Research Paper ■

Systematically Assessing the Situational Relevance of Electronic Knowledge Resources: A Mixed Methods Study

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Abstract Electronic Knowledge Resources (EKR) are increasingly used by physicians, but their situational relevance has not been systematically examined.

Objective: Systematically scrutinize the situational relevance of EKR-derived information items in and outside clinical settings.

Background: Physicians use EKR to accomplish four cognitive objectives (C1-4), and three organizational objectives (O1-3): (C1) Answer questions/solve problems/support decision-making in a clinical context; (C2) fulfill educational-research objectives; (C3) search for personal interest or curiosity; (C4) overcome limits of human memory; (O1) share information with patients, families, or caregivers; (O2) exchange information with other health professionals; (O3) plan-manage-monitor tasks with other health professionals.

Methods: Longitudinal mixed methods multiple case study: Cases were 17 residents' critical searches for information, using a commercial EKR, during a 2-month block of family practice. Usage data were automatically recorded. Each "opened" item of information was linked to an impact assessment questionnaire, and 1,981 evaluations of items were documented. Interviews with residents were guided by log files, which tracked use and impact of EKR-derived information items. Thematic analysis identified 156 critical searches linked to 877 information items. For each case, qualitative data were assigned to one of the seven proposed objectives.

Results: Residents achieved their search objectives in 85.9% of cases (situational relevance). Additional sources of information were sought in 52.6% of cases. Results support the seven proposed objectives, levels of comparative relevance (less, equally, more), and levels of stimulation of learning and knowledge (individual, organizational).

Conclusion: Our method of systematic assessment may contribute to user-based evaluation of EKRs.

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Introduction

Electronic Knowledge Resources (EKRs) such as drug databases are increasingly used by attending physicians and residents. These physicians are using EKRs to access both general information (e.g., diagnosis and treatment), and clinical rules regarding specific patients.¹ To facilitate the use of EKRs at the point-of-care and at the moment-of-need,

many residents and physicians have adopted the use of handheld computers (PDAs) in addition to the use of desktop and laptop computers.²⁻⁶ While meta-analyses and experimental studies have shown that clinical rules may improve professional practice, our literature review also indicates that one-third of searches for EKR-derived general information may have a positive cognitive impact on physicians.⁷ As a result, EKRs may improve medical training, practice and continuing education.

Numerous studies have examined EKR use in medicine, specifically the relevance of EKR-derived information, and users' satisfaction with this information. However, to our knowledge, no studies have systematically examined the situational relevance of EKR-derived items of information in and outside clinical settings. In other words, information items derived from EKRs are relevant when they help physicians achieve their patient care or learning activities.⁸ The present paper aims to systematically scrutinize the situational relevance of EKR-derived information items in and outside clinical settings. This may contribute to the development of user-based evaluation of the situational relevance of information derived from EKRs.

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Background

EKRs are generally comprised of two types of software, (1) clinical information-retrieval technology, and (2) decision support systems.¹ Clinical information retrieval technology provides information in the form of text documents, images, sound, or movies.⁹ This information is derived from databases that contain clinical practice guidelines, synopses of clinical research, electronic journals or textbooks, and medical websites. In contrast, clinical decision support systems match information with patient-specific data, using unambiguous algorithms, to provide patient-specific recommendations, e.g., clinical decision rules and calculators. Either type of software will supply the user with information items that may or may not address the users' clinical question. We define an information item as any discrete unit of information derived from an EKR in response to a user query. When the user opens an information item it becomes what we term an 'information hit'. The relevance of these information hits can then be assessed.

The general relevance of medical information is usually based on value judgments and expert opinion, e.g., expert panels are asked to rate the relevance of scientific articles (bmjupdates⁺). Topical relevance might be quantified without user or expert opinion, to measure the ability of a search engine to match keywords to subject material.¹⁰ In contrast, situational relevance is a subjective opinion, based on experience of a single human user. In the context of EKR use, the user identifies what information resulting from a search best fulfills their specific information needs.¹⁰ In this way health professionals may assess the situational relevance of each information hit according to their search objective.⁸ We define situational relevance as the value of an information hit, for a single health professional, in a particular organizational context at a certain point in time, relative to their search objective, e.g., a clinical question may be answered using an information hit.⁸

We proposed a framework that defined situational relevance in relation to search objectives associated with physicians' information seeking behavior. Information-seeking behavior is usually conceived of as "a conscious effort to acquire information in response to a need or gap in knowledge" (p. 5).¹¹ Based on a literature review and an exploratory case study, we proposed a framework comprised of seven objectives, each describing a different reason why physicians use EKRs.⁸ Of these seven objectives, four refer to cognitive objectives (C1-C2-C3-C4) and three to organizational objectives (O1-O2-O3):

- (C1) Answer questions/solve problems/support decision-making in a clinical context;
- (C2) Fulfill educational-research objectives;
- (C3) Search in general, for personal interest or for curiosity;
- (C4) Overcome limits of human memory;
- (O1) Share information with patients, families or caregivers;
- (O2) Exchange information with other health professionals;
- (O3) Plan-manage-monitor tasks with other health professionals.

The cognitive objectives are linked to the physicians' individual needs and mental facilities. These individual cognitive objectives are subsumed into broader categories of organizational objectives (social issues of information-seeking behavior), when physicians search for information with/for others in a health organization context. Organizational objectives are linked to social actions. Our previous research indicated that the proposed framework was parsimonious in comparison with existing taxonomies.⁸ Thus, our research question is as follows: Is the proposed framework comprehensive enough to address all the objectives that arise in and outside clinical settings? The present paper examines the seven-objective framework, by systematically scrutinizing residents' acquisition of EKR-derived information items in a family medicine residency context.

Methods

In a cohort of 26 family medicine residents, we conducted a naturalistic longitudinal field research using a mixed methods multiple case study that combined quantitative and qualitative data collection and analysis.¹² Cases were defined as critical searches for information, specifically, searches that were clearly described and had clear consequences from a researchers' perspective. As we previously noted, when a user searches an EKR, they retrieve information items that may or may not address a search objective. In our work, when a user opens an information item, and reads its content, it becomes an information hit. Consequently, for this study a *search* was defined by the user's objective, and was comprised of the information hits deemed relevant to that objective.⁸ Information hits constituted our smallest units for data collection and analysis. A tracking function in combination with a computerized questionnaire allowed us to automatically record all information hits and their momentary assessment by participants. It was assumed that participants read all of the hits that they rated.

Twenty first-year residents and six second-year residents consented to participate. Participants completed an impact assessment questionnaire for information hits they retrieved on personal digital assistant (PDA) over a six-month period. Participants received weekly training to use a commercial EKR designed for primary care (InfoRetriever: versions 2003 and 2004) on a PDA (Dell AXIM X5). InfoRetriever allows simultaneous searching of seven databases. Four databases consist of clinical information retrieval technologies: An electronic textbook (5 Minute Clinical Consult), the database of Patient-Oriented Evidence that Matters (POEMs), abstracts of Cochrane reviews and guideline summaries. The remaining three databases consist of clinical decision support systems: Clinical decision and prediction rules, Diagnostic test calculators, and History and physical exam calculators. Training was conducted during a two-month Evidence Based Medicine course.¹³ We used an InfoRetriever tracking function to identify and record all information hits in a log file on participants' PDAs. Log files provided specific data on information hits viewed by the resident, with each hit defined by a title and unique identification number, when the information was opened (date and time stamp), and what search strategy was employed.

Over the course of the study, 4,948 of 5,160 (95.9%) information hits were rated for their self-perceived impact:

(positive) practice improvement, learning, recall, confirmation, reassurance, (neutral) no impact, and (negative) frustration. The definition of this impact, the history of our impact assessment method, and quantitative findings derived from impact-related data, are presented elsewhere.^{1,7,13} In the present qualitative assessment, we focused on situational relevance using a sub-sample of 1,981 information hits (38.4%) made by 17 first-year residents, during a two-month block of family practice. The rationale for this focus on a sub-sample of information hits was the building of a workable homogeneous set of qualitative data (similar residents in a similar training context). Of 20 first-year residents, three dropped out of the study for medical or pedagogical reasons. Thus, 17 residents were interviewed about their searches for information.

The mixed methods design involved complementary quantitative and qualitative data collection and analysis. Quantitative data on information hits and their impact, reported at the time of the search, enhanced retrospective interviews. The interviewer used search log data to stimulate recall concerning specific searches. Ethics approval was obtained from the McGill University Institutional Review Board.

Quantitative Data Collection and Analysis

Our impact assessment questionnaire was presented to participants, using a method inspired by Computerized Ecological Momentary Assessment, typically used in behavioral research to reduce recall bias.¹⁴ This technique and the corresponding computerized questionnaire are presented elsewhere.¹³ Participants were instructed to complete the questionnaire using the 'not applicable' answer for forgotten information hits or hits opened in error. Questionnaires were usually answered within three days, and reminders were displayed daily or upon opening the PDA to encourage completion of unanswered questionnaires. Questionnaire responses were added to an InfoRetriever usage log file on each PDA, and transferred to a research server via the Internet.

Qualitative Data Collection and Analysis

Qualitative data consisted of observations, log-reports, archives and interviews. Observations on participant-researcher interactions were documented, notably emails about technical problems. System logs were saved as text files (e.g., participant_16_log-report.txt). The textual content of information hits with self-reported impact was also archived in text-files (e.g., participant_16_hit_235.txt). Thus, these various sources of evidence allowed us to critically interpret data gathered during the resident interviews, in particular the relationship between the interview statements of the residents and the actual information item the system log showed they retrieved. In addition, qualitative data permitted us to identify individual searches for information from a series of information hits.

Searches were identified following a three-step procedure. (1) Prior to interviews, log-reports were analyzed by the interviewer; information hits opened during the same hour of the same day were assembled into potential searches. (2) During interviews, potential searches were reviewed and usually confirmed by participants. (3) Post interview, extracts of log-reports, archival data and interviews were

systematically assigned to each search using NVivo2 software for qualitative data analysis.

The first author (PP) has expertise in qualitative research, has worked as a family doctor and interviewed all participants. PP had no prior knowledge of the participants. Interviews varied in duration from 15 to 120 minutes. The interviewer retrospectively scrutinized the context of InfoRetriever usage, as well as searches for information (interview guide available on request). During the interviews PP specifically avoided any mention of the seven objectives proposed in our framework. This was done to discover new types of objectives unaccounted for in the present framework. Interviews were audio taped, and transcripts were analyzed by the authors according to the Critical Incident Technique and a three-step thematic analysis.

Participants' objectives for using InfoRetriever were extracted from interviews on critical incidents that revealed trustworthy factual stories (qualitative evidence). Critical searches were identified using the Critical Incident Technique, which provides detailed empirical illustrations of important events.¹⁵ A critical incident is a clear event from the observers' perspective, and has clear consequences. In accordance with this definition, a critical search that defines a case is a clear event from the researchers' perspective with identifiable consequences. An event was clear if there were unambiguous answers to five screening questions.

Screening questions: Why did you do this search? Did you do this search by yourself or in the presence of someone else? Do you remember where you were when you did this search? Did you do this search at the moment you needed the information or at a later time? Did you search in another source of information? *Consequences:* If this search provided recommendations, can you tell me what were they and did you apply them? Did this search permit you to improve your practice?

Thematic analysis: (1) Transcripts were independently analyzed by two researchers. Extracts of transcripts were assigned to themes by going back and forth from textual data to themes.¹⁶ Themes and sub-themes were suggested by the reading of transcripts, e.g., 'Context / Emergency room', while the seven proposed objectives were used as pre-defined themes. Through the assignment of extracts to objective-related themes, each critical search was associated to one of the seven proposed objectives. (2) Disagreements between researchers were resolved by discussion and consensus or by a third party (RG). (3) For each case, two researchers systematically assigned extracts of log-reports, archival data and interviews to themes using specialized software (NVivo2), and summarized empirical illustrations of objectives in a single sentence. Then, results were exported as matrixes from the NVivo2 software to Excel for tables, graphics and statistical tests. Results are presented below in accordance with this mixed methods data collection and analysis.

Results

Information hits and searches are presented in Table 1. The 1,981 information hits acquired by 17 residents correspond to 314 searches. On average, 2.5 information hits per day were acquired over 47.2 days. *Log-report analysis:* Of 1,981 information hits, 1,350 (68%) were linked to a search. Infor-

Table 1 ■ Residents' Information Hits and Searches for Information

Resident	HITS			SEARCHES				
	Search-related	Other NA	Total number	Critical (cases)	Forgotten	With no impact	Unclear	Total number
MD01	59	73	132	14	7	1	0	22
MD02	108	37	145	15	7	2	1	25
MD03	83	14	97	17	3	0	0	20
MD04	120	33	153	17	6	0	0	23
MD05	10	11	21	2	1	1	0	4
MD06	109	17	126	12	8	1	1	22
MD07	41	15	56	8	4	0	0	12
MD08	66	59	125	6	9	4	5	24
MD09	46	16	62	2	5	1	0	8
MD10	95	24	119	10	21	8	0	39
MD11	31	15	46	2	5	0	0	7
MD12	123	65	188	11	8	2	0	21
MD13	128	117	245	9	6	6	0	21
MD14	89	56	145	7	1	11	1	20
MD15	35	15	50	5	3	0	3	11
MD16	79	51	130	6	8	0	0	14
MD17	128	13	141	13	6	1	1	21
TOTAL	1350	631	1981	156	108	38	12	314
MEAN	79.4	37.1	116.5	9.2	6.4	2.2	0.7	18.5
%	68%	32%	100%	50%	34%	12%	4%	100%

mation hits not linked with a search referred to participants' reports of 'not applicable' and 'ask me later'. Reports of 'ask me later' refer to a small number of searches, done a day or two before the interview, where participants preferred to postpone their answer, e.g., a resident searched during an emergency situation, and did not want to answer questionnaires when they opened their PDA. Interviews revealed that 12 residents (70.6%) reported situations consistent with training instructions; e.g., to answer 'not applicable' when information hits were opened in error. Other 'not applicable' information hits referred to the following situations: Hits opened more than once, not enough time to answer, browsing, tracking error (a resident experienced technical problems with their PDA, and was asked to check 'not applicable' for the corresponding period), irrelevant hits, 'not my hits' when PDA was used by a colleague, and excessive burden. Excessive burden referred to situations where residents retrieved numerous information hits during the EBM course, then felt overwhelmed by the high number of corresponding questionnaires. Of 314 searches, 156 (50%) were critical searches confirmed by interviews (having at least one information hit with a report of positive or negative impact), 108 (34%) were forgotten searches (participants typically stated "I don't remember"), 38 (12%) were searches with 'no impact', and 12 (4%) were unclear searches from the researchers' perspective (participants typically did not answer at least one of the five screening questions, e.g., where they were).

The 156 cases identified as critical searches corresponded to 877 information hits. Of these, 441 (50%) hits were reported as having a positive or negative cognitive impact (Table 2). On average, the 17 residents (MD01 to MD17) made 5.6 information hits per case (from 2.5—MD11 to 9.8—MD13), and in 50% of these hits (2.8), they reported a cognitive impact (from 1.3—MD08 to 6.0—MD12). There were on average 9.2 cases per resident (from 2—MD05, MD09, MD11 to 17—MD03, MD04).

In 134 cases (85.9%) residents perceived information retrieved within InfoRetriever as having situational relevance to their search objective (Table 3). This information was (1) more relevant than that of another source, (2) relevant when InfoRetriever was the single source or equally relevant as compared to information of another source, or (3) relevant but less than that of another source. In 74 cases (47.4%), we considered that sources of information were InfoRetriever and supervisors. Even though supervisors were not systematically mentioned in interviews, they constituted a major

Table 2 ■ Cases: 156 Critical Searches by Residents and Corresponding Information Hits

Residents	Critical Searches (CS)	CS-related hits	Hits per CS	CS-related hits with impact	Hits with impact per CS
MD01	14	48	3.4	25	1.8
MD02	15	87	5.8	49	3.3
MD03	17	79	4.6	44	2.6
M04	17	109	6.4	41	2.4
M05	2	7	3.5	6	3.0
M06	12	78	6.5	34	2.8
M07	8	30	3.8	19	2.4
M08	6	21	3.5	8	1.3
M09	2	8	4.0	8	4.0
M10	10	52	5.2	20	2.0
M11	2	5	2.5	3	1.5
M12	11	104	9.5	66	6.0
M13	9	88	9.8	33	3.7
M14	7	24	3.4	12	1.7
M15	5	15	3.0	8	1.6
M16	6	48	8.0	20	3.3
M17	13	74	5.7	45	3.5
TOTAL	156	877	NA	441	NA
MEAN	9.2	51.6	5.6	25.9	2.8
			min: 2.5 max: 9.8	min: 1.3 max: 6.0	

Table 3 ■ Situational Relevance of Information Derived from InfoRetriever by Objective (N=156 Critical Searches)

Objective	Situational relevance				Total %	N
	More relevant	Relevant	Relevant but less	Not relevant		
C1 clinical question-problem-decision	1.9%	32.7%	0.6%	6.4%	41.7%	65
C2 educational-research objective	0.6%	26.9%	1.3%	3.8%	32.7%	51
C3 curiosity-personal interest	0.0%	7.7%	0.0%	1.3%	9.0%	14
C4 overcome memory limitation	0.0%	5.8%	0.0%	0.6%	6.4%	10
O1 share information with patients	0.0%	1.9%	0.0%	0.6%	2.6%	4
O2 exchange information with profs	1.3%	2.6%	0.0%	1.3%	5.1%	8
O3 plan-manage-monitor	1.3%	1.3%	0.0%	0.0%	2.6%	4
Total %	5.1%	78.8%	1.9%	14.1%	100%	
N	8	123	3	22		156

More relevant = Information derived from InfoRetriever is more relevant as compared to information from other source(s) for achieving the objective.

Relevant = Information derived from InfoRetriever is relevant for achieving the objective, or equally relevant as compared to information from other source(s).

Relevant but less = Information derived from InfoRetriever is relevant for achieving the objective but less relevant as compared to information from other source(s).

Not relevant = Information derived from InfoRetriever is not relevant for achieving the objective.

source of residents' information, i.e. the dyad of resident-supervisor. In 82 cases (52.6%), residents retrieved information from other sources. Other sources of information were lecturers, colleagues, journals, books, leaflets, personal notes and other EKR. Table 3 shows four ordinal categories of situational relevance: more relevant, relevant, less relevant, and not relevant. The category 'relevant' was illustrated by at least one case for all of the seven proposed objectives. The three other categories of relevance were not systematically illustrated depending on objective: 'Not relevant' refers to 14.1% of cases illustrated by six objectives, 'more relevant' refers to 5.1% of cases illustrated by four objectives, and 'less relevant' refers to 1.9% of cases illustrated by two objectives.

The 156 cases illustrated all seven types of proposed objectives, and no cases suggested a new objective (Appendix, available as an online data supplement at www.jamia.org). The proportion of cases by objective is presented in Figure 1.

Figure 1. Proportion and number of critical searches by type of objective

(C1) To answer a clinical question, solve a problem, or support decision-making related to a resident's clinical practice (n = 65): For example, participant MD04 searched InfoRetriever to support decision-making on whether to x-ray a patient with a knee injury. According to MD04, "I knew the patient needed an x-ray, but it just happened that my supervisor said no, the patient doesn't need one. Well, the Ottawa Knee Rules say he does" (see MD04S02 in Appendix). MD04 retrieved one relevant information hit, namely the POEM entitled "Ottawa Knee Rules are effective in ruling out knee fracture" (one bottom line sentence and a 233-word synopsis of a research paper). He showed this synopsis to his supervisor, and the patient was x-rayed. As mentioned, a resident and a supervisor constitute a training dyad because supervisors have responsibility for residents' actions. Accordingly, supervisors were not considered as 'other health professionals', and this MD04-supervisor interaction was not associated with an organizational objective. In other words, the presence of resident-supervisor interactions like ordering tests or prescribing treatment did not lead us to assign corresponding extracts to organizational objectives.

(C2) To fulfill an educational or research objective not directly related to the resident's patient (n = 51): By way of illustration, MD04 retrieved the same information hit five times in preparing for a presentation on thoracic outlet syndrome. MD04 stated "I was asked in the emergency room (what is thoracic outlet syndrome?), and I presented (information from the 5MCC e-textbook). That was the first time I looked for that information, and the staff said ok, why don't you do a presentation on it in two weeks? So then, the second time, I presented to residents and staff and I had my PDA, which is like a teaching tool" (see MD04S10 in Appendix).

(C3) To search in general, or satisfy personal curiosity or interests (n = 14): For example, MD06 retrieved five relevant information hits (three clinical practice guide-

lines, one POEM and one page in the 5MCC e-textbook) to satisfy curiosity about the diagnosis of anxiety and depression while in the medical library. According to MD06, *"I had seen a few patients with anxiety and depression a few days before, and I wanted to check information. I had the time"* (see MD06S07 in Appendix, available as an online data supplement at www.jamia.org).

(C4) To overcome memory limitations ($n = 10$): Ten critical searches were associated with C4 and supported the proposed relationship with other individual objectives (Appendix). In six cases, C4 overlapped C1 as the search for information was also done to answer a clinical question. By way of illustration, MD04 retrieved three relevant information hits on head injury and coma to calculate a patient's Glasgow coma score. MD04 said *"I forgot the Glasgow coma scale, and I needed refreshing"* (see MD04S16 in Appendix). In three cases, C4 overlapped C2 since the participant's objective was educational. For example, MD12 searched about treatments for osteoporosis during a journal club (see MD12S04 in Appendix). In one case, C4 overlapped C3 since MD14 also searched out of curiosity: *"I was just merely looking... for the pleasure of looking"* (see MD14S07 in Appendix).

(O1) To share information and negotiate with patients, family or community caregivers ($n = 4$): For example, MD15 retrieved the same relevant page three times from the 5MCC e-textbook to share information with a patient about pityriasis rosea. As stated by MD15, *"I saw a patient in dermatology clinic, and I was showing him what pityriasis rosea is. I was also learning as I did not really know what it was"* (see MD15S05 in Appendix). This case illustrates how organizational objectives can subsume individual objectives, namely C2 in this case. The Appendix illustrates that organizational objectives may subsume all types of individual objectives.

(O2) To exchange information with other health professionals, namely colleagues or members of health organizations ($n = 8$): By way of illustration, MD04 retrieved two information hits to exchange information with colleagues about an adult patient with suspected pertussis (one clinical practice guideline and one page from the 5MCC e-textbook). MD04 said regarding the patient of another resident, *"I was in the resident room, we were discussing (with colleagues), and the supervisor said: this could be pertussis. I only heard [sic] of pertussis in children, and I said it cannot be pertussis. Well I searched (InfoRetriever) by myself, and I don't even think it talked about adult pertussis"* (see MD04S04 in Appendix, available as an online data supplement at www.jamia.org). This statement nevertheless did not match the information hit read by MD04, since this hit does mention adult pertussis in sections on risks, treatment, follow up, and age-related factors. MD04 found a relevant information item, but missed the relevant information within this item.

(O3) To plan, manage or monitor tasks with other health professionals ($n = 4$): For example, MD03 retrieved three information hits to manage, with a nurse, care of an agitated in-patient with Parkinson's disease. She retrieved one abstract of a Cochrane review, and two POEMS, including the relevant POEM entitled "Risperi-

Figure 2. Objectives associated with information-seeking behavior

done preferred for aggressive syndrome." According to MD03's perception of this search, the POEM was more relevant than information from two printed textbooks. As stated by MD03, *"I was called by a nurse regarding a patient who was very difficult. Nurses wanted me to give something to the patient but he had already received medication and I did not know what to do. Information was more specific in InfoRetriever because the patient had Parkinson's disease, and I could not use the treatment recommended in my (printed) book. (InfoRetriever) said that Haldol was the first-line drug for restless patients, and that Risperidone was the second line drug for patients with Parkinson's"* (see MD03S09 in Appendix).

Furthermore, our results suggest the seven proposed objectives are associated with different patterns of residents' information-seeking behavior for three reasons. First, the number of information hits per case varies depending on search objective (Figure 2). Residents searched on average 10.0 hits/case for C2 education-research-related searches, 5.9 hits/case for C3 curiosity-related searches, 3.4 hits/case for C1 clinical question-problem-decision-related searches, 2.3 hits/case for C4 memory-related searches, and on average 2.7 hits/case for searches linked to organizational objectives (O1+O2+O3-related cases). This variation has been tested as follows.

Given the limited number of searches that were linked to organizational objectives, we grouped all these searches into one category (O1+O2+O3-related cases). The null hypothesis was that the proportion of information hits per case for all categories of objective-related searches would be equal. This hypothesis was assessed using a marginal model, which accounted for the correlation in the cases performed by the same physicians. The multivariate Wald and the Generalized Score¹⁷ values were respectively 27.75 and 7.51 (following a Chi-square distribution with four degrees of freedom). The null hypothesis could not be rejected with certitude since it was rejected with the Wald test (p -value < 0.0001), but not with the Score test (p -value = 0.1112).

Second, the proportion of cases with at least one relevant information hit varied depending on search objective. This

variation suggests an apparent objective-related gradient of situational relevance. The proportion of cases with relevant information hits regularly decreased in the following manner. Residents found relevant information in **90.0%** of C4 memory-related cases ($n = 9$), in **88.2%** of C2 education-research-related case ($n = 45$), in **85.7%** of C3 curiosity-related cases ($n = 12$), in **84.6%** of C1 clinical question-problem-decision-related cases ($n = 55$), and in **81.3%** of cases linked to organizational objectives (O1+O2+O3: $n = 13$). This gradient has been tested as follows.

Regarding three of five categories of objectives, the number of cases with irrelevant information was too small to use a marginal model (C3: two cases; C4: one case; O1+O2+O3: three cases). Thus, we compared the average number of information hits per case between the category of education-research-curiosity-related objectives (C2+C3) and the category of other objectives (C1+C4+O1+O2+O3). The null hypothesis was that the proportion of cases with relevant information hits for these two categories of objective-related searches would be equal. The multivariate Wald and the Generalized Score¹⁷ values were respectively 0.08 and 0.08 (following a Chi-square distribution with one degree of freedom). The null hypothesis was not rejected with the Wald test (p -value = 0.7757) and the Score test (p -value = 0.7777).

Third, other results indicated that the seven proposed objectives were associated with different patterns of information-seeking behavior. Specifically, that residents' behavior varied in relation to the types of EKR, search issues and social contexts.

Types of EKR

Residents used decision support systems in 60% of C4 memory-related cases (clinical rules, diagnostic test calculators, and exam calculators), and information retrieval technology in 40% of these cases (textbook, POEMs, abstracts of Cochrane reviews and guideline summaries). Regarding other objectives, they most frequently used information retrieval technology: In 88% of C1 clinical question-problem-decision-related cases, in 86% of C2 education-research-related cases, in 93% of C3 curiosity-related cases, and in 94% of cases linked to organizational objectives (O1+O2+O3).

Search Issues

Residents used InfoRetriever for diagnostic issues in 60% of C4 memory-related cases, and for treatment issues in 20% of these cases. By contrast, they less frequently used InfoRetriever for diagnostic issues to achieve other objectives: In 36% of C1 clinical question-problem-decision-related cases, in 20% of C2 education-research-related cases, in 33% of C3 curiosity-related cases, and in 19% of cases linked to organizational objectives (O1+O2+O3). They most frequently used InfoRetriever for treatment issues to achieve other objectives: In 47% of C1 clinical question-problem-decision-related cases, in 55% of C2 education-research-related cases, in 40% of C3 curiosity-related cases, and in 75% of cases linked to organizational objectives (O1+O2+O3). Other issues were even less frequently addressed, whatever the objective (prevention, prognosis and topic overview).

Social Contexts

In a Family Medicine context, residents most frequently used InfoRetriever to overcome memory limitations (70% of C4-related searches). In a conference room, they most frequently used InfoRetriever to fulfill educational objectives (67% of C2-related cases). In a specialized care unit or the emergency department, InfoRetriever was used mostly for curiosity and personal interest (43% of C3-related cases). InfoRetriever was also used outside health organizations (at home, in a library, subway or a car) notably for curiosity and personal interest (29% of C3-related cases), as well as to fulfill educational objectives such as preparing a presentation (20% of C2-related cases).

Discussion

Our results indicate that the situational relevance of information derived from an EKR may reach about 86% on average in a family medicine residency context. To our knowledge, no studies have systematically assessed the relevance of information items retrieved by health professionals from EKRs in and outside clinical settings. As compared to previous naturalistic studies on physicians' information seeking behavior, the present study scrutinized searches both within a clinical decision-making context (before, during or after encounters with patients) and outside of a clinical context (lecture, library, home, subway or car). In the literature, situational relevance is usually at best examined within a clinical context when researchers directly observe clinicians' information needs and information-seeking behavior. The high relevance rate observed in our study may be the result of using the Critical Incident Technique (exclusion of 'forgotten' searches, 'unclear' searches and searches with 'no impact' less likely to include relevant information hits). According to a recent literature review, "a substantial number of primary care physicians' questions could be answered by consulting electronic databases," and when other information sources were included, the proportion "of satisfactory answers rose to the range of 70% to 80%."¹⁸ For example, Gorman et al. (2004) observed and interviewed 103 primary care practitioners in half-days of clinical practice.¹⁹ These clinicians asked an average of 0.83 questions per patient, pursued an average of 47% of their questions, and reported being successful in finding an answer to 77% of questions pursued using all types of information sources, including EKRs.

Our qualitative results indicate that the proposed seven types of objectives for searching within EKRs are associated with different information-seeking behaviors. In particular, search objectives vary in accordance with the type of EKR technology used (clinical information retrieval technology vs. clinical decision support systems) search issues and social contexts. We cannot make definitive conclusions from the statistical analysis. The number of clusters was small (17 residents) and the Generalized Score test is too conservative and may not reject null hypotheses when it should.²⁰ Moreover, our results refine the proposed framework, and support the following conceptual relationships between the seven types of objective. On the one hand, objective C4 (overcome memory limitation) overlaps with the three other cognitive objectives: C1 (answer clinical question), C2 (for education and research) and C3 (for curiosity and personal

interest). On the other hand, the four individual objectives (C1, C2, C3 and C4) are subsumed in a larger category comprised of all three organizational objectives (O1+O2+O3: share information with patients, exchange information with professionals, plan-manage-monitor tasks with professionals).

In addition, our results suggest a gradient of situational relevance. The proportion of searches with relevant information hits varies in relation to the seven objectives. Our understanding is that this gradient may reflect a specific individual influence and a specific social influence that critically affect the information-seeking behavior of physicians in practice. *Individual influence*: Pre-search knowledge or an expectation that relevant information may be found, affect information seeking behavior. *Social influence*: Time and social pressures affect information seeking behavior. Our understanding is supported by the literature. Specifically, the most commonly reported obstacles to searching for information are "the physician's doubt that an answer exists,"²¹ and time pressure.^{18, 21}

The relationship between objectives and information seeking behavior, combined with the gradient of situational relevance, leads to three propositions for future research. *Proposition one—High relevance rate (+++)*: Physicians in practice are likely to find relevant information hits in 90% of C4 memory-related searches when they know that information may be found. *Proposition two—Moderate relevance rate (++)*: Physicians in practice may find relevant information hits in 85% of C2 education-research-related searches, and C3 curiosity-related searches, when they do not necessarily expect that relevant information may be found, and when there may be no or less time pressure as compared to a clinical context. *Proposition three—Low relevance rate (+)*: Physicians in practice may find relevant information hits in 80% of C1 clinical question-problem-decision-related searches, and searches linked to organizational objectives (O1+O2+O3), when they do not necessarily expect that relevant information may be found, and when they search under time and social pressure.

Using a Computerized Ecological Momentary Assessment approach, our framework and these propositions may contribute to advance the evaluation of situational relevance using a computerized form as proposed in Figure 3. The proposed evaluation procedure is multidimensional and includes two information hit-related relevance assessment scales, and one search-related relevance assessment scale. The two information hit-related relevance assessment scales are based on (1) three levels of comparative relevance (less, equally, more), and (2) degrees of objective-achievement (from objective not achieved 0% to objective completely achieved 100%).

The search-related scale is based on the seven objectives and two proposed levels of stimulation of learning and knowledge.⁸ These levels are illustrated by our results. The two proposed levels are an individual level (+), and a higher organizational level (++). At the individual level, residents used information to address the four cognitive objectives. At the organizational level, residents used information to address the three organizational objectives. For example, exchanging information with colleagues stimulated residents'

For each search:

1. Why did you do this search for information (check all that applies)?
 - ☐ to answer a question, solve a problem, or support decision-making related to clinical practice
 - ☐ to fulfill an educational or research objective not directly related to a patient
 - ☐ to search in general, or satisfy personal curiosity or interests
 - ☐ to overcome memory limitations
 - ☐ to share information and negotiate with patients, family or community caregivers
 - ☐ to plan, manage or monitor tasks with other health professionals
 - ☐ to exchange information with other health professionals (e.g., colleagues)
 - ☐ other objective (please describe): _____
2. Did you feel time or social pressure when you did this search? ☐ YES ☐ NO
3. Did you know prior to this search that relevant information existed? ☐ YES ☐ NO

For each specific item of information:

1. Estimate the extent to which this item of information helped to achieve your search objective(s) above?

Objective not at all achieved	Objective completely achieved
0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%	

2. What is the relevance of the present item of information as compared to other items from the same source or from other sources (e.g., colleagues) regarding the achievement of the above search objective(s)?
 - ☐ more relevant ☐ equally relevant ☐ less relevant
 - ☐ not applicable (no other sources)

Figure 3. Proposed data collection form to systematically assess the situational relevance of electronic knowledge resources

learning and the creation of shared knowledge. The organizational level of stimulation of learning and knowledge presupposes an individual level.

This evaluation procedure of situational relevance contrasts with usual information item-related feedback on user satisfaction, e.g., users' ratings of products on Amazon.com, and may benefit both researchers and information providers. For each information hit, researchers may calculate a score of situational relevance that integrates the degree of achievement of the search objective (from 0% to 100%), the level of comparative relevance (less, equally, more) and that of stimulation of learning and knowledge (individual, organizational). The proposed approach may offer information providers a crucial user-based evaluation of relevance for database maintenance, specifically the ability to order information hits by relevance and to exclude irrelevant hits.

There are four main limitations to our study. First, we systematically examined residents' use of only one of many

EKRs. Scrutinizing the usage of other EKRs might have produced different results regarding the proportion of searches with relevant information hits. We nevertheless believe that our framework could be used to compare the situational relevance of information derived from different EKRs.

Second, research participants were residents. Thus, our results may not generalize to other groups of health professionals, such as physicians in general clinical practice. In a group of experienced physicians, the proportion of C1 clinical question-problem-decision-related objectives may be higher, while the proportion of C2 education-research-related objectives may be much lower. No new types of objective were suggested by our data in a family medicine residency context, while experienced physicians might suggest new unexpected objectives for searching EKRs. Physicians in practice may nevertheless confirm results of the present study, that searching for educational purposes or curiosity refers to a different information-seeking behavior as compared with searching for answers to a clinical question with a patient in the office.

Third, 32% of information hits were not linked to a search and not systematically scrutinized. These were isolated information hits corresponding to self-reports that the hit was 'not applicable'. As mentioned, our mixed methods study permitted us to cast some light on these information hits, and suggest 'not applicable' refer to six situations: opened in error, forgotten hits, duplication of hits, too many hits at once, exploration, and computer used by someone else.

Finally, the high relevance rate observed in our study could be seen as an overestimation from resident self-report and recall bias (retrospective interviews). However, we believe that our combination of multiple sources of quantitative and qualitative evidence (observations, log-reports, archives and interviews) and techniques addressed the latter issue for five reasons. (1) Computerized Ecological Momentary Assessment is believed to reduce recall bias, and guided our interviews. (2) The Critical Incident Technique has been recognized over the last 50 years as both reliable and valid in providing detailed empirical illustrations of important events. (3) The validity of our results is supported by the exclusion of 158 searches (50%) as non-critical searches (forgotten searches, searches with no impact, unclear searches). (4) We combined quantitative and qualitative data in a dialectical complementary manner, and excluded unclear searches when an interview was contradicted by the log-report. For example, MD06 reported a search for information on otitis with colleagues during an evidence-based medicine course, but the date did not correspond to this course, none of his colleagues searched otitis on that day, and this search was excluded. (5) Other examples reveal that interviews were supported by archives containing the textual content of information hits, or might be critically scrutinized when residents missed information, as illustrated by the discrepancy with MD04's search for pertussis (MD04S04).

For future research, our work could contribute to systematically examining unanswered questions concerning search reiteration and abandonment. Health professionals often

find irrelevant information hits with respect to their search objective,²¹ and reiterate their search until they find relevant information. However, they also abandon a search within EKRs when results are not quickly obtained. In our study, MD08 searched for information to answer a prognosis question on temporo-mandibular joint syndrome, stated that no relevant information was found, and did not pursue the search in other sources, while one of the authors (PP) found the answer he had missed (MD08S07 in Appendix, available as an online data supplement at www.jamia.org). Similarly, MD14 searched for information to answer a question about management of a patient with hyperthyroidism, did not find relevant information, and did not pursue this search in other sources (MD14S06 in Appendix).

Conclusion

The present paper outlines our experience with the systematic examination of Family Medicine residents' acquisition of EKR-derived information items. Our results contribute to a better understanding of the growing use of PDA software in clinical care, and methods for assessing the situational relevance of EKR derived information. This work could encourage professional bodies to recognize use of information retrieval technology as a form of practice-based learning that contributes to continuing education. Furthermore, the proposed organizational framework has the potential to improve our knowledge of EKR-based information-retrieving processes in and outside clinical settings. A better understanding of these processes could help technology developers, health professionals, and decision-makers overcome EKR-related implementation barriers.

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