Four Levels of Outcomes of Information-Seeking: A Mixed Methods Study in Primary Health Care

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Primary health care practitioners routinely search for information within electronic knowledge resources. We proposed four levels of outcomes of information-seeking: situational relevance, cognitive impact, information use, and patient health outcomes. Our objective was to produce clinical vignettes for describing and testing these levels. We conducted a mixed methods study combining a quantitative longitudinal study and a qualitative multiple case study. Participants were 10 nurses, 10 medical residents, and 10 pharmacists. They had access to an online resource, and did 793 searches for treatment recommendations. Using the Information Assessment Method (IAM), participants rated their searches for each of the four levels. Rated searches were examined in interviews guided by log reports and a think-aloud protocol. Cases were defined as clearly described searches where clinical information was used for a specific patient. For each case, interviewees described the four levels of outcomes. Quantitative and qualitative data were merged into clinical vignettes. We produced 130 clinical vignettes. Specifically, 46 vignettes (35.4%) corresponded to clinical situations where information use was associated with one or more than one type of positive patient health outcome: increased patient knowledge \( (n = 28) \), avoidance of unnecessary or inappropriate intervention \( (n = 25) \), prevention of disease or health deterioration \( (n = 9) \), health improvement \( (n = 6) \), and increased patient satisfaction.

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(n = 3). Results suggested information use was associated with perceived benefits for patients. This may encourage clinicians to search for information more often when they feel the need. Results supported the four proposed levels of outcomes, which can be transferable to other information-seeking contexts.

Introduction

Information use and subsequent outcomes are rarely studied (Case, 2002, 2006). In contrast, numerous studies examine the performance of databases to retrieve information, and information seekers’ satisfaction. For instance, physicians routinely seek treatment recommendations from electronic knowledge resources, but there are few studies on the outcomes associated with physicians’ information-seeking (McGowan et al., 2009; Pluye, Grad, Dunikowski, & Stephenson, 2005; Pluye, Grad, Shulha, Granikov, & Leung, 2011). In this article, we assess the value of clinical information (how information is valuable from a users’ viewpoint) using four levels of outcomes of information-seeking. We define clinical information as articles, syntheses, or synopses of clinical research to answer clinical questions. Our goals were to produce clinical vignettes for describing four levels of outcomes of information-seeking and to test these outcomes when clinicians in primary health care evaluate information from one online resource.

The proposed levels of outcomes of information-seeking consist of situational relevance (Level 1), cognitive impact (Level 2), information use (Level 3), and subsequent patient health outcomes (Level 4). These levels are defined in relation to a specific information-seeking context: a particular information object is acquired, for example, a web page, in a specific situation, for example, a clinician–patient encounter. These two conditions are necessary to observe the “imbrication” (Leonardi, 2011) between information objects, technology, and users, who are the ultimate decision-makers about the value of information.

This article is based on a theoretical model from information studies (Saracevic & Kantor, 1997), and a mixed methods study on outcomes of information-seeking reported by three types of primary care clinicians: nurse practitioners, pharmacists, and medical residents. These clinicians accessed an online knowledge resource, e-Therapeutics+, providing topic summaries with treatment recommendations. As information searches in e-Therapeutics+ were tracked, the clinicians could systematically assess their searches for each of the four levels of outcomes using the Information Assessment Method (IAM). A bibliography on the 10-year development and validation of the IAM, which is the product of publicly funded research, is available at http://iam2009.pbworks.com. Our research questions were as follows: What is the impact of the first three levels of outcomes of information-seeking (situational relevance, cognitive impact, and information use) on the fourth level (patient health outcomes)? For how many patients does a clinician need to retrieve clinical information from electronic resources to report health benefits for one (the number needed to benefit from information [NNBI])? We defined patient health benefits as the clinicians’ perception that health outcomes for a patient were better with than without an answer to their clinical question. We did not have access to patients for better understanding the context of such information use, and knowing the patients’ viewpoint on these benefits, whereas researchers should ideally collect and analyze the perception of patients, of health professionals, and of the dyad patient–professional (interactions).

Rarely do studies focus on outcomes such as our proposed Level 4. Therefore, this article contributes to filling a knowledge gap. In addition, clinicians do not systematically search for information when they feel the need, for example, physicians pursue only one half of their clinical questions (Ely, Osheroff, Chambliss, Ebell, & Rosenbaum, 2005); thus, knowing more about how patients benefit from retrieved information should stimulate clinicians to search more often. In this article, we first define four levels of outcomes of information-seeking. Then we describe and test outcomes reported by primary care clinicians who searched e-Therapeutics+. In conclusion, we discuss the potential transferability of these levels of outcomes to other contexts and suggest future research.

Background and Literature Review

Twenty-five years after the first call for more research on information-seeking outcomes (Taylor, 1986), multiple theories, conceptual frameworks, and empirical research examine information-seeking, but few authors report outcomes other than relevance (Fisher, Erdelez, & McKechnie, 2005). In addition, despite Paisley’s call (1968) for combining methods, quantitative and qualitative methods are usually applied in separate studies, and mixed methods research is rare (Julien, Pecoskie, & Reed, 2011). There is also a need for more observational studies (Julien et al., 2011) and studies using narrative causation to describe the potential contribution of information in problem-solving and decision-making (Day, 2011). Our work addresses these needs. We studied four levels of outcomes of information-seeking and conducted a naturalistic mixed methods study where the quantitative evaluation of retrieved information guided qualitative interviews, and where quantitative and qualitative data were merged into patient-centered clinical stories.

Information “has value only in context”: the value given by its users (Taylor, 1986). Specifically, a theoretical model conceptualizes the value of information using three constructs in sequence: acquisition, cognition, and application (hereinafter the ACA model; Saracevic & Kantor, 1997). In previous work, we operationalized this model to study the value of information according to health professionals (Grad et al., 2011; Pluye, Grad, Dawes, & Bartlett, 2007). In acquisition, health professionals search for information with an
intention, namely to fulfill an objective. In cognition, they absorb, understand, and integrate information objects, for example, a webpage. In application, they may use this newly understood and cognitively processed information. This ACA cycle is iterative: it “may be repeated several times for the same task or problem” (Saracevic & Kantor, 1997, p. 534).

However, we submit that the scope of the ACA model is limited (Pluye, Grad, Shulha, et al., 2011). This model does not specifically include outcomes outside the relevance of information (acquisition) and its cognitive impact (cognition), for example, it does not distinguish between the application of information and the outcomes of this application. Historically, it has been difficult to associate a discrete information object and an information-seeking event with the application of that object by users. Although the ACA model postulates an “application” construct, it does not follow that the application of one information object leads to an identifiable outcome. For example, Saracevic and Kantor (1997) describe a scenario where a scholar visits a library to find information that will contribute to the writing of a paper, where the “information gained from the library exhibits its value in the application and the final product” (p. 535). The value of that information can nevertheless only be represented as an “abstract space of possible decisions” and a “range of possible actions available to users before and after making use of a library” (p. 534).

In contrast, electronic knowledge resources allow the systematic tracking of the application of discrete information objects, thus the examination of outcomes of information use. This is a departure from the past when information was delivered on paper (Case, 2002). As a result, we propose a new model integrating the ACA model and the proposed levels of outcomes (hereinafter the ACA-LO model), which can be summarized as follows. In an iterative information-seeking sequence (ACA), clinicians search electronic knowledge resources for clinical information to fulfill specific objectives (acquisition); they integrate relevant information with their previous knowledge (cognition); and they can apply it for a particular patient (application). In corresponding levels of outcomes (LO), some retrieved information objects achieve one or more than one of the clinicians’ objectives (Level 1). This achievement documents the relevance of information objects in a specific situation from a user viewpoint (situational relevance). Only a fraction of relevant information objects have positive cognitive impact on clinicians (Level 2). Of these, only certain information objects are used for a specific patient (Level 3). Finally, information that is used may be associated with patient health outcomes (Level 4). We identify four levels because situational relevance (Level 1) is necessary for positive cognitive impact (Level 2) that is necessary for using the information for the management of a patient (Level 3), which in turn is necessary for expecting patient health benefits (Level 4).

The proposed ACA-LO model is operationalized by the IAM. Using literature reviews and qualitative, quantitative, and mixed methods studies, we have documented the feasibility, content validity, construct validity, and substantive validity (theoretical rationale) of the IAM questionnaire (Pluye et al., 2005; Pluye, Grad, Mysore, Knaapen, Johnson-Laflaur, & Dawes, 2007; Pluye, Grad, Shulha, et al., 2011). For example, 40 family physicians participated in a content validation of the IAM 2011 questionnaire, presented in Figure 1 (Bindiganavile Sridhar, 2011). In the IAM 2011, information-seeking outcomes are defined using seven types of information-seeking objectives associated with clinicians’ searches for information (Level 1), 10 types of cognitive impact of information on users (Level 2), five types of information use by clinicians (Level 3), and five types of patient health outcomes (Level 4).

As stated by Leckie, Pettigrew, and Sylvain (1996), “outcomes are the results of the information-seeking process; [and an] optimal outcome is that the information need is met and the professional accomplishes the task at hand” (p. 187). To this Level-3 user outcome, the ACA-LO model suggests adding patient health outcomes, as Level 4. In the next section, we describe and test outcomes reported by primary care clinicians who searched e-Therapeutics++. To do this, we took into account that outcomes associated with one information object can be influenced by another source, for example, peer interaction (Chaudiron & Haidjade, 2010). Although we systematically tracked information objects and interviewed clinicians about their use in clinical situations, we did not consider the complexity of the social context where the information was needed, sought, and used. For instance, we did not have access to the patients. In holistic approaches, information users are understood in their context (linguistic, social, cultural), and interpersonal interactions and communication are taken into account (social construction of information), specifically in organizational settings (Choo, 2005; Dervin & Nilan, 1986; Savolainen, 2002; Wilson, 1997).

**Method**

Our methodology followed the principles of participatory action research within organizations (Argyris, Putnam, & McLain Smith, 1985; Foote-Whyte, 1991). Our three aims were to improve knowledge and practice (organizational learning), to engage organization members (reflective practitioners), and to involve organization partners in all research aspects (integrated knowledge translation). Our research team was multidisciplinary and included librarians, nurses, pharmacists, and physicians. Our partner was the Canadian Pharmacists Association (CPhA), a professional organization represented by pharmacist editors, and technical and marketing staff. The Editor-in-Chief (CPhA) participated in this research as a coprincipal decision maker. After 3 years of work, a researcher and a CPhA partner were interviewed and reported that the participatory research process was beneficial, productive, and sustained. They also reported this research was facilitated by trust, respect, and shared values.
Q1. Why did you do this search for information? **Check all that apply**
☐ To address a clinical question (problem) about a specific patient
☐ To fulfil a personal educational objective
☐ To satisfy curiosity or for personal interest
☐ To look up something I had forgotten
☐ To share information with a patient, their family, or home health aides
☐ To exchange information with other health professionals (e.g., a colleague)
☐ To manage aspects of patient care with other health professionals

Q2. Did you find relevant information that partially or completely met your objective(s)?
☐ Yes ☐ No

Q3. What is the impact of this information on you or your practice? **Check all that apply**
☐ My practice was (will be) changed and improved
☐ I learned something new
☐ This information confirmed I did (am doing) the right thing
☐ I am reassured
☐ I am reminded of something I already knew
☐ I am dissatisfied
☐ There is a problem with the presentation of this information
☐ I disagree with the content of this information
☐ This information is potentially harmful

Q4. Did you (will you) use this information for a specific patient?
☐ Yes ☐ No ☐ Possibly  **If YES: Check all that apply**
☐ As a result of this information I managed (or will manage) this patient differently
☐ I had several options for this patient, and I used (will use) this information to justify a choice
☐ I did not know what to do, and I used (will use) this information to manage this patient
☐ I thought I knew what to do, and I used this information to be more certain about the management of this patient
☐ I used this information to better understand a particular issue related to this patient
☐ I used (will use) this information in a discussion with this patient, or with other health professionals about this patient
☐ I used (will use) this information to persuade this patient, or to persuade other health professionals to make a change for this patient

Q5. For this patient, did you observe (or do you expect) any health benefits as a result of applying this information?
☐ Yes ☐ No ☐ Possibly  **If YES: Check all that apply**
☐ This information helped to improve (will help to improve) this patient’s health status, functioning or resilience (i.e., ability to adapt to significant life stressors)
☐ This information helped to prevent (will help to prevent) a disease or worsening of disease for this patient
☐ This information helped to avoid (will help to avoid) unnecessary or inappropriate treatment, diagnostic procedures, preventative interventions or a referral, for this patient
☐ This information helped to decrease this patient’s worries about a treatment, diagnostic procedure or preventative intervention
☐ This information helped to increase this patient’s knowledge, or their family or home health aides’ knowledge

FIG. 1. The Information Assessment Method: IAM-pull 2011 questionnaire.

and interests, while it consumed an unanticipated amount of CPhA time and effort. The CPhA had an advisory role for planning this research and analyzing the data, and an equal role for collecting data and disseminating results. The participatory process required multiple e-mails, for example, up to two per day in preparation for data collection, and teleconferences, for example, weekly phone calls for preparing data collection and meetings. The partnership was supported by a 4-page document entitled “Guiding principles.” This document included sections on coordination, conflict management, data ownership, and interpretation and dissemination of findings. Overall, our three participatory aims
were achieved, for example, the IAM was implemented for research purposes, and the CPhA has sustained its use to stimulate and collect feedback from pharmacists and family physicians. This feedback improves resource content and influences editorial practice (Tang, 2012).

In accordance with the methodological notion of imbrication, we did not study only the clinicians, or only the information. We studied how health professionals used information in clinical situations. Imbrication represents the interdependency between professionals (human agencies) and information objects (material agencies) in a work situation: “when they become imbricated (interlocked in particular sequences), they together produce, sustain or change either routines or technologies” (Leonardi, 2011, p. 149). On the one hand, imbrication means that clinicians have the capacity to form and achieve objectives, for example, answer a clinical question using an electronic resource, then implement the retrieved treatment recommendation. On the other hand, it means that resources also act somehow “on their own,” and clinicians do not entirely control the retrieval of treatment recommendations. Inspired by the structuration theory (social actors and structures influencing each other), imbrication reconciles two extreme worldviews: Clinicians are autonomous independent professionals who do what they want (free will) versus clinicians are organization members constrained by local routines and state-level institutional standards (contingency). Imbrication is useful for our work as it produces outcomes and cannot be replicated the same way over time, that is, imbrication at Time 1 influences the way it occurs at Time 2. This has been considered in our statistical analysis.

Study Design

We conducted a mixed methods research study using a “convergence” design (Creswell & Plano Clark, 2010). The mixed methods design is described in Figure 2. A quantitative longitudinal study was combined with a qualitative multiple case study (Yin, 2009). Participants were 10 nurse practitioners, 10 family health team pharmacists, and 10 medical residents working in primary health care. Cases were critical searches for information by participants for specific patients. To obtain a systematic and comprehensive description of these cases, quantitative and qualitative data were integrated at both collection and analysis stages (O’Cathain, Murphy, & Nicholl, 2010). The quantitative data collection documented participants’ searches for clinical information as well as their reflections on each rated search, using IAM. Guided by quantitative data, the qualitative data collection allowed us to describe participants’ perception of the search context and their objectives, the relevance of sought information and its cognitive impact, the use of this information for a specific patient, and subsequent patient health outcomes. Quantitative and qualitative data were then merged into clinical stories (hereinafter called vignettes). We collected qualitative and quantitative data for the four levels of outcomes.

Quantitative Data Collection

Participants were asked to use e-Therapeutics+ when seeking clinical information for their practice, at least once per week over 8 months in 2008–2009, and to rate each

![FIG. 2. Mixed methods convergence design. (Color figure can be viewed in the online issue, which is available at wileyonlinelibrary.com.)](image-url)
Qualitative Data Collection

Based on a list of searches from individual log files, we collected qualitative data from participants about their most recent searches with potential information use for a patient (purposeful sample). Five sources of qualitative data were used: field notes (logbook, monitoring sheets), documents (annotated log reports), video files (Camtasia screen captures of information-seeking), interviews (transcribed verbatim), and archives (information hits). The interviewer was a research professional with expertise in qualitative methods (critical anthropology) and was unknown to participants. Prior to each interview, log reports containing IAM ratings were analyzed by the interviewer to identify the most recent rated searches where “I used (or will use) this information for a specific patient” was reported; then, to stimulate their memory of that search, log reports and IAM ratings were reviewed with each participant. For each search, interviewees were asked to describe the clinical situation including the patient’s age, gender, and health problems, and elaborate on their IAM ratings, including patient health outcomes (patient behavior, knowledge, and satisfaction) associated with their use of information (clinician behavior). Interviews were audiotaped, and transcripts were analyzed.

Considering the duration of the study and the wide geographic dispersion, participants were interviewed twice by phone. The midterm interview was conducted about 3 months after the quantitative data collection began, and the final interview after it ended. Interviews addressed the most recent searches and moved back in time (sampling downward). On average, the median time window between searches and interviews was 41 days (range = 1–123). In the midterm interview, participants were asked to report their concerns regarding the accuracy and readability (content and format) of e-Therapeutics+: “How often (always, often, occasionally, never) do you feel information is inaccurate/not clearly written/not clearly presented?” Interview length varied from 37–124 minutes (median = 77 minutes). Participants were asked to describe searches with information use for a patient. The interview guide contained five sections: (a) The reading of the log report to stimulate interviewee memory, and one introductory question to verify whether the search was remembered; (b) four screening questions to establish whether the search was clearly remembered (Do you remember that on [read date and time on log report] you did a search on [read topic]? 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 search at the point-of-care, or before, or after an encounter with a patient?); (c) a think-aloud protocol including video-recording of the reconstruction of the information-seeking behavior with interviewee narration to identify specific information hits used for a patient (Ericsson & Simon, 1993; Kushniruk, 2001); (d) open questions about the clinical story around the search and their use of information; and finally (e) semistructured questions guided by the log report, asking interviewees to explain their responses to the IAM questionnaire.

Then, we extracted the description of critical searches (cases) from interviews. Critical searches were identified using the critical incident technique (Flanagan, 1954), which has been commonly used to assess the performance of health professionals, specifically their information behavior (Urquhart et al., 2003). This technique is usually considered valid to provide detailed empirical illustrations (Anderson & Nilsson, 1964). A critical incident is a clear event from the observers’ viewpoint, and has clear effects. Following this definition, a search was critical when the clinical situation and the use of information were clearly described. A flow diagram of the data collection is presented in Figure 3.

Mixing Quantitative and Qualitative Data

Critical searches (cases) were analyzed to describe participants’ use of clinical information and subsequent effects on patient health. Using specialized software (NVivo7), qualitative and quantitative data were integrated. For each case, data were comprised of content from information hits...
(screen shots), the corresponding log file containing IAM ratings, and interview transcripts. We combined a deductive with an inductive thematic analysis (Boyatzis, 1998). Data were deductively assigned to types of information use and health outcomes derived from IAM items. Data were also inductively analyzed to explore new themes (e.g., a “short-term negative health outcome” emerged as a type of outcome).

Each transcript was analyzed by three of us. First, a research professional with expertise in qualitative methods (JJL or MEC) assigned extracts of transcripts to themes by going back and forth from textual data to themes. For each case, the data were synthesized into a brief clinical vignette, which integrated quantitative and qualitative data to provide a comprehensive picture, as shown in Figure 4. Second, the first author (PP) reviewed all data (all searches), and initial vignettes. Disagreements with PP regarding the interpretation of the data (summarized in the vignettes) were resolved by discussion and consensus. To ensure rigor in mixing data, the divergences between qualitative and quantitative data were specifically discussed, and strategies to solve these issues were systematically documented, for example, “exclusion” of unclear searches from the set of critical searches (Pluye, Grad, Levine, & Nicolau, 2009). Third, other coauthors independently reviewed subsets of transcripts and vignettes corresponding to critical searches.
# Level 1 outcome (situational relevance): On May 30, 2008, P04 did a search at work, with a student, and during an encounter with a patient [QUALITATIVE DATA]. They retrieved two information hits about psoriasis. The reported search objectives were: to address a clinical question, to fulfill an educational or research objective, to look up something they forgot, to exchange information with other health professionals, and to plan, manage, coordinate, delegate or monitor tasks with other health professionals [QUANTITATIVE DATA]. “This was in regard to a woman in her late 50s who has quite bad psoriasis. […] She presented with some exacerbation of her psoriasis, and there was a secondary cellulitis on top of it, on her hands. […] I was wondering what the next step would be for her as a topical treatment for psoriasis. She was already on a topical steroid. I think she was on a mid-potency corticosteroid. This wasn't working, so she needed something stronger. […] [I was] going over the treatment of psoriasis with my student. […] I had used this medication long ago, but hadn’t used it in recent history. I wasn’t sure. […] [I wanted to exchange information and plan] with this student.” According to P04, the information from e-Therapeutics+ was in agreement with and more relevant than the information from a paper-based resource (pharmacological book for nurse practitioners). “I think it was just a table regarding […] steroids in general, for topical treatment in general. […] It was probably less relevant. I probably got more information from [e-Therapeutics+]” [QUALITATIVE DATA].

# Level 2 outcome (cognitive impact): Two hits were associated with a report of positive cognitive impact (practice improvement, learning, reminder, motivation to learn, confirmation, and reassurance) [QUANTITATIVE DATA]. Regarding practice improvement, P04 stated: “I'm more comfortable with Dovonex now. […] [My practice will be changed and improved] just knowing what to prescribe as a next-line treatment. […] The psoriasis exacerbation is something that I don't see often.” [QUALITATIVE DATA].

Retrieved information hit(s):
(1) e-Therapeutics+ (CIRT): Therapeutics tab – psoriasis – Table 3: Topical Psoriasis Therapies – row on Dovonex (P04S06H01).
(2) e-Therapeutics+ (CIRT): e-CPS tab – Dovonex monograph (P04S06H02).

# Level 3 outcome (information use): Information on psoriasis was retrieved, and used to better understand a specific issue with respect to the management of the patient, and to justify the management of the patient [QUANTITATIVE DATA]. “As for non-pharmacological treatment, she was doing all of those, and we just reviewed that, so that was the justification for continuing on [this management]. […] I used it [calcipotriol] in addition to the treatment. […] I don’t have a whole lot of experience with psoriasis that does not respond to first-line treatment [topical steroids].” [QUALITATIVE DATA].

# Level 4 outcome (patient health): Regarding patient health, P04 reported that the information contributed to prevent health deterioration and improve health (probabilistic outcome) [QUANTITATIVE DATA]: “She came back a couple of days later and she was doing much better. [The management] [justified] by the found information [avoided it [psoriasis]] from getting worse, from the presentation worsening and then needing to go up to an even stronger treatment. […] When she came in [before the search], she couldn’t even move her hands. So it had a great impact on her ability to function” [QUALITATIVE DATA].

FIG. 4. A clinical vignette.

(cases) with patient health outcomes. For each case, they were asked whether the clinical story was convincing or trustworthy, and whether reported outcomes could be associated with sought information. Disagreements were resolved by discussion and consensus. Finally, a practicing family physician (RG) reviewed all vignettes with patient health outcomes from a clinical perspective, for clarity.

Clinical vignettes summarize cases jointly displaying qualitative and quantitative data. In line with the “mixed methods matrix technique,” we built a metamatrix in Excel where rows represented vignettes and columns mixed data on each case (O’Cathain et al., 2010). We used descriptive statistics to assess the distribution of mixed methods data by level of outcome. To measure the NNBI, we divided the number of searches for a specific patient (reported via IAM ratings) by the number of cases with at least one patient health benefit (reported in vignettes). The NNBI was also calculated for each of the three types of profession.

We then used multiple logistic regression analysis using generalized estimated equations to assess the impact of the first three levels of outcomes of information seeking (situational relevance, cognitive impact, and information use) on the fourth level (patient health outcomes). The Level 4 outcome was modeled as a binary dependent variable ($I = 1$ at least one positive outcome; $0 =$ otherwise). We adjusted for the clustering of participants who evaluated multiple information items (Lian & Zeger, 1986). The data were sorted by the date that each rating was completed and then generalized estimating equations (GEE) were used to account for the dependence of subsequent ratings by the same participants while controlling for the type of health professional (Jennrich & Schluchter, 1986). In our GEE analyses, we assumed an autoregressive order-one correlation structure of residuals (Jennrich & Schluchter, 1986). In this type of structure, the assumption is that the residual correlation between two ratings for the same participant...
depends on their proximity in time, and equals a single coefficient to a power equal to the number of time periods separating the two ratings of interest.

Results

Participants worked in primary health care in three Canadian provinces: 10 Manitoba-registered nurse practitioners, 10 Ontario family health team pharmacists, and 10 Québec family medicine residents. Twenty-one participants (70%) worked in an academic setting (four nurses, seven pharmacists, and 10 residents), for example, a university-affiliated family medicine teaching unit. There were 26 women and four men, all in active practice, ranging in age from 24 to 57 (median = 37 years). On average, clinicians participated in the study for 31.3 weeks (from 18–44 weeks) in 2008–2009, and logged on to e-Therapeutics+ 80 times during the study period (range = 14–395 logins).

At midterm interview, all participants had experience using e-Therapeutics+, and expressed little concern about its accuracy and readability. One pharmacist and two residents felt that the information was occasionally inaccurate. One pharmacist felt that the information was often not clearly written (content). Three pharmacists, three residents, and two nurses felt that the information was occasionally not clearly presented (format).

Participants rated 793 searches. Of those, 477 (60.2%) were covered by interviews. Table 1 shows that IAM ratings of the purposeful sample of searches covered by interviews are similar to all ratings. In 299 searches covered by interview, the search objective was directly linked to a patient (ratings: “to address a clinical question,” or “to share information with a patient,” or “to plan/manage tasks with other health professionals”).

Regarding the 477 searches covered by interview, we examined 312 that were rated, “I used (or will use) this information for a specific patient.” Of those, 182 were not considered for further qualitative data analysis: The interviewee forgot 78 searches, did not confirm the use of information for 73 searches, and provided unclear stories for 31 searches (Figure 3). The remaining 130 searches were remembered, clearly described, and information use was confirmed. For these cases, quantitative and qualitative data were merged into clinical vignettes. Vignettes are available online at www.iamclinicalvignettes2.mcgill.ca.

The following results are derived from these 130 cases. During interviews, participants reported that searches were conducted after (69; 53.1%), during (45; 34.6%), and/or before (20; 15.4%) the participant–patient encounter. The sum is superior to 100% as in four cases, e-Therapeutics+ was consulted twice: during/after the encounter (n = 2), before/during (n = 1), and before/after (n = 1). “Before the encounter” referred to situations where participants prepared for the patient visit. “After the encounter” referred, for instance, to situations where participants reviewed laboratory results after the visit.

<table>
<thead>
<tr>
<th>IAM items</th>
<th>All searches (N = 793)</th>
<th>Searches covered by interviews (N = 477)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Search objective</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Address a clinical question/prob/decision making about a specific patient</td>
<td>490 (61.8%)</td>
<td>284 (59.5%)</td>
</tr>
<tr>
<td>Share information with a patient/caregiver</td>
<td>248 (31.3%)</td>
<td>142 (29.8%)</td>
</tr>
<tr>
<td>Exchange information with other health professionals</td>
<td>201 (25.3%)</td>
<td>105 (22.0%)</td>
</tr>
<tr>
<td>Look up something I had forgotten</td>
<td>189 (23.8%)</td>
<td>99 (20.8%)</td>
</tr>
<tr>
<td>Fulfill an educational or research objective</td>
<td>104 (13.1%)</td>
<td>70 (14.7%)</td>
</tr>
<tr>
<td>Search in general or for curiosity</td>
<td>100 (12.6%)</td>
<td>54 (11.3%)</td>
</tr>
<tr>
<td>Plan, manage, coordinate, delegate, or monitor tasks with other health professionals</td>
<td>85 (10.7%)</td>
<td>43 (9.0%)</td>
</tr>
<tr>
<td>Information use</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Any types of information used</td>
<td>496 (62.5%)</td>
<td>286 (60.0%)</td>
</tr>
<tr>
<td>Information used to maintain or justify the management of this patient</td>
<td>328 (41.4%)</td>
<td>199 (41.7%)</td>
</tr>
<tr>
<td>Information used to change the management of this patient</td>
<td>272 (34.3%)</td>
<td>155 (32.5%)</td>
</tr>
<tr>
<td>Information used to change your understanding of specific issues regarding this patient</td>
<td>204 (25.7%)</td>
<td>117 (24.5%)</td>
</tr>
<tr>
<td>Information used to persuade the patient or other health professionals to make changes</td>
<td>165 (20.8%)</td>
<td>88 (18.4%)</td>
</tr>
<tr>
<td>Patient health</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Any type of expected patient health outcomes</td>
<td>444 (56.0%)</td>
<td>256 (53.7%)</td>
</tr>
<tr>
<td>Avoid unnecessary or inappropriate treatment, diagnostic procedure or preventive intervention</td>
<td>282 (35.6%)</td>
<td>166 (34.8%)</td>
</tr>
<tr>
<td>Prevent disease or health deterioration (including acute episode of chronic disease)</td>
<td>272 (34.3%)</td>
<td>158 (33.1%)</td>
</tr>
<tr>
<td>Increase patient acceptability of treatment, diagnostic procedure or preventive intervention</td>
<td>256 (32.3%)</td>
<td>147 (30.8%)</td>
</tr>
<tr>
<td>Increase patient knowledge about health or healthcare</td>
<td>191 (24.1%)</td>
<td>112 (23.5%)</td>
</tr>
<tr>
<td>Improve patient health or functioning or resilience</td>
<td>185 (23.3%)</td>
<td>100 (21.0%)</td>
</tr>
</tbody>
</table>

Note. Cognitive impacts were not asked in the e-mailed IAM questionnaire, thus not reported here.

Interviewees reported that searches were usually conducted in a clinic or an office setting (117; 90.0%), and occasionally at home (13; 10.0%). They searched most often by themselves (101; 77.7%), and less commonly in the presence of the patient (20; 15.4%), or with a colleague.
The sum is superior to 100% because in two cases, the resource was consulted twice. A clinician searched in the presence of the patient then with a dietitian (P19S09). Another clinician (P06S01) stated that they searched with the patient “to look for [treatment] options,” then on their own as they “continued to read.” In about one third of cases (45; 34.6%), the interviewee stated they did not consult another source of information. When another source was consulted, they reported that e-Therapeutics+ was equally (64; 49.2%), more (13; 10.0%), or less (8; 6.2%) relevant. Other sources of information were described as other electronic resources (32; 24.6%), textbooks, and journals (20; 15.4%), and other professionals (18; 13.8%). The mixed methods results per level of outcome are presented below and summarized in Table 2.

**Level 1 Outcome: Situational Relevance**

In all cases, interviewees said the information from e-Therapeutics+ was relevant and met a search objective. They usually reported that a clinical question about a specific patient was answered (109; 83.9%). For example, they described questions that concerned drugs and instructions for patients. P24 (a medical resident) saw a postpartum patient with a urinary tract infection (P24S01): “I had to look up an antibiotic to give her [the patient]. It was after her delivery. [The clinical question was] what antibiotic to give [in this situation]?” P07 (nurse practitioner) wanted to treat a patient with onychomycosis (a fungal infection of toenails), but did not want to prescribe an oral antifungal (P07S02). P07 said “I wanted a better understanding of how to prescribe [a topical drug name] because I know there are specific instructions [to share with the patient]. You paint it on, remove it, and I wanted to be more specific.”

**Level 2 Outcome: Cognitive Impact**

As a result of the information, interviewees usually said that they were reassured (100; 76.9%), reminded of something they forgot (87; 66.9%), and learned something new (76; 58.5%). By way of illustration, P18S05 (pharmacist) retrieved information on selective serotonin reuptake inhibitors (SSRIs) after an encounter with a patient suffering from obsessive-compulsive disorder, and was reassured by what they found: “I thought that SSRIs are the best choice [for this patient] and are better tolerated. So I was reassured because it looked like it might be the case.” For example, P21 (medical resident) saw a 16-year-old boy suffering with an ear infection that had been treated twice as there was no clinical improvement associated with the first antibiotic (P21S02). P21 wanted to represcribe the second antibiotic and stated: “I forgot the dose [in adults] and it reminded me of the dose. […] I wanted to double check the dose.” As another example, P02 (nurse practitioner) retrieved information for a woman with nausea and vomiting of pregnancy (P02S02). P02 stated they learned something new with respect to clinical trials of ginger in this situation. “I learned about the use of ginger. I knew Ginger Ale was used, but [before this search] I never told someone to go out and try ginger.”

**Level 3 Outcome: Information Use**

In 65 cases (50.0%), interviewees described how they used the information to maintain the management of a

**TABLE 2. Summary of mixed methods results per level of outcome of information seeking.**

<table>
<thead>
<tr>
<th>Clinical vignettes (n = 130)</th>
<th>Level 1: Situational relevance (search objective met)</th>
<th>Any type of search objective met</th>
<th>130 (100%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Address a clinical question (problem or decision making) about a specific patient</td>
<td>109 (83.8%)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Share information with a patient or home/family caregiver</td>
<td>65 (50.0%)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Look up something forgotten</td>
<td>43 (33.1%)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Exchange information with other health professionals</td>
<td>41 (31.5%)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Plan, manage, coordinate, delegate, or monitor tasks with other health professionals</td>
<td>19 (14.6%)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Search in general or for curiosity</td>
<td>15 (11.5%)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Fulfill an educational or research objective</td>
<td>13 (10.0%)</td>
<td></td>
</tr>
<tr>
<td>Level 2: Cognitive impact</td>
<td>Any type of positive cognitive impact</td>
<td>130 (100%)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Reassurance</td>
<td>100 (76.9%)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Confirmation of good practice</td>
<td>98 (75.4%)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Reminder of something already known</td>
<td>87 (66.9%)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Learning something new</td>
<td>76 (58.5%)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Practice changed and improved</td>
<td>74 (56.9%)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Motivation to learn more</td>
<td>54 (41.5%)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Dissatisfaction</td>
<td>10 (7.7%)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Problem with information</td>
<td>1 (0.8%)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Disagreement with information</td>
<td>0 (0.0%)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Information potentially harmful</td>
<td>0 (0.0%)</td>
<td></td>
</tr>
<tr>
<td>Level 3: Information use</td>
<td>Any type of information use</td>
<td>130 (100%)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Information used to maintain the management plan of the patient</td>
<td>65 (50.0%)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Information used to change the understanding of specific issues regarding the patient</td>
<td>57 (43.8%)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Information used to justify the management plan of the patient</td>
<td>45 (34.6%)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Information used to persuade the patient or other health professionals to make changes</td>
<td>29 (22.3%)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Information used to change the management plan of the patient</td>
<td>11 (8.5%)</td>
<td></td>
</tr>
<tr>
<td>Level 4: Patient health</td>
<td>Any type of outcomes</td>
<td>47 (36.2%)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Increase patient knowledge about health or health care</td>
<td>28 (21.5%)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Avoid unnecessary or inappropriate treatment, diagnostic procedure, or preventive intervention</td>
<td>25 (19.2%)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Prevent disease or health deterioration (including acute episode of chronic disease)</td>
<td>9 (6.9%)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Improve patient health or functioning or resilience</td>
<td>6 (4.6%)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Increase patient satisfaction with treatment, diagnostic procedure or preventive intervention</td>
<td>3 (2.3%)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Transitory negative outcome</td>
<td>1 (0.8%)</td>
<td></td>
</tr>
</tbody>
</table>

Note. For each level, the sum may exceed 130 (Levels 1, 2, and 3) or 47 (Level 4) as data were associated to one or more than one category of outcome.
patient. For instance, P29 (resident) used the information on
the treatment of constipation to maintain their treatment of a
pregnant woman (P29S05). P29 stated, “I decided not to
give [lactulose]. [. . .] I was more confident to say ‘let’s try
[wheat bran] first’ [. . .].” It [e-Therapeutics+] just confirmed
that I had made the right decision on the spot, and that I
didn’t have to go back and change my plan.”

In 45 cases (34.6%), interviewees described situations
where they did not know what to do or hesitated between
two options, and how information was thus used to justify
the management of a patient. For example, P28 (resident)
hesitated to increase the dose of antihypertensive medica-
tion for an elderly woman with high blood pressure
(P28S04). As P28 said, “My clinical question was by how
much to increase her dose? [As a result of the informa-
tion], I ended up increasing the dose [and prescribed] 16
mg and 8 mg. I didn’t increase her from 16 mg to 32 mg
all the way.”

In 29 cases (22.3%), interviewees described how they
used information to persuade health professionals or patients
to make a change. For example, P18 (pharmacist) used
information on endometriosis to persuade a patient and a
gynecologist to request a bone mineral density test
(P18S06). For the gynecologist, the test was not indicated as
the patient was too young. Thus, as stated by P18, “[I needed
to persuade] the patient and the physician [to do the test],”
and once the test was done, “they realized the effect
[osteopenia] the drug has [on the patient].”

In 11 cases (8.5%), interviewees described how they used
information to modify the management plan for a patient.
For example, P23 (resident) encountered an elderly patient
who had a history of a transient ischemic attack, had stopped
preventive treatment with clopidogrel, and continued to take
aspirin (P23S02). P23 used the information to decide to stop
aspirin and represcribe clopidogrel. “Based on the High-
light, [. . .] the risk of bleeding while on both is increased
compared to [clopidogrel] alone, without being more effective.
So that’s why we said we should go only with
[clopidogrel], not with the combination.”

**Level 4 Outcome: Patient Health**

The 47 cases (36.2%) with patient health outcomes are
reported in the Appendix. In 46 cases (35.4%), interviewees
reported positive health outcomes (benefits). In 28 cases
(21.5%), they described how the information contributed to
increasing patient knowledge about health or healthcare.
For example, P11 (pharmacist) stated the information used
to decide to stop a medication causing urinary incontinence
contributed to increasing patient knowledge (P11S02):
“After the search, I found that she was suffering a drug side
effect, so that was a huge knowledge for her. It really [helped
the patient feel] ‘I’m not going crazy’!”

In 25 cases (19.2%), interviewees described situations
where an unnecessary or inappropriate treatment, diagnostic
procedure, or preventive intervention was avoided because
of the information. This health benefit corresponded to the
following patient behaviors: (a) the patient was asked to
avoid something, for example, planned use of a natural
product that could interact with prescribed medication; (b)
the patient was asked to do something different, compared
with what was planned before the search, for example,
reduce a drug dose; (c) the patient was asked to do some-
thing more appropriate, which the clinician had not planned
to do before the search, for example, further testing; (d) the
patient did not have to do something the clinician planned to
do before the search, for example, consult a specialist; (e)
the patient did not have to do something as a result of an
option considered by the clinician before the search, for
example, hesitation between two drugs. By way of illustra-
tion, P04 (a nurse practitioner) said that she used informa-
tion on dyslipidemia to avoid an unnecessary treatment that
would have required further blood tests (P04S01): “The
physician had wanted to put [the patient] on a medication,
[but] by reading e-Therapeutics+, we decided that it prob-
ably wasn’t the best course of action. [. . .] This medication
could have increased his liver enzymes to the point where
we would be worried about it; so [the information also]
prevented having to test [liver enzymes] more frequently.”

In nine cases (6.9%), interviewees described how informa-
tion contributed to prevent disease or health deteriora-
tion. For example, P11 (a pharmacist) retrieved information
on the absence of interaction between a drug and grapefruit
(P11S05). P11 retrieved this for an elderly patient, and stated
that it prevented health deterioration: “[the drug] will help
lower their cholesterol; [and] they are much more coopera-
tive about taking their cholesterol medication, now that they
know it does not interfere with [grapefruit].” In six cases
(4.6%), interviewees described how information contributed
to improve patient health or functioning. For example, P13
(a pharmacist) encountered a patient with migraine who had
been treated with a triptan and ibuprofen without benefit
(P13S07). P13 retrieved information on migraine, used it to
prescribe a different triptan, and stated, “[the patient] called
back and left a message to say that it did work.” In three
cases (2.3%), interviewees described how information con-
tributed to increase patient satisfaction with treatment, diag-
nostic procedure, or preventive intervention. For instance,
P01 (a nurse practitioner) encountered an elderly patient
with osteoporosis who wanted to simplify her medication.
P01 retrieved information on bisphosphonate, and used it to
switch to a medication that can be taken weekly instead of
daily: “[the patient] said it would be easier to remember”
(P01S01).

In one case (0.8%), the sought information was asso-
ciated with a transitory negative health outcome. P23 (a
medical resident) retrieved information about the dose of
domeridone for children, which justified his management
of a baby with gastroesophageal reflux disease (P23S05). As
the baby was hospitalized, a nurse mentioned to P23 that the
current dose of domperidone was higher than the maximum
recommended dose. As a result of their search for informa-
tion, P23 decreased the dose, which was followed by a
return of symptoms, and led P23 to reincrease the drug dose.
The patient had not been vomiting for the last week. I decided to decrease the dose to the maximum recommended dose. I think he was taking 7.5 mg 4 times a day, so I decreased it to 5 mg. [...] [Later on the baby] started to vomit again so we had to increase the dose again above the maximum. [...] [Since then] I think he was fine. For the last 2–3 days, there was no vomiting.”

Impact of Outcome Levels 1, 2, 3 on Level 4

Based on mixed methods results (n = 130 vignettes), we assessed the impact of the first three levels of outcomes of information-seeking (situational relevance, cognitive impact, and information use) on the fourth level (patient health outcomes). Results are presented in Table 3. The type of professional did not make a difference (nurse practitioner or pharmacist or medical resident). One Level-1 outcome category trended towards statistical significance for the association with perceived health benefits: to share information with a patient or home/family caregiver, odds ratio (OR) = 2.62; 95% CI 0.94, 7.29. No Level-2 category was significantly associated with health benefits. One Level-3 category was significantly associated with perceived health benefits: The retrieved information was used to persuade the patient or other health professionals to make changes, OR = 2.57; 95% CI 1.02, 6.42.

Number Needed to Benefit From Information

As mentioned, interviewees conducted 299 searches for a patient (e.g., to address a clinical question). In this situation, they described patient health benefits associated with the use of retrieved information in 43 cases (14.4%). Stated otherwise, they needed to retrieve clinical information from e-Therapeutics+ for seven (6.95) patients to report health benefits for one (299/43). This suggests a NNBI of seven. For nurse practitioners (108/18) and family health team pharmacists (120/20) the NNBI was six; for family medicine residents, the NNBI was 14 (71/5).

In contrast, interviewees conducted 178 searches while browsing e-Therapeutics+ just out of curiosity or without a specific patient in mind (e.g., to achieve an educational or research objective). In this situation, they described patient health benefits associated with the use of information in three cases (2.3%). On one hand, P27 and P28 (residents) searched broadly on a topic after seeing a patient (P27S03; P28S06). They reported the search was not directly done for the patient, but the information was later used for another patient. For example, P28S06 browsed e-Therapeutics+ in the corridor of the emergency room, and said: “[We had] a gentleman having chest pain [in the emergency room]. [...] I logged [into e-Therapeutics+] later [...] to refresh myself. [Were you doing the search thinking about the patient?] No. That’s the thing. I was just reviewing it [the information].” On the other hand, P09 (a nurse practitioner) stated that they browsed e-Therapeutics+ because of their participation in the study, and applied the information for a patient at a later time (P09S03). P09 said, “[I did this search because] I had to review [e-Therapeutics+ Highlights in the context of my participation in the study]. That was the reason I caught on to this in the first place, and that happened to be relevant to the situation that I had [later].”

Discussion

Our clinical vignettes support the proposed ACA-LO model with four levels of information-seeking outcomes. In addition, our statistical analyses suggest the importance of using retrieved information to convince or persuade others to make changes, as this was a type of information use associated with perceived patient health benefits. This constitutes a symbolic use of information as proposed by Owen (1999) and Alkin and Taut (2003) in the context of program evaluation; thus, our results suggest the importance of symbolic information use for nurses, pharmacists and medical residents in primary health care. Knowledge is a core trait of professionalism, and using research-based clinical information from high quality resources is becoming key for maintaining professionals’ legitimacy and power (Macdonald, 1995).
Based on the ACA-LO model, we propose the NNBI concept, which can be useful for librarians, patients, clinicians, and policy makers. Further experimental research may measure the NNBI to compare electronic knowledge resources in different contexts using objective outcome measures supported by data from the electronic medical record. This can help libraries to select efficient electronic knowledge resources (those with the highest benefit/cost ratio). If used by patients, the NNBI concept may enhance their confidence in asking librarians to seek more information in high-stakes situations, for example, a treatment associated with serious adverse effects. The lower the NNBI, the more value clinicians will see in looking for information (if all searches had benefits, the NNBI would be 1). Considering that clinicians do not systematically pursue their clinical questions, an NNBI of around 10 should encourage clinicians to systematically search for information when they perceive a need, and to take information-retrieval training courses. For policy makers, such NNBI value may justify providing incentives for searching because applying what is already known will have an important impact on health care and health.

Based on three observational studies, an NNBI of around 10 seems to be a plausible hypothesis for planning further experimental research. We found an NNBI of seven in the present study (varying from six to 14 depending on participants’ profession). In a pilot study, we tracked and assessed searches in one knowledge resource (InfoRetriever) by 17 family medicine residents over 2 months (Pluye, Grad, Mysore, Shulha, & Johnson-Lafleur, 2011). Of 84 critical searches for information for patients, 12 (14.3%) were associated with patient health benefits. This suggested an NNBI of seven. In another study, we tracked and assessed searches in one knowledge resource (Essential Evidence Plus) by 41 practicing family physicians over 3 months (Pluye et al., 2012). Of 715 searches directly linked to a patient, 53 (7.4%) were associated with patient health benefits. This suggested an NNBI of 14.

We recently reviewed the literature, and outside our work, we found no studies that systematically tracked clinicians’ searches, and comprehensively assessed theory-driven outcomes of information-seeking (Bindiganavile Sridhar, Pluye, Grad, & Granikov, 2012). We excluded studies where clinicians’ searches were mediated by librarians who are information-seeking experts (Lindberg Siegel, Rapp, Wallingford & Wilson, 1993; Marshall, 1992; McGowan, Hogg, Campbell, & Rowan, 2008). We included studies where clinicians searched resources directly by themselves, and found one qualitative study that described searches and subsequent patient health outcomes. In this study, 29 Australian clinicians (13 hospital physician specialists and 16 clinical nurse consultants) were interviewed about their use of an electronic knowledge resource called the Clinical Information Access Program (Westbrook, Coiera, Gosling, & Braithwaite, 2007). Interviewees described 85 searches. Of those, 19 (22.4%) were associated with patient health benefits such as health improvement (e.g., quality of life improved), and avoidance of an unnecessary procedure or medication. We can consider this as an NNBI of four. The main reason for the difference between this lower (better) NNBI compared to results of our studies might be as follows. In the Australian study, interviewees were asked to recall examples of searches that were helpful or unhelpful in their clinical work. Given the limits of human memory, it seems likely that participants selectively reported on searches that led to potential health benefits. In contrast, in our studies all searches were systematically tracked regardless of outcome, and interviews of clinicians were informed by a log report of rated searches.

Our work also reveals other original results. We found one case with a transitory negative patient health outcome, while in health sciences the potential adverse effects of information have been studied only in controlled lab settings (McKibbon, 2005; Westbrook, Gosling, & Coiera, 2005). Furthermore, we found three cases where patient health benefits were associated with browsing, not from searching directly for a patient (P09S03, P27S03, and P28S06). Browsing refers to nonspecific or unfocused information needs, and is not usually associated with such outcomes. It is defined as “actively looking through information (. . .) without a particular problem to solve or question to answer” (Bodoff, 2006, p. 70). It leads to incidental acquisition of information, and is described as berry-picking, exploring, moving around, playing, scanning, and searching by curiosity (Bodoff, 2006; Toms, 1998; Williamson, 1998). Our results suggest browsing-related outcomes are rare, but not negligible: 1.7% of searches while browsing e-Therapeutics+ were associated with benefits for a patient.

Our research faces at least four limitations. First, we cannot draw statistical inferences to a wider population from a small convenience sample of 30 participants. Moreover, the number of cases may not have provided adequate power for a robust regression analysis. In addition, we tracked and assessed participants’ searches in one electronic knowledge resource, and results could have been different if another resource was searched.

Second, the NNBI may be underestimated because patient health benefits were based on clinician perception (clinical vignettes) rather than objective measures such as blood pressure. We had no access to patients, and did not prospectively follow patients to determine whether recommendations made by their clinician were implemented, and perceived benefits observed. For example, in certain conditions about half of the patients do not take their medication as prescribed (Haynes, Ackloo, Sahota, McDonald Heather, & Yao, 2008). Common reasons for this are linked to treatments (e.g., adverse effects), patients (e.g., cognitive-memory decline), and clinician–patient relationships (e.g., poor instructions). Moreover, clinicians constitute only one source of information among others, which can also influence patients, such as colleagues, friends, relatives, libraries, and the Internet. For example, patients routinely use the Internet as a health information resource, which might improve patients’ knowledge, participation in health care,
and health, while a major barrier is health literacy (Benigeri & Pluye, 2003; Canadian Council on Learning, 2008). Further studies should try to include the perception of patients, of all information providers, and of the dyads patient–provider (interactions). In addition, the association between preventive or therapeutic interventions and observed benefits are at best probabilistic extrapolations from clinical research. It is difficult to determine for individual patients in routine clinical settings whether a specific intervention contributes to health outcomes.

Third, the NNBI may be overestimated because we interviewed participants only once with respect to each case. If participants observed benefits for a patient after the interview, this would have led to lowering the NNBI (the lower the NNBI, the better). In future research, longer follow-up on all searches could yield additional evidence of benefit, or potential adverse effects, to measure a net NNBI (benefit after deduction of harm). Follow-up may also allow the detection of similar patients for which this information could be used. If participants observed benefits for these patients, this would have led to lowering the NNBI. Fourth, as opposed to holistic approaches (Choo, 2005; Dervin & Nilan, 1986; Savolainen, 2002; Wilson, 1997), we were not able to consider the complexity of the social context where the information was needed, sought, and used, while we systematically tracked information objects.

The strength of our research is the ability to establish a chain of evidence between information retrieved in routine practice and reported benefits for a specific patient. The combination of quantitative and qualitative data strengthened our work for at least two reasons. First, the computerized IAM questionnaire reduced recall bias because IAM-based log reports guided the think-aloud protocol and interviews, by stimulating participants’ recall. Second, the critical incident technique is known to be valid and the validity of our results is strengthened by the fact that 182 (58.3%) searches were identified as “noncritical” when participants’ memory was not completely clear or a divergence between qualitative and quantitative data was noted. The triangulation of multiple sources of qualitative evidence (namely, archives, log reports, think-aloud protocol, interviews, and observations) permitted us to critically examine clinician interviews.

Finally, we submit that the proposed ACA-LO model is transferable in other contexts. Evaluators and researchers can adapt the IAM questionnaire for their information technology users, and create a systematic and comprehensive user-centered evaluation instrument of the value of information, based on four levels of outcomes of information seeking: situational relevance, cognitive impact, information use, and ultimate outcome. As mentioned in the introduction, two conditions are necessary to observe the imbrication between information objects, technology, and users (ultimate decision makers about the value of information): A particular type of information object is acquired, for example, a web page, in a specific situation, for example, a decision-making process. These conditions constrain the adaptation of the IAM questionnaire in the larger universe of information seeking.

We can already provide two examples of how the IAM questionnaire can be adapted in other contexts. First, we validated an IAM questionnaire for patients and consumers (Pluye et al., 2012). As mentioned, online consumer health information is increasingly used, and can improve consumer knowledge, participation in health decision making, and health. However, we found no comprehensive instrument to evaluate its value from a consumer viewpoint. The literature suggested seven types of situational relevance, five types of cognitive impact, five types of information use, and eight types of information-related patient health outcomes. Based on these types, the IAM questionnaire was adapted and tested with 16 consumers and an expert panel. Information providers will implement this questionnaire for collecting feedback from consumers, and optimizing the quality of their products. Second, we recently received funding to adapt the IAM questionnaire for health administrators who will be asked to assess information produced by research teams based at their hospital. This organization plans to use the IAM for feedback and product improvement.

Conclusion

In this article, we reported a systematic and comprehensive examination of patient health benefits associated with the use of information directly retrieved by primary health care clinicians from an electronic knowledge resource. Our mixed methods study supports the ACA-LO model with four levels of outcomes of information seeking. Based on this model, we propose a new concept, the number needed to benefit from information (NNBI), which can be used in experimental research with objective measures of outcomes to compare resources, and encourage clinicians to search more often when they feel the need. We claim that our model and levels of outcomes are transferable to other kinds of users and contexts.

Acknowledgments

Ethics approval was obtained from the Institutional Review Board of the Faculty of Medicine at McGill University. This study was supported by two public research funding agencies: the Canadian Institutes of Health Research and the Fonds de la recherche en santé du Québec. The authors gratefully acknowledge the help of all participants, also Soumya Bindiganavile Sridhar, Lorie Kloda, Jim Henderson, and Jane MacDonald, as well as judicious comments and suggestions from the members of the Information Technology Primary Care Research Group.

References


Appendix

<table>
<thead>
<tr>
<th>Search ID</th>
<th>Bottom line of the clinical vignettes</th>
<th>Types of outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>P01S01</td>
<td>Information on osteoporosis was used to justify the management of the patient (change in medication), and it contributed to increased patient satisfaction.</td>
<td>x</td>
</tr>
<tr>
<td>P01S05</td>
<td>Information on pneumonia was used to justify the management of the patient (Levaquin). It contributed to avoid an inappropriate treatment (Doxycycline).</td>
<td>x</td>
</tr>
<tr>
<td>P03S04</td>
<td>Information on antidepressants was used to justify the management of the patient and to persuade the patient to make a change (do not stop medication, but continue decreasing the dose). It contributed to increased patient knowledge and avoid unnecessary diagnostic evaluation.</td>
<td>x</td>
</tr>
<tr>
<td>P03S08</td>
<td>Information on an antiemetic drug was used to justify the management of the patient and to persuade them to make a change (new medication). This contributed to increased patient knowledge and improved patient functioning (follow-up).</td>
<td>x</td>
</tr>
<tr>
<td>P04S01</td>
<td>Information on dyslipidemia (lipid-lowering agents) was used to persuade a physician to make a change (from adding a new medication to maintaining current medication). It contributed to avoidance of unnecessary treatment and blood tests.</td>
<td>x</td>
</tr>
<tr>
<td>P04S06</td>
<td>Information on psoriasis was used to justify the management of a patient (topical calcipotriol added to topical steroids). It contributed to prevent health deterioration and improve health of the patient.</td>
<td>x</td>
</tr>
<tr>
<td>P06S04</td>
<td>Information on transient ischemic attack (TIA) was used to justify the management of the patient (replace aspirin by clopidogrel). It contributed to increased patient knowledge, avoidance of an inappropriate treatment, and prevention of health deterioration.</td>
<td>x</td>
</tr>
<tr>
<td>P06S07</td>
<td>Information on diabetes mellitus was used to justify the management of the patient (continue medication). It contributed to the avoidance of an unnecessary intervention and the prevention of health deterioration.</td>
<td>x</td>
</tr>
<tr>
<td>P07S02</td>
<td>Information on Penlac for tinea pedis was used to justify the management of the patient (medication and patient counseling). It contributed to increased patient knowledge about the use of a medication.</td>
<td>x</td>
</tr>
<tr>
<td>P07S05</td>
<td>Information on back and neck pain was used to justify the management of the patient (prescription). It contributed to the avoidance of inappropriate treatment.</td>
<td>x</td>
</tr>
<tr>
<td>P07S06</td>
<td>Information on vertigo was used to justify the management of the patient (maximum dosage of the medication). It contributed to the avoidance of an unnecessary intervention and inappropriate treatment.</td>
<td>x</td>
</tr>
<tr>
<td>P07S07</td>
<td>Information on insomnia was used to justify the management of the patient and to persuade the patient to make a change (medication). It contributed to the avoidance of an unnecessary treatment.</td>
<td>x</td>
</tr>
<tr>
<td>P07S08</td>
<td>Information on medications for osteoporosis and high blood pressure was used to maintain the management of a patient (prescription renewal). It contributed to increased patient knowledge about their medication.</td>
<td>x</td>
</tr>
<tr>
<td>P08S05</td>
<td>Information on chronic peripheral neuropathy was used to justify the management of a patient, and persuade other health professionals to make a change (change medication). It contributed to increased patient knowledge about treatment options.</td>
<td>x</td>
</tr>
<tr>
<td>P08S07</td>
<td>Information on intermittent claudication was used to maintain the management of the patient (continue medication with optimized dose). It contributed to increased patient knowledge about the treatment.</td>
<td>x</td>
</tr>
</tbody>
</table>

TABLE A1. Level-4 outcome: Description of searches with patient health outcomes.
### TABLE A1. (Continued)

<table>
<thead>
<tr>
<th>Search ID</th>
<th>Bottom line of the clinical vignettes</th>
<th>Types of outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>P08S11</td>
<td>Information on an implanted defibrillator was used to maintain the management of a patient (patient counseling to follow-up with a specialist). It contributed to increased patient knowledge about the necessity of a follow-up.</td>
<td>x</td>
</tr>
<tr>
<td>P09S01</td>
<td>Information on low back pain was used to modify the management of the patient, and to persuade other health professionals to make changes regarding the treatment for this patient who cannot use NSAIDs. It contributed to increased patient knowledge, and to the avoidance of an inappropriate treatment.</td>
<td>x x</td>
</tr>
<tr>
<td>P09S03</td>
<td>Information on epilepsy and contraception was used to maintain the management of the patient, and to persuade a patient and another health professional to make a change (use oral contraceptive with higher dose of estrogen). It contributed to increased patient knowledge.</td>
<td>x</td>
</tr>
<tr>
<td>P10S02</td>
<td>Information on attention deficit hyperactivity disorder (ADHD) was used to maintain the management of a patient (prescription of a medication). It contributed to increased patient knowledge.</td>
<td>x</td>
</tr>
<tr>
<td>P11S02</td>
<td>Information on urinary incontinence was used to justify the management of the patient, and to persuade the patient and other health professionals to make a change (discontinue medication causing incontinence). It contributed to increased patient knowledge, the avoidance of an inappropriate diagnostic procedure, and an improvement of the patient’s health.</td>
<td>x x x</td>
</tr>
<tr>
<td>P11S05</td>
<td>Information on Crestor and potential interaction with grapefruit was used to justify the management of the patient (new prescription for Crestor). It contributed to increased patient knowledge, the avoidance of an inappropriate treatment, and the prevention of health deterioration.</td>
<td>x x x</td>
</tr>
<tr>
<td>P11S07</td>
<td>Information on antianxiety medication was used to maintain the management plan (change patient medication to a drug covered by health insurance), and to persuade other health professionals to make this change. It contributed to increased patient satisfaction.</td>
<td>x</td>
</tr>
<tr>
<td>P13S07</td>
<td>Information on migraine was used to justify the management of the patient (try a different Triptan). It contributed to the improved health of the patient.</td>
<td>x</td>
</tr>
<tr>
<td>P14S03</td>
<td>Information on atrial fibrillation was used to modify the management of the patient (drug already stopped, and not restarted with higher dose), and to persuade another health professional to make changes (no increase of drug dose). It contributed to the avoidance of an inappropriate treatment.</td>
<td>x</td>
</tr>
<tr>
<td>P14S06</td>
<td>Information on drug interactions (Warfarin and Probencid and Septra) was used to persuade other health professionals to make changes (double the dose of Warfarin). It contributed to the avoidance of an inappropriate treatment.</td>
<td>x</td>
</tr>
<tr>
<td>P14S07</td>
<td>Information on attention-deficit hyperactivity disorder (ADHD) was used to justify the management of a patient (avoid second line treatment). It contributed to the avoidance of an inappropriate treatment.</td>
<td>x</td>
</tr>
<tr>
<td>P15S02</td>
<td>Information on medication to stop smoking was used to maintain the management of a patient (prescription for Champix). It contributed to increased patient knowledge about this treatment.</td>
<td>x</td>
</tr>
<tr>
<td>P15S04</td>
<td>Information on the treatment of rheumatoid arthritis was used to persuade the patient to change (prescription for methotrexate medication). It contributed to increased patient knowledge about the disease and the treatment.</td>
<td>x</td>
</tr>
<tr>
<td>P15S06</td>
<td>Information on treatment for constipation was used to justify the management of a patient (Metamucil dosage). It contributed to increased patient knowledge about constipation and the treatment.</td>
<td>x</td>
</tr>
<tr>
<td>P15S07</td>
<td>Information on adverse reactions of a treatment for high blood pressure was used to maintain the management of a patient (continue medication). It contributed to increased patient knowledge about this medication (adverse reactions).</td>
<td>x</td>
</tr>
<tr>
<td>P16S01</td>
<td>Information on treatment to prevent malaria was used to justify the management of a patient (combine anticoagulant and antimalarial medications, and increase the frequency of the monitoring of anticoagulation). It contributed to increased patient knowledge, and to the prevention of health deterioration.</td>
<td>x x</td>
</tr>
<tr>
<td>P16S02</td>
<td>Information on an adverse reaction of an anticoagulant was used to better understand a specific issue regarding a patient (metallic taste associated with Warfarin medication). It contributed to increased patient knowledge, and to the avoidance of an inappropriate procedure (e.g., switch to another drug) or unnecessary health care visit (e.g., referral to another MD).</td>
<td>x x</td>
</tr>
<tr>
<td>P16S04</td>
<td>Information on a drug interaction between Famvir and Warfarin was used to justify the management of a patient (Warfarin dosing and INR monitoring). It contributed to increased patient knowledge and to the avoidance of an inappropriate procedure.</td>
<td>x x</td>
</tr>
<tr>
<td>P16S05</td>
<td>Information on priapism was used to justify the management of a patient (change medication). It contributed to increased patient knowledge and satisfaction.</td>
<td>x x</td>
</tr>
<tr>
<td>P16S06</td>
<td>Information on joint pain was used to maintain the management of a patient (stop treatment as planned). It contributed to increase patient knowledge.</td>
<td>x</td>
</tr>
<tr>
<td>P18S03</td>
<td>Information on acne, specifically drug interactions between tetracyclines and warfarin, was used to justify the management plan for a patient (switch back to previous prescription of tetracycline), and to persuade other health professional to make this change. It contributed to increased patient knowledge and the avoidance of inappropriate treatment.</td>
<td>x x</td>
</tr>
<tr>
<td>Search ID</td>
<td>Bottom line of the clinical vignettes</td>
<td>Types of outcomes</td>
</tr>
<tr>
<td>-----------</td>
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<td></td>
<td></td>
<td>1 2 3 4 5 6</td>
</tr>
<tr>
<td>P18S05</td>
<td>Information on obsessive-compulsive disorder was used to maintain the management plan for a patient (start medication), and to persuade the patient to make this change. It contributed to increased patient knowledge.</td>
<td>x</td>
</tr>
<tr>
<td>P18S06</td>
<td>Information on endometriosis was used to justify the management plan for a patient (stop DepoProvera injections, and check bone mineral density), and to persuade the patient and other health professional to make this change. It contributed to increased patient knowledge, and the prevention of health deterioration.</td>
<td>x x</td>
</tr>
<tr>
<td>P18S09</td>
<td>Information on Clozapine adverse effects was used to maintain the management of the patient (no change in medication). It contributed to the avoidance of inappropriate treatment and the prevention of health deterioration.</td>
<td>x x</td>
</tr>
<tr>
<td>P23S02</td>
<td>Information on transient ischemic attack (TIA) was used to modify the management of a patient (replace the combination aspirin/clopidogrel by clopidogrel alone). It contributed to increased patient knowledge, and to the avoidance of an inappropriate treatment.</td>
<td>x x</td>
</tr>
<tr>
<td>P23S05</td>
<td>Information on gastroesophageal reflux disease (GERD) was used to justify the management of a patient (decrease the dose of domperidone). It contributed to the return of the symptoms (negative short-term outcome), which led to reincreasing the drug dose (no long-term outcomes).</td>
<td>x</td>
</tr>
<tr>
<td>P24S01</td>
<td>Information on urinary tract infection (UTI) was used to justify the management of a patient (use the right medication for lactating postpartum patient with UTI). It contributed to the avoidance of inappropriate treatment.</td>
<td>x</td>
</tr>
<tr>
<td>P27S03</td>
<td>Information on migraine was used to modify the management of a patient (prescribe triptans). It contributed to the avoidance of inappropriate treatment, and to improvement in the patient’s health.</td>
<td>x x</td>
</tr>
<tr>
<td>P28S02</td>
<td>Information on acute low-back pain was used to justify the management of a patient (use the right management for acute mechanical back pain). It contributed to increased patient knowledge, to the avoidance of inappropriate procedures, to the prevention of health deterioration, and to improvement in the patient’s health.</td>
<td>x x x x</td>
</tr>
<tr>
<td>P28S04</td>
<td>Information on high blood pressure was used to justify the management of a patient (increase dose of an antihypertensive medication). It contributed to the avoidance of inappropriate procedures, and to the prevention of health deterioration.</td>
<td>x x</td>
</tr>
<tr>
<td>P28S06</td>
<td>Information on acute coronary syndrome was used to modify the management of a patient (potential drug interaction and no use of nitrates). It contributed to increased patient knowledge, and to the avoidance of inappropriate treatment.</td>
<td>x x</td>
</tr>
<tr>
<td>P29S01</td>
<td>Information on constipation (adverse drug effect) was used to justify the management of a patient (starting Buspirone while gradually stopping Lyrica). It contributed to the avoidance of inappropriate treatment.</td>
<td>x</td>
</tr>
</tbody>
</table>

Note. Types of patient health outcomes: 1 = Increased patient knowledge about health or healthcare; 2 = avoidance of unnecessary or inappropriate treatment, diagnostic procedure, or preventive intervention; 3 = prevention of disease or health deterioration (including acute episode of chronic disease); 4 = improvement in patient health, functioning, or resilience; 5 = increased patient satisfaction with treatment, diagnostic procedure, or preventive intervention; 6 = transitory (short-term) negative patient health outcome. INR = International normalized ratio.