of the computer–user interaction. Twenty studies satisfied criteria of inclusion: three randomized controlled trials, six cohort studies, one case–control study, six cross-sectional studies, three case series and one laboratory-like study (Appendix). Of those, only two studies reported independently assessed impacts, 16 studies reported self-reported impacts on physician practice while two of these 16 also examined impact on patient health (Table 1). In a trial, 130 newly graduated family physicians were randomly assigned to use computerized or paper-based practice guidelines (Jousimaa *et al*. 2002). Computerization did not change the use of guidelines nor their impact. In another trial, 168 fourth-year medical students were randomly assigned to use *InfoRetriever* on a hand-held computer, a printed pocket card and their usual sources of information (Leung *et al*. 2003). The *InfoRetriever* group only showed significant gains in self-perceived confidence in clinical decision making. One cohort study suggests an association between the use of computerized guidelines and physicians' adherence to guidelines (Baker *et al*. 2001).

This review suggests information retrieval technology impacts on clinical practice, and shows some contradictory findings and substantial variation across studies (Appendix). Considering this controversy and the limited number of studies, in accordance with Wensing *et al*. (1998) and Zielstorff (1998), the evaluation of how information retrieval technology may impact on physician practice is essential. Given that little is known of this impact, we did not state proposals at the outset. Qualitative methods are particularly relevant in assessing new technologies and answering the question of 'what is going on here?' (Murphy & Dingwall 2001, p. 175). Thus, the specific objective of the present article is to explore and qualitatively illustrate this impact in the context of primary care group practice. To fulfil this objective, we conducted an organizational case study in family medicine. The choice of a family practice setting is justified by the vast array of information sources used

Table 1 Distribution of selected studies according to type of impact

*Type of impact**	*Impact self-reported by physicians*	*Impact independently assessed*
Impact on physician practice	Haynes *et al*. (1990)	Jousimaa *et al*. (2002)
	Haynes *et al*. (1991)	Baker *et al*. (2001)
	Veenstra (1992)	
	Lindberg *et al*. (1993)	
	Gorman *et al*. (1994)	
	Chambliss & Conley (1996)	
	Jousimaa *et al*. (1998)	
	Manning & Gadd (2001)	
	Richwine & McGowan (2001)	
	Swinglehurst *et al*. (2001)	
	Taylor & Leitman (2001)	
	Cullen (2002)	
	Rothschild *et al*. (2002)	
	Crowley *et al*. (2003)	
	Leung *et al*. (2003)	
	Schwartz *et al*. (2003)	
Impact on patient health	Gorman *et al*. (1994)	
	Lindberg *et al*. (1993)	

*Two selected studies are not included in this table: (1) Abraham *et al*. (1999) – laboratory-like study; (2) Klein *et al*. (1994) – cohort study/cost analysis.

in family medicine and the need for general information in the field (Ebell *et al*. 1997; Reid 2001).

Method

This study was conducted between February 2001 and February 2003. We used the case study method and focussed on a single 'revelatory case' (Yin 1994, p. 40). The case is a Canadian family medicine centre that receives about 36 000 outpatient visits annually. The study assessed how handheld information retrieval impacts on medical practice. This technology was introduced in 2001; clinicians at the centre had access to medical information via databases on both CD-ROM and the internet, provided at three workstations since 1998. Family physicians working at least part time at the centre were approached to participate. Eight of nine eligible family physicians consented, ranging in age from 30 to 60 years. Participants were board-certified family physicians in active office practice who were also involved in the hospital care of their patients. All taught residents and medical students.

A foundation grant provided each participant with a *Compaq iPAQ* model 3650 (and printed operating manual) preloaded with *InfoRetriever* version 3.1. Upgrades to versions 3.2 and 4.0 occurred at roughly 3-month intervals thereafter. *InfoRetriever* was the first evidence-based medicine database for family medicine available on handheld computer (Chesanow 2000). By design, the information presented by *InfoRetriever* is highly filtered for both clinical relevance to primary care and validity (Slawson *et al*. 2001). About 2 months into the study period, participants requested and received two pharmaceutical databases, *Lexidrugs* and *Interact* version 3.1.4. At the time of recruitment, no participant was using *InfoRetriever* or handheld computer technology in his/her medical practice. *InfoRetriever* combines information retrieval technology with decision support systems. Examples of information retrieval technology include all Cochrane systematic review abstracts, POEMs published monthly in journals such as the *British Medical Journal* and the *Journal of Family Practice*, and summaries of treatment guidelines. Examples of decision support systems are decision and prediction rules for diagnosis or risk assessment.

The second author consulted with a developer of *InfoRetriever* to review the content of a training curriculum. He developed a structured curriculum on the assumption that physicians would be more likely to carry their *iPAQ* if it were used for personal information management (e.g. agenda and contacts) in addition to the retrieval of medical information. Training consisted of four consecutive weekly lunchtime meetings in March–April 2001, where experiences were shared through discussions in small-group problem-oriented sessions. Participants were invited to a 1-hour booster training session about halfway through the 24-week assessment period. Table 2 further describes the content of each training session. Six of eight participants attended all four training sessions, while one missed the final two sessions, which addressed the use of *InfoRetriever*. Two participants left on maternity leave: one at the halfway point of the study and a second just after the 24-week follow-up period. Both participants on maternity leave were not available for interview.

In-depth semi-structured interviews were conducted with the six remaining participants about 7 months after the introduction of the *iPAQ* in November 2001. The first author (P.P.) had never met any of the participants prior to the interview and is a qualitative researcher who last worked as a family doctor 4 years prior to this study. The second author (R.G.) is a family physician colleague to all participants. While R.G. had a preconceived notion that databases on handheld computer would be useful to participants, P.P. could fully explore perceptions without such constraints. Therefore, P.P. conducted all interviews and posed questions defined *a priori*, which focussed on the following themes: usefulness and use of the databases on the *iPAQ*, technical performance, impact and critical incidents (the list of questions is available on request). These themes are logically inter-related, as usefulness and technical performance influence the use of any technology and use is a prerequisite for impact (Davis 1989). 'Even if an application would objectively improve performance, if users don't perceive it as useful, they are unlikely to use it' (p. 335). The usefulness and technical performance of the databases on the *iPAQ* were presented elsewhere (Grad *et al*. 2002).

An impact is an effect or an influence (*Canadian Oxford Dictionary* 1998). We defined impacts as

Table 2 Training programme for handheld computer use in family practice

Session	*Skills taught*	*Potential benefits*
I	Basic hardware issues; Windows environment; agenda; contacts; tasks; File Explorer; Excel; Word	Electronic agenda; contacts (telephone numbers/email addresses)
II	Review of previous session; using Excel to create and update a patient list; partnering with a desktop PC	Easily accessed patient list; backing up information to prevent loss of data
III	*InfoRetriever* part 1	Introduction: 'usefulness equation'; searching for answers to questions from clinical vignettes; drug prescribing information; Cochrane Database of Systematic Reviews abstracts; POEMs (brief critical appraisals of the most relevant literature)
IV	*InfoRetriever* part 2	Clinical prediction rules; information on diagnostic tests and physical exam manoeuvres including sensitivity, specificity, predictive value and likelihood ratios; summaries of evidence-based practice guidelines
V	Booster session (14 weeks after completion of the initial training phase)	Reinforcement of concepts covered in the initial training phase

effects or influences of the handheld databases on clinical decision making and the doctor–patient relationship. Impacts were examined according to critical incidents and participants' general perception. In our opinion, the collection of critical incidents revealed impacts in the form of trustworthy factual stories (qualitative evidence) and was usefully complemented by participants' general perception. First, one question concerned potential incidents: *Can you recall the most important events about the use of InfoRetriever or Lexidrugs, either positive or negative?* Given the retrospective nature of interviews, the critical incident technique provided detailed empirical illustrations. Referring to Flanagan (1954), an event must meet two criteria to be classified as a critical incident: the event is clear from the observers' perspective and its consequences are clearly defined. In other words, a vague event is not a critical incident (Chell 1998).

Second, two questions were asked on perceived impacts: *Can you recall the most important impact that InfoRetriever or Lexidrugs had on your clinical decision making process?* And, *Did the use of InfoRetriever or Lexidrugs have any impact on your relationship with your patients?* Interviews took place in participants' offices and varied in duration from 15 to 60 minutes. Interviews were audio-taped and then transcribed.

From February 2002 to February 2003, both authors read and coded data independently and described the case along with a three-stage thematic analysis (Paillé 1996). According to Yin (1994), the development of 'a descriptive framework' constitutes an adequate analytic strategy for a revelatory case study (p. 104). First, extracts of transcripts were categorized according to themes from interview questions. For example, we identified extracts whose meaning referred to the themes of 'critical incidents' and 'perceived impact'. To be coded as a critical incident, an event-related transcript had to clearly describe a particular search for information and at least one consequence. Then, these extracts were classified into three categories based on aspects of the technology under study, namely the hardware (*iPAQ*), *InfoRetriever*, and *Lexidrugs* or *Interact*. Finally, subthemes were developed from the data, and were organized in a matrix (Huberman & Miles 1991).

Consensus between authors on the interpretation of data was obtained after nine meetings at which the assignment of sections of text to themes and subthemes was discussed and debated. Furthermore, P.P. imported the transcripts into qualitative data analysis software for coding and editing reports at each stage of analysis (NVivo 1.3). By way of these staged reports, P.P. and R.G. reached consensus. Two partic-

ipants then read and validated our findings. These findings are presented below with regards to the subthemes of critical incidents and perceived impact related to information retrieval technology derived from the databases studied.

Findings

Critical incidents indicate four specific impacts arising from the handheld databases. They are summarized in Table 3. Each impact is illustrated with an exemplary incident relative to the use of *InfoRetriever*. First, participants learned new knowledge or updated their knowledge. As participant 4 said, 'I was trying to find treatments for depression and *InfoRetriever* was useful because I was able to look at a few things with the patient to review what is the current evidence. I said: Judging by this, there isn't a lot of evidence. So at least the patient and I have both felt: Well, we're gonna try this, we're just gonna do it, but we don't have a lot to back it up'.

Second, participants recalled forgotten knowledge. For example, participant 4 said: 'I couldn't remember the name of a medication used for the treatment of obesity and it turned out it's Sibutramine. I looked up obesity treatment and it was great. It was with the patient, and I said: Ah, there is some evidence. So it was really helpful. Here I had it. Boom, I found it. Otherwise, it would take a long time. I would have had to leave the room, and go find somebody'.

Third, participants confirmed their knowledge, as illustrated by participant 5: 'I was with the resident in the teaching room, and the resident was being argumentative (laugh) when I made a suggestion that he should put his diabetic patient on aspirin. He wanted the evidence, and I know the evidence is out there. I

Table 3 Summary of critical incidents

Participant	*Critical incidents related to the use of* InfoRetriever	*Critical incidents related to the use of* Lexidrugs *or* Interact
1	None	None
2	None	None
3	None	None
4	**# Learning (1):** • Updating knowledge on treatment of depression **# Recall of forgotten knowledge (1):** • Recalling a treatment for obesity **# Frustration (1):** • Searching unsuccessfully for hiccups	None
5	**# Learning (1):** • Updating knowledge on radiological exams for GERD **# Confirmation (1):** • Recommending aspirin for diabetes **# Frustrations (2):** • Searching unsuccessfully for mastitis • Searching unsuccessfully for Osgood-Schlatter's disease	**# Learning (2):** • Adjusting dose of an analgesic drug according to creatinine clearance • Avoiding the prescription of a muscle relaxant in combination with a narcotic **# Frustration (1):** • Searching unsuccessfully for a new medication
6	**# Confirmation (1):** • Checking antibiotic therapy for sinusitis	**# Learning (2):** • Finding the Canadian equivalent of a US drug • Finding the Canadian equivalent of a US drug **# Frustration (1):** • Searching unsuccessfully for a new chemotherapeutic agent

GERD, gastroesophagus reflux disease.

was able to find enough information on *InfoRetriever* to prove something to him'.

Fourth, participants felt frustrated when they did not find information. As participant 4 put it, 'there was a patient who had the hiccups and I wanted to look up the treatment. I didn't know if there was anything more current. and I could not figure out how to actually get information on "hiccups" [within *InfoRetriever*]. I couldn't find it. So it was frustrating, and the resident was sitting there and I was trying madly to find it and I finally gave up'.

In addition, findings relative to participants' perception indicate two general impacts: reassurance and practice improvement. Exemplary illustrations of these impacts are presented in Box 1. Participants 4 and 5 used their *iPAQ* almost weekly and perceived impacts in both decision making and doctor–patient relationships. This impact consisted in being reassured by the availability of the databases on the *iPAQ* and improving their practice. Participant 6 used his handheld computer almost daily. He perceived an impact in decision making, as he was reassured by the availability of the databases on his *iPAQ*. He did not perceive an improvement in practice, perhaps because he was accustomed to consulting databases on his desktop computer. Participants 2 and 3 used their *iPAQ* infrequently and they perceived no impact in clinical decision making or doctor–patient relationships. Participant 1 never used his *iPAQ* and there was obviously no perceived impact. He preferred to use his desktop and books.

Box 1 Exemplary illustrations of perceived impact

Reassurance

'Knowing that you have somewhere [*InfoRetriever*] to look for quick access to information is always reassuring. You never know when a question arises, and if you don't have [*InfoRetriever*], and if you don't have the time to check it at that particular moment, you'll probably forget the question. For that reason, I think it's a great thing to have.'

Practice improvement

'[*InfoRetriever*] increases your ability to access information and to make decisions. But it does, if you use it in an interactive way with the patient. [Example] This up-to-date information facilitated and improved the doctor–patient relationship. The decision making together was better because we had more current information.'

Discussion

Considering computers as memory, our findings indicate that five physicians at the centre shared a handheld computer memory. They reveal six types of impact of information retrieval technology: practice improvement, reassurance, learning new knowledge, recall of forgotten knowledge, confirmation of knowledge and frustration. Learning and recall may explain why physicians perceived practice improvement. Once learned or recalled, information can be interpreted and negotiated with patients, as in the first illustration, and may improve practice. Moreover, learning, recall and confirmation may explain why these physicians felt reassured by the availability of information retrieval technology on the handheld computer at-the-point-of-care and at-the-moment-of-need.

These types of impact may be interpreted in accordance with the results of mentioned empirical studies (Appendix). For example, confirmation and reassurance reflect the gain in self-perceived confidence reported by Leung *et al*. (2003). According to Crowley *et al*. (2003), 43% of searches changed patient care (echoing learning and recall), and 39% confirmed patient care (echoing confirmation), while participants failed to obtain useful information for 18% of searches (potential frustration). Lindberg *et al*. (1993) used the critical incident technique and reported learning-related or confirmation-related incidents and ineffective searches (echoing frustration).

For their part, Jousimaa *et al*. (2002) indicated that computers did not change the use of guidelines nor their impact. This is not a surprising result, as a compilation of over 1000 guidelines has constituted the most common source of information and has 'assist[ed] primary care physicians' in Finland since 1989 (p. 588). In this context, we can hypothesize that the format of guidelines, electronic or paper, did not matter much. In our opinion, this trial demonstrates the feasibility of using information retrieval technology in daily clinical practice when physicians cannot benefit from a regular dissemina-

tion of updated paper-based guidelines, rather than contradicting our findings and results from other empirical studies. For example, in the Canadian context, this technology probably enables physicians to pursue more clinical questions than they otherwise would.

In addition, the medical literature usually points out the low frequency of use of this technology (Appendix). Considering this rarity, our study suggests it is feasible to collect data on use-related events, and to examine critical incidents in detail from these events. This examination has the potential to minimise the self-report bias that usually overestimates the perceived impact of information (Adams *et al*. 1999). Assuming the feasibility of collecting such data via a computerized questionnaire based on a log of searches, our findings have implications for the further evaluation of information retrieval technology in clinical practice (Box 2).

Furthermore, according to Yin (1994), descriptive results of revelatory case studies have to be examined from a different perspective. To do so, the sharing of a memory in the centre under study led us to mobilize studies on organizational memory in March 2003. According to the literature on organizational learning, organizations memorize knowledge, actions and procedures shared by the actors (Argyris & Schön 1978; Hedberg 1981; Walsh & Ungson 1991; Cohen & Bacdayan 1996; Levitt & March 1996). The concept of organizational memory is based on the centennial notion of collective memory and is defined as shareable interpretations of past experiences that influence activities (Stein 1995). Referring to the literature review of Huber (1996), organizational memory has two components: the traditional storage of information in social networks or paper-based manuals of procedures and computerized memory. The organizational knowledge stored in social networks can be mobilized for decision making after a few phone calls to find 'someone in the firm who has the relevant experience' (Olivera 2000, p. 819). In medicine, the frequently solicited knowledge of colleagues is the equivalent of networks memory. Networks are essential repositories for sustaining tacit knowledge in communities of practice (Nonaka 1994; Brown & Duguid 1996; Girod-Séville 1996; Weick & Roberts 1996), while computers are 'very effective repositories for retaining explicit knowledge' (Argote 1999, p. 90). Computerized memory offers the advantage of rapid access and easy updating (Goodman & Darr 1998). Moreover, information retrieval technology satisfies two criteria of organizational memory: stored information and a means by which knowledge from the past is brought to bear on present decision-making processes (Walsh & Ungson 1991; Stein & Zwass 1995).

Thus, our findings may be interpreted in accordance with an organizational memory perspective. *Learning:* organizational memory is 'a critical part of the learning process' (Casey 1997, p. 111). *Recall:* 'Organisational memory can be recalled to support decision making and problem solving' (Stein 1995, p. 30). *Confirmation*: other potential impacts of organizational memory for decision making are more effective or legitimate decisions (Dickson *et al*. 1977; Walsh & Ungson 1991). *Frustration*: in computerized inter-organizational memory, 'initially one must search to find possible solutions. The next problem is to match potential solutions with the problem at hand. Since there are many ways to represent problems and solutions, and since there are likely to be differences in language and conventions across

Box 2 Implications for further evaluation of the impact of information retrieval technology in daily clinical practice

According to the log, you searched 'name of the technology' for 'search topic' on 'date and hour':

- If the search topic was covered, what was the impact of this search?
  1. No impact
  2. Practice improvement (clinical decision making was enhanced)
  3. Reassurance (I was more confident)
  4. Confirmation (I was doing the right thing)
  5. Recall (I recalled something I had forgotten)
  6. Learning (I learned something new or updated my knowledge)
  7. Other impact (describe in your own words)
- If the search topic was not covered, how frustrated were you with the lack of information?
  8. Extremely frustrated
  9. Moderately frustrated
  10. Not frustrated

[organizations], matching requires time and effort' (Goodman & Darr 1998, p. 431). Moreover, finding nothing affects the perceived value of this memory; thus, 'one is less likely to look again' in the future (p. 432).

Information retrieval technology, notably the handheld information under study, is shared by multiple health organizations and may be examined as a type of inter-organizational memory. 'Embedding knowledge in technology is also an effective way of transferring knowledge to other sites' (Argote 1999, p. 90). This transfer between organizations leads to the notion of inter-organizational memory. Empirical studies suggest three essential features of this memory: rapid retrieval, validity and relevance of knowledge (Goodman & Darr 1998; Olivera 2000). 'With respect to how knowledge is collected, it is worth noting that, for some memory systems, the content has been somehow filtered. For example, a best practice database may be formed by collecting practices, evaluating them, and selecting the practices that are considered most valuable given some criteria' (Olivera 2000, p. 816). These features echo those of evidence-based information retrieval technology, particularly *InfoRetriever*. Furthermore, classifying information retrieval technology as inter-organizational memory is congruent with the model for decision making proposed by Elson *et al*. (1997) in the literature on medical informatics. In this model, 'clinicians have easy access to centrally developed and maintained resources' that store and retrieve information as 'external memory' (p. 271). All of this suggests that family physicians may share the same computer memory through multiple organizations and so homogenize and improve their practice at a supra-organizational level. Considering that organizational memory constitutes a characteristic of organizational routines (Pluye *et al*. 2004), the wide diffusion of a computerized inter-organizational memory may change the routines of physicians and health organizations. Before consulting colleagues, as suggested by participant 4, physicians will use information retrieval technology.

The review of the medical literature, our findings and this organizational perspective lead us to propose an ordinal scale to assess the impact of this technology (Box 3). This proposal makes a potential contribution to methods. Indeed, the self-reported impact of this technology is examined using non-ranked open questions or assessed by scoring the perceived importance of this impact (Appendix). Moreover, the impact of medical information is usually assessed in the same manner (Marshall 1992; Sackett & Straus 1998).

The present study nevertheless faces three main limitations. First, all participants perceived the handheld information as useful, five of six used it but only three of six described impact-related critical incidents or perceived impacts. Considering

Box 3 Proposal: an ordinal scale to evaluate the perceived impact of information retrieval technology on clinical practice

High level of positive impact

A search for information has a high level of positive impact when physicians report 'practice improvement', 'learning' or 'recall'. These impacts are consistent with the literature on organizations, and refine the notion of 'change of care' in the medical literature. 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 physicians report 'reassurance' or 'confirmation'. These impacts are consistent with the literature on organizations, and refine the notion of 'confirmation of care' in the medical literature. There is no change regarding patient care but there is a positive impact on the doctor, namely an effect or an influence on physician practice.

No impact

A search for information has no impact on physician practice and does not change patient care.

Negative impact

A search for information has a negative impact when physicians find no information and feel frustrated. The literature on organizations suggests this type of frustration discourages the use of information retrieval technology, and therefore has a negative effect or influence on professional practice. This impact refines the consequence of unsuccessful or ineffective searches in the medical literature.

these small numbers, our findings consist of proposals to be tested. Second, single case study results are classically less transferable to other contexts than those of multiple case studies (Yin 1994). Nevertheless, the match between our findings and the results of studies on computerized inter-organizational memory suggests some transferability. Third, this article bypasses the issue of the quality of computerized information (Benigeri & Pluye 2003). High-quality health informatics services may contain errors (Rigby *et al*. 2001), and even guidelines based on a high level of evidence contain inconsistencies (Tierney *et al*. 1995; Morris 2001). Moreover, these problems echo the controversial quality of organizational memory. 'Retrieval may not always be a good thing. The retrieval of dysfunctional methods, values or prejudices is a case in point' (Stein 1995, p. 31). Indeed, 'the controlled retrieval of information may contribute to a non-routine response when a routine decision would have been appropriate', and vice versa: 'the automatic retrieval of information may be allowed to shape a routine decision response when a non-routine response is called for' (Walsh & Ungson 1991, p. 75). In other words, physicians must use their personal experience and knowledge of the patient, in addition to information retrieval technology, for medical decision making.

Despite these limitations, the present organizational case study contributes to knowledge as an attempt to build a new basis for assessing impacts of this technology. The distinction we make between this technology and clinical decision support systems has thus far received little attention. This distinction makes an ontological contribution via the literature on organizations and the notion of computerized inter-organizational memory. There is little reference 'to a theoretical basis for understanding the many issues that arise in developing and implementing' information retrieval technology and decision support systems (Kaplan 2001, p. 16), and there is a need for process assessment and qualitative research (Zielstorff 1998; Kaplan 2001). This distinction also makes a methodological contribution. As mentioned in the background section, computers may combine information retrieval technology and decision support systems, thus searches in the latter (well-known impact) constitute an ideal comparison group to evaluate searches in the former (controversial impact) by weighing practice standards under scrutiny with their level of evidence.

Conclusion

In conclusion, physicians' memory has limited capacity (Weed 1997) and information retrieval technology supplements their memory. Our article suggests this technology constitutes an inter-organizational memory, shared within and throughout health organizations (providing practice standards from multiple countries). Indeed, this conceptualization challenges the usual definition of professionalism and 'good practices' that is embedded in a health care jurisdiction (Miettinen & Flegel 2003). In line with others, we have found that computerization may enhance the work of physicians and their workplace autonomy (Burris 1998). Our paper encourages policymakers to develop, as well as physicians to use information retrieval technology.

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Appendix Literature review: description of empirical studies (sorted by date)

Study and design	*Participants and research topic(s)*	*Use*	*Impacts: (A) proportion of searches having an impact; (B) proportion of participants reporting an impact; (C) other impact*
Crowley *et al*. (2003) Cohort study	82 internal medicine residents formulated clinical questions and searched the internet for answers.	Residents searched for answers to 93% of 625 clinical questions over 10 months.	(A) 43% of searches changed patient care, and 39% confirmed patient care.
Leung *et al*. (2003) Randomized controlled trial (crossover design)	169 fourth-year medical students were randomly assigned to one of three groups: (1) *InfoRetriever* on a handheld computer; (2) a printed pocket card; and (3) control. Students completed questionnaires at baseline and after each 8-week rotation. The response rate was 100%.	Not measured.	(C) Only the *InfoRetriever* group reported statistically significant gains in self-perceived confidence in clinical decision making.
Schwartz *et al*. (2003) Cohort study	3 family physicians searched online databases for answers to 92 clinical questions.	Physicians searched TRIP,* *InfoRetriever* and other online databases, respectively, 81, 35 and 27 times over 3 months.	(A) 30% of searches in 'evidence-based' databases influenced current patient care and 38% will affect future care.
Cullen (2002) Cross-sectional study	294 of 363 randomly selected family physicians answered a questionnaire on their internet searches.	49% searched internet in 2001, at least once, for clinical information using medical databases and popular engines.	(B) Of those, respectively, 45% and 30% reported that these searches changed or confirmed treatment and diagnosis.
Jousimaa *et al*. (2002) Randomized controlled trial	139 newly graduated family physicians were randomly assigned to use computerized guidelines (EBMG†) or paper-based guidelines. 130 completed the study. External reviewers assessed outcomes using medical records.	Guideline use was similar in 'computer' and 'paper' groups. For each physician, there were on average 2 searches per working day.	(C) Guideline adherence was similar in 'computer' and 'paper' groups. More than 3 of 4 consultation decisions were congruent with guidelines.
Rothschild *et al*. (2002) Cross-sectional study	946 of 3000 randomly selected physicians and medical students (various specialties) answered a questionnaire on their searches of a handheld pharmaceutical database.	25% searched the database in 2000 more than 5 times per day, 57% between 1 and 5 times, and 18% less than 1 time.	(B) 72% reported that almost one clinical decision a week was better.
Baker *et al*. (2001) Cohort study	190 family physicians had access to an internet diabetes guideline (13 325 patients) – automated data recording.	55 physicians (29%) used the guideline on average 7 times over 1 year.	(C) Guideline use was associated with guideline adherence.‡

Appendix Literature review: description of empirical studies (sorted by date)

Study and design	*Participants and research topic(s)*	*Use*	*Impacts: (A) proportion of searches having an impact; (B) proportion of participants reporting an impact; (C) other impact*
Manning & Gadd (2001) Case study (narratives)	35 residents and 18 staff in family medicine searched databases on handheld computers. Of those, a contrasting sample of 6 and 2 were interviewed (most and least experienced users).	Not addressed.	(C) Interviewees reported that residents learned more using handheld databases, and generated better clinical questions and answers.
Swinglehurst *et al*. (2001) Case series	20 family physicians and 2 nurses asked 60 clinical questions. Searches were mediated by a family physician using evidence-based databases and Medline.	57 searches provided answers over 10 months.	(A) 28% and 54% of searches changed physician practice in relation to the current patient and any other patient.
Taylor & Leitman (2001) Cross-sectional study	400 physicians answered questions in a US nationwide survey on the impact of online medical information on physician behaviour.	89% used internet in 2001 at least once. Of those, 90% sought medical information online.	(B) Of those who sought medical information online, from 73% to 93% reported an impact.[§]
Richwine & McGowan (2001) Case series	39 physicians (specialty not specified), 45 nurses, 6 assistants and 20 other health professionals answered a web-questionnaire on one search using books, journals and databases via internet.	Not addressed.	(B) 75% handled patient care differently from they would have handled it otherwise.
Abraham *et al*. (1999) Laboratory-like study	10 medical students had access to a specialized database to solve 4 clinical cases each (scenarios), compared with 10 other students and 12 faculty who did not have access to the database.	Students searched the database to solve 68% of the cases. All searched at least once.	(C) They correctly solved 55% of cases and performed better compared with students and faculty (no significant difference).
Jousimaa *et al*. (1998) Cohort study	102 of 477 health professionals searched the PDRD[†], and completed a questionnaire after 29% of their searches.	Each professional searched in 1995 on average 0.6 times per day (from 0.03 to 6.5).	(A) 69% of searches changed patient care (results regarding 7% of 15 267 searches).
Chambliss & Conley (1996) Cohort study	9 family physicians asked 103 questions over 217 half-days. Searches were mediated by librarians and researchers using databases and textbooks.	80% of searches were performed in Medline or a combination Medline–textbooks.	(A) 35% of searches had a major or a fairly major impact on physician practice.
Gorman *et al*. (1994) Cross-sectional study	Of 966 family physicians, a sample of 25 asked 295 clinical questions over 2 half-days. Of those, 60 randomly selected questions were researched by librarians using online bibliographic databases.	Physicians pursued 30% of questions, and searched databases for fewer than 1%. Librarians judged 88% of selected questions to be appropriate for Medline.	(A) 51% of searches would have impacted on physician practice, and 40% on patient health (physicians received librarians' answers 6–12 months later).

Appendix Literature review: description of empirical studies (sorted by date)

Study and design	*Participants and research topic(s)*	*Use*	*Impacts: (A) proportion of searches having an impact; (B) proportion of participants reporting an impact; (C) other impact*
Klein *et al*. (1994) Case control study	Librarians in 3 hospitals mediated physicians' literature searches in Medline. Patients' medical records were compared by diagnosis-related group cost of patient care.	Searches concerned 192 patients over 1 year (10,409 control cases).	(C) In 74% of the pairs, costs were lower when the searches were done in the first half of the stay (costs being associated with physician practice).
Lindberg *et al*. (1993) Cross-sectional study	Of 1160 health professionals, 552 described their recent searches in Medline (Critical Incident Technique): 71% were MDs, 14% PhDs, 3% nurses, 1% dentists and 11% other professionals.	Not addressed.	(A) 476 of 1158 (41%) searches changed or confirmed patient care while 438 (38%) had a positive impact on patient health.
Veenstra (1992) cross-sectional study	30 of 45 residents in a department of medicine completed a questionnaire on literature searches mediated by a librarian (261 searches).	Senior, transitional, junior residents and interns sought on average, respectively, 3.2, 1.8, 1.4 and 2.6 librarians' searches over 11 months.	(A) Residents reported, respectively, that a mean of 46%, 43%, 40% and 59% of searches impacted on patient care.
Haynes *et al*. (1991) Randomized controlled trial	59 of a sample of 95 hospital-affiliated physicians were randomized by pairs 'pay/no pay' for their Medline searches. They answered a computerized questionnaire after each search, and were interviewed for one-third random sample of searches ($n = 99$).	The percentage of physicians who searched Medline over 6 months was 52% for the 'pay group' (median of 2 searches) vs. 87% for the 'no pay group' (median of 4 searches).	(A) 19% of searches changed or confirmed patient care in the 'pay group', and 28% in the 'no pay group'.
Haynes *et al*. (1990) Cohort study	128 hospital-affiliated physicians or medical students and 30 clerks searched Medline. Interviews were conducted for 280 of a random sample of 300 searches.	81% did on average 2.7 searches per month over 4 months.	(A) 30% of searches changed or confirmed patient care.

Notes

*TRIP: Translating Research Into Practice (http://www.tripdatabase.com).

†EBMG and PDRD: The Physician's Desk Reference and Database – PDRD – is a Finnish computerized collection of guidelines available since 1989, and is renamed Evidence-Based Medicine Guideline – EBMG – (Jousimaa *et al*. 2002).

‡There was a statistically significant association between physicians' guideline use and guideline adherence only for one of three routine monitoring tests prescribed to patients (lipid profile).

§Physicians answered that online medical information affected their knowledge about new treatments (93%), about symptoms and possible diagnoses (87%), the way they interact with patients (79%), the types of diagnoses made (79%) and their drug prescriptions (73%) [Non peer-reviewed 'marketing' publication].

¶For 227 physicians, 15 267 searches were recorded. Of those, 10 837 led physicians to read one article or more. Moreover, 102 physicians returned questionnaires completed immediately after 2102 searches (29% of their searches). These physicians answered the question 'Did the information influence your decision?' after 1058 of 2102 searches.

