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Physicians' Assessment of the Value of Clinical Information: Operationalization of a Theoretical Model

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ABSTRACT

Inspired by the acquisition–cognition–application model (T. Saracevic & K.B. Kantor, 1997), we developed a tool called the Information Assessment Method to more clearly understand how physicians use clinical information. In primary healthcare, we conducted a naturalistic and longitudinal study of searches for clinical information. Forty-one family physicians received a handheld computer with the Information Assessment Method linked to one commercial electronic knowledge resource. Over an average of 320 days, 83% of 2,131 searches for clinical information were rated using the Information Assessment Method. Searches to address a clinical question, as well as the retrieval of relevant clinical information, were positively associated with the use of that information for a specific patient. Searches done out of curiosity were negatively associated with the use of clinical information. We found significant associations between specific types of cognitive impact and information use for a specific patient. For example, when the physician reported "My practice was changed and improved" as a result of this clinical information, the odds that information was used for a specific patient increased threefold. Our findings provide empirical data to support the applicability of the acquisition- cognition-application model, as operationalized through the Information Assessment Method, in primary health- care. Capturing the use of research-based information in medicine opens the door to further study of the relation- ships between clinical information and health outcomes.

INTRODUCTION

In information studies, multiple models have conceptualized information behavior; however, no single model has dominated the research landscape, in part because models focus on different elements of information behavior. As Wilson (1999) explained, some models focus on the complexity of determining and expressing an information need, including activities associated with choosing information resources to meet that need (i.e., information seeking behavior). Other models concern cognitive and behavioral interactions involving the information seeker and the information retrieval system (i.e., information search behavior). These different types of models are complimentary and "nested" within the larger domain of information behavior (Wilson, 1999).

The acquisition–cognition–application (ACA) model is unique in that it describes sequential phases involved in the assessment of the value of information, whereby the value of information is ultimately exhibited by its application or use (Saracevic & Kantor, 1997). Originally, the ACA model was illustrated through a scenario whereby a scholar comes to a library to consult books or articles to be better informed about the state of knowledge in a particular field (acquisition). During his or her reading,

cognition takes place. In the application phase, choices are made about which information is used to create his or her paper (Saracevic & Kantor, 1997). In this sense, the ACA model is particularly suited to study information use in sequence, complementary to models which illustrate information seeking and information search behavior. In this article, we show how a naturalistic and longitudinal study of searches for clinical information in primary healthcare provides empirical data to support the applicability of the ACA model, as operationalized through the Information Assessment Method (IAM). Our citation-tracking review of Saracevic and Kantor (1997) uncovered no prior study in medicine that has used the ACA model as the foundation for an assessment tool.

Our IAM is a research tool that operationalizes the ACA model to study the value of objects of clinical information as perceived by the health professional in practice. This is conceptually different from the general utility of electronic resources at the point of care, which has been well studied (Haynes et al., 1990; Magrabi, Westbrook, Coiera, & Gosling, 2004; Tudiver, 2003). In accordance with the ACA model, health professionals (a) search for information to fulfill an objective, and retrieve objects of information such as a synopsis of clinical research (acquisition); (b) they absorb, understand, and integrate that synopsis (cognition); and then (c) they may use this newly understood and cognitively processed synopsis (application). In the context of primary care practice, when the family doctor rates an information object such as a synopsis of original clinical research, for example, IAM 2008 (see Appendix) conceptualizes its value in three constructs: situational relevance, cognitive impact, and use or application of clinical information for a specific patient.

Acquisition

The construct of situational relevance is defined by acquiring information that achieved a search objective. In this construct, we seek to understand whether a search objective is met. Therefore, the IAM questionnaire asks the clinician to evaluate the situational relevance of the retrieved information. In information science, and particularly information retrieval, relevance can be seen from two perspectives: system relevance and user relevance. While the system perspective is concerned with the relevance of retrieved information with respect to an explicit query, situational relevance is a manifestation of the user perspective (Saracevic, 2007). Situational relevance refers to the relationships between retrieved information objects and a specific task or problem, as experienced by the clinician. Relevance is determined by how well the retrieved information contributes to the resolution of the problem. Our use of situational relevance to help measure the value of retrieved information is largely driven by the fact that physicians are frequently attempting to solve explicit patient-related problems.

In a literature review, we (Pluye, Grad, Dawes, & Bartlett, 2007) previously examined

physicians' search objectives Our findings were operationalized in the IAM questionnaire as seven reasons or objectives for a search. These discrete search objectives do not represent the complexity of the information seeking behavior of health professionals nor do they necessarily represent the nonspecifiable needs that result from anomalous states of knowledge (Belkin, 1980). However, they do summarize the main reasons why physicians search for information. While information technology continues to evolve rapidly, the basic information needs that arise from clinical practice are relatively stable. For example, in a study that predated the widespread use of electronic resources, answering clinical questions about specific patients was the main driver of information need (Covell, Uman, & Manning, 1985). This type of need has not changed over time.

Cognitive Impact

In this construct, we seek to understand the types of cognitive impact that result when health professionals reflect on one object of retrieved information. IAM operationalizes the construct of cognitive impact through nine items that are a mix of both positive (e.g., I learned something new) and negative (e.g., I disagree with this information). The user may check one or more than one type of cognitive impact, and as such, a complex range of possibilities can be observed.

Application

In this construct, we simply seek to document whether there is an intention to use the retrieved information with a specific patient, operationalized as a "yes or no" question. In line with the ACA model, the application of retrieved information depends on (a) successfully acquiring information that is relevant to a search objective (i.e., situational relevance) and (b) a positive cognitive impact of that information on the professional (i.e., cognition). Consequently, two levels of analysis have emerged in our work: Level 1 is an evaluation of the search objective(s), and Level 2 is an evaluation of the cognitive impact of information hits. Thus, IAM is a multilevel questionnaire for the evaluation of retrieved clinical information.

IAM is the product of publicly funded research, and both content and construct validity are presented elsewhere (Bindiganavile Sridhar, 2011) and are summarized at http://iam2009.pbworks.com

METHODS

Our study protocol was approved by the McGill University Faculty of Medicine Institutional Review Board.

Design and Participants

A prospective longitudinal study was conducted involving a cohort of physicians to whom research-based information was provided on a handheld computer. From 9 of 10 provinces, 41 family physicians (FPs) consented to participate, 36 of whom were certified by the College of Family Physicians of Canada. There were 24 men and 17 women, all in active practice, ranging in age from 28 to 70 (*Mdn* = 44) years. Twenty-eight (68%) had a connection through teaching or research to a faculty of medicine. Participants entered the study between November 2007 and May 2008. Each participant had a unique start date defined by the date of their first rated search. Data collection ended March 2009.

Intervention/Instruments

Within IAM 2008 (see Figure 1), search objectives were operationalized as a checklist. This checklist of search objectives comprised seven reasons such as "to address a clinical question" or "to look up something I forgot." The construct of situational relevance was defined by acquiring information that achieved a search objective. The construct of cognitive impact was operationalized in a checklist of brief statements, such as "This information confirmed I did the right thing" (positive cognitive impact) or "There was a problem with this information" (negative cognitive impact). The use or application of clinical information for a specific patient was documented as a "yes or no" response.

"Yes" responses to the question on application were pursued through semistructured interviews. In these interviews, IAM ratings linked to a specific search were used by the inter- viewer to stimulate the participants' memory of that event. In psychological research, studies have examined real-time data using this technique, called Computerized Ecological Momentary Assessment. These studies have demonstrated that the technique can enhance memory of events, such as searches for clinical information applied to a specific patient (Shiffman, 2000; Stone & Shiffman, 1994).

Each participant received a handheld computer (personal digital assistant) or Smartphone with IAM and Essential Evidence Plus® software providing access to the following resources: clinical decision rules, diagnostic calculators, abstracts of Cochrane Reviews, POEMs,® (see Figure 2) and EBM (Evidence Based Medicine) Guidelines ranked highly in terms of their Evidence-Based Methodology (Banzi, 2010).

We performed the initial software installation so the device was ready to go on delivery. Participants were trained to use IAM and Essential Evidence Plus,® and to transfer their rated searches to our server. As a single-user device, IAM on the PDA documented the date and time of all information hits attributed to each participant. Searches contained one or more than one information hits, which were pages opened in resources within Essential Evidence Plus.®

While PDAs had Wi-Fi enabled through the Windows Mobile 6 operating system, no data plan was provided. As such, PDA software was used offline. On each PDA, IAM copied the tracking of information hits from Essential Evidence Plus,® allowing each information hit to be IAM-rated by participants, who earned continuing education credits for this activity. Rating a search required the participant to open IAM, and participants were reminded to rate their searches at device startup (see Figure 3).

Data Analysis

For each IAM question, we descriptively summarized the ratings of information hits. In bivariate analyses, we cross-tabulated the cognitive impact of clinical information with its situational relevance and with its use for a specific patient. We used mixed logistic regression models to examine associations between information use (i.e., the outcome) and covariates: search objectives, achieving these search objectives (i.e., situational relevance), and the type of cognitive impact arising from the retrieved clinical information (Diez-Roux, 2000). The regression model correctly accounted for the clustering of hits within searches and of searches within physicians.

RESULTS

Acquisition of Clinical Information

Over an average of 320 days, 2,131 searches for clinical information were conducted by 40 family physicians. (One participant provided no data.) This frequency of searches averages to roughly one search per physician per week, similar to another study of one information resource in primary care (Magrabi, Westbrook, Kidd, Day, & Coiera, 2008). With respect to their main patient setting, 1 family physician had no Internet access, 37 (90%) physicians reported high-speed access, and 3 physicians did not know what type of connection they had. Prior to the study, 34 (83%) physicians reported using online practice guidelines or journals. During the study, we made no attempt to influence the use of electronic knowledge resources. In terms of computer self-efficacy, 8 (20%) physicians rated their level of skill as advanced, 32 (78%) physicians as intermediate, and 1 physician as beginner.

Of these 2,131 searches, 83% were IAM-rated. Each physician rated on average 44 searches (range=6–148). Seventy-five percent of rated searches were done with more than one objective in mind; the most frequently reported objective was to address a clinical question.

In terms of situational relevance, at least one search objective was successfully met in 1,336 rated searches (76%). Age of the physician was not associated with the propensity to use retrieved clinical information for a specific patient, even in the presence of all other variables; however, older family

physicians were more likely to report searches done "to look up something I had forgotten." The odds of reporting this reason for searching increased by an estimated factor of 1.31 for every 10 years of increase in age (estimated odds ratio = 1.31, 95% CI: 1.17–1.44).

Cognition (Cognitive Impact of Clinical Information)

As more than one type of cognitive impact could be reported per information hit, 7,275 cognitive impacts were linked to 3,300 rated hits.

Application of Clinical Information

Fifty-two percent of rated information hits (n=1,708) were used for a specific patient.

Association Between Acquisition and Cognitive Impact (A–C)

A relationship between situational relevance and cognitive impact was suggested in so far as positive cognitive impact was more likely when the search objective was met. Failing to meet search objectives was seen more commonly with negative cognitive impact.

Associations Between Cognitive Impact and Information Use for a Specific Patient (C–A)

Clinical information that had a positive cognitive impact was more likely to be used for a specific patient. This suggests an effect of cognitive impact on the use of clinical information.

In a mixed logistic regression model that included all nine types of cognitive impact, we found significant associations between specific types of cognitive impact and information use for a specific patient. Three types of cognitive impact were positively associated while one type of cognitive impact was negatively associated with the use of information.

For example, the odds that clinical information was used for a specific patient increased by an estimate of 3.4-fold when the physician reported "My practice was (will be) changed and improved" as a result of this information. In contrast, reports of "I learned something new" (by itself) were negatively associated with the use of information for a specific patient.

Associations Between Acquisition and Information Use for a Specific Patient (A–A)

In addition to searches done to address a clinical question, clinical information perceived as relevant to the situation (when a search objective was met) was positively associated with the use of that information for a specific patient.

However, searches done out of curiosity were negatively associated with the use of that clinical

information. We found no statistical interaction between searches done to address a clinical question and the achievement of search objectives.

DISCUSSION

Our findings provide empirical data to support the applicability of the ACA model in primary healthcare, as operationalized through the Information Assessment Method. This is seen through the associations that we observed in the sequential steps of the acquisition of relevant clinical information, positive cognitive impact, and information use (i.e., application) for a specific patient.

Using IAM linked to one electronic knowledge resource, we were able to identify what specific objects of information family physicians used in practice. Thus, while Saracevic and Kantor (1997) stated that "there is certainly no way in most situations to trace the impact of this specific event" (p. 534), referring to a scholar's visit to the library, we may now capture the use of research-based information in clinical practice through ecological momentary assessments. Capturing the use of research-based information opens the door to further study of the linkages between information and health outcomes in clinical practice.

Family physicians search knowledge resources because of objective(s) that are related to, but precede, the acquisition step. What sparked the process of acquisition was captured by our reasons for searching, which was mainly about addressing questions arising from clinical practice. Family physicians most frequently reported types of cognitive impact related to reinforcement of their current practice. This is not surprising, for several reasons. First, the family physicians in this study were on average 44 years of age. As they were fairly experienced, the information they retrieved frequently reinforced their belief that they knew what to do. Second, given that research-based information from clinical trials or systematic reviews frequently lacks the details needed for the uptake of study results in practice (Glasziou, 2008) it seems likely that it is easier to maintain current practice than to change it.

Limitations

At the acquisition phase, our ability to document searches was limited to a single resource, searched mostly for answers to questions arising from clinical practice. This is different from the phenomenon explored by information scientists who examine the complexity of information behavior. Two thirds of our cohort of family physicians had some involvement in teaching students or residents. Thus, unlike other studies that have excluded academic physicians (Gorman et al., 1995), our data were obtained from a select group who were motivated to search, specifically for teaching. Different results might be observed in another cohort of physicians with a different distribution of reasons to search.

In conclusion, the value of information can be studied in a meaningful way among physicians using IAM. Two versions of IAM are in use: one for assessing research-based e-mail alerts (push), and a second for assessing the value of retrieved clinical information (pull). In the push context, we have previously documented the content validity and construct validity of the cognitive component of IAM (Grad et al., 2008; Pluye et al., 2010). This push version of IAM is presently used by thousands of Canadian physicians in the context of their continuing education. In the pull context, we previously explored the clinical outcomes of retrieved information applied by medical residents to specific patients (Pluye et al., in press) This and other work has allowed us to refine the IAM questionnaire, and led us to release a version which operationalizes the use of clinical information and health outcomes. In future research, we propose that the integration of IAM within the electronic medical record will be an important step toward the study of information-related patient health outcomes. Linking reported outcomes directly with patient records and large administrative databases would allow researchers to verify the association between objects of clinical information and patient health.

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TABLES AND FIGURES

TABLE 1. Reasons for searching.

Reason	
Address a clinical question/problem/decision about a specific patient	1,310 (74%)
Look up something I had forgotten	672 (38%)
Share information with a patient/caregiver	624 (35%)
Exchange information with other health professionals	520 (29%)
Search in general or for curiosity	496 (28%)
Fulfill an educational or research objective	434 (25%)
Plan, manage, coordinate, delegate, or monitor tasks with other health professionals	197 (11%)

TABLE 2. Types of reported cognitive impact

This information confirmed I did (will do) the right thing	1,516	46%
I was reassured	1,468	45%
I learned something new	1,246	38%
I recalled something	1,136	34%
My practice was (will be) changed and improved	963	29%
No impact	780	24%
Negative impact (all four types combined)	166	5%

TABLE 3. Meeting the search objective versus type of cognitive impact.

Type of cognitive impact	Objective met (n = 2,482; 75.2%)	Objective not met (n = 818; 24.8%)
Positive Cognitive Impact		
My practice was (will be) changed and improved	899 (36.2%)	64 (7.8%)
I learned something new	1,104 (44.5%)	142 (17.4%)
This information confirmed I did (will do) the right thing	1,378 (55.5%)	138 (4.2%)
I was reassured	1,351 (54.4%)	117 (14.3%)
I recalled something	1,021 (41.1%)	115 (14.1%)
Negative Cognitive Impact		
I am dissatisfied, as this information has no impact on my practice	10 (0.4%)	69 (8.4%)
I am dissatisfied, as there is a problem with this information	21 (0.9%)	46 (5.6%)
I disagree with this information.	6 (0.2%)	1 (0.1%)
I think this information is potentially harmful	11 (0.4%)	2 (0.2%)
This item of information had no impact at all on me or my practice	288 (11.6%)	492 (60.2%)

TABLE 4. Information use for a specific patient versus type of cognitive impact.

Type of cognitive impact	Used for a specific patient (n = 1,708; 51.8%)	Not used for a specific patient (n = 1,592; 48.2%)
Positive Cognitive Impact		
My practice was (will be) changed and improved	709 (41.5%)	254 (16.0%)
I learned something new	756 (44.3%)	490 (30.8%)
This information confirmed I did (will do) the right thing	1,081 (63.3%)	435 (27.3%)
I was reassured	1,027 (60.1%)	441 (27.7%)
I recalled something	803 (47.0%)	333 (20.9%)
Negative Cognitive Impact		
I am dissatisfied, as this information has no impact on my practice	23 (1.4%)	56 (3.5%)
I am dissatisfied, as there is a problem with this information	22 (1.3%)	45 (2.8%)
I disagree with this information.	2 (0.1%)	5 (0.3%)
I think this information is potentially harmful	5 (0.3%)	8 (0.5%)
This item of information had no impact at all on me or my practice	106 (6.2%)	674 (42.3%)

TABLE 5. Associations between types of cognitive impact and the use of information for a specific patient.

Mixed logistic regression model	Use of information ~ Cognitive impact	
Type of cognitive impact	Estimated odds ratio	95% confidence interval
My practice was (will be) changed and improved	3.4	2.6–4.4
This information confirmed I did (will do) the right thing	2.3	1.8–2.9
I recalled something	1.4	1.1–1.7
I learned something new	0.7	0.5–0.9

TABLE 6. Associations between search objectives, relevant clinical information (objective met), and the use of information for a specific patient.

Mixed logistic regression model	Use of information ~ Situational relevance + Search objectives	
Search objectives	Estimated odds ratio	95% confidence interval
To address a clinical question	13.4	9.4-19.1
Search in general or for curiosity	0.3	0.2-0.4
Search objective met	10.3	7-15.2

FIG. 1. IAM 2008 on the handheld computer.

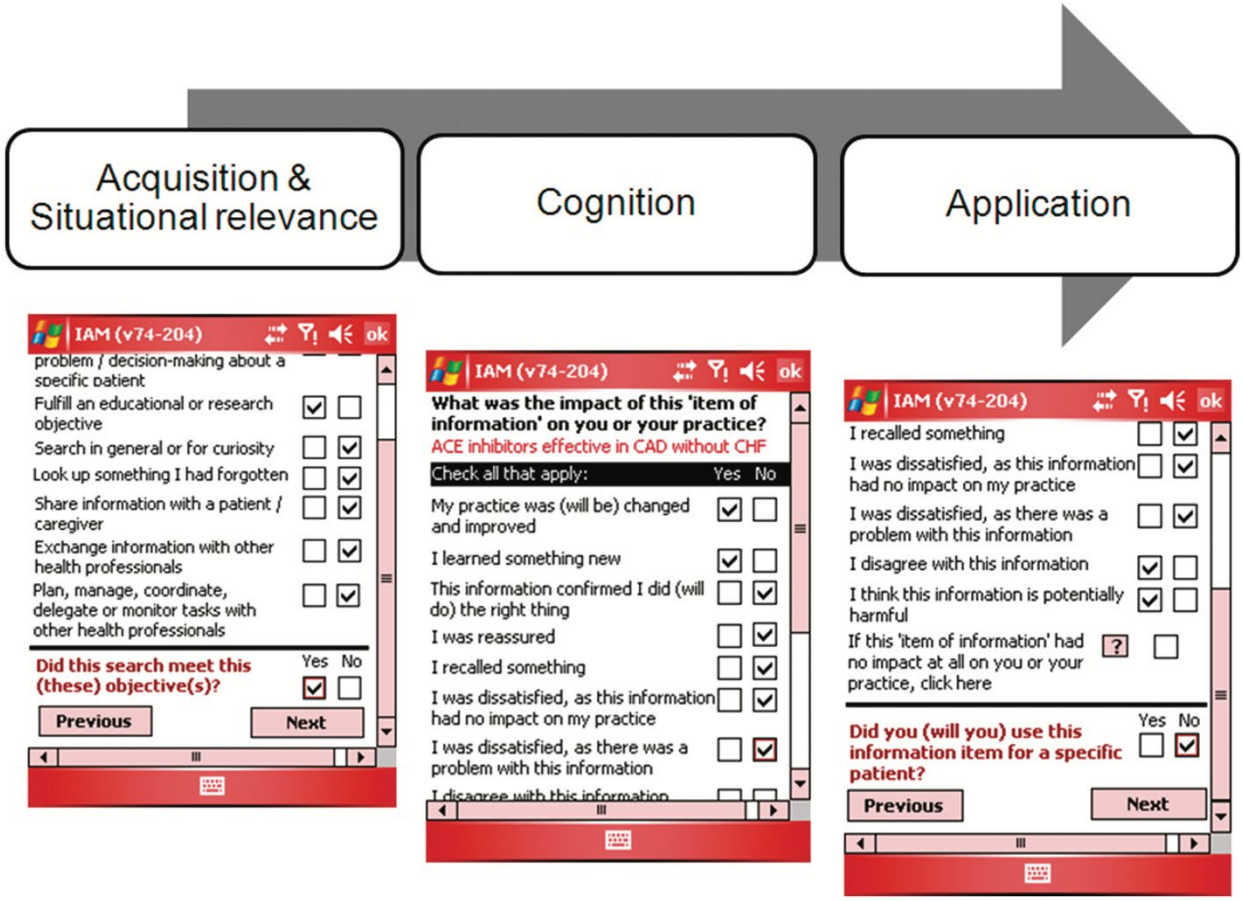


FIG. 2. An example of one POEM.®

High dose statin reduces cardiac events in pts with high CRP (JUPITER)

Clinical question
In patients with normal LDL cholesterol but elevated C-reactive protein, is a high dose statin effective for primary cardiovascular prevention?

Bottom line
In this study of patients with normal LDL and elevated CRP, use of a high dose statin reduced the risk of death over a 2 year period (NNT = 180). A
about $216,000. This study raises many questions. What is the long term safety of lowering LDL cholesterol to 55 mg/dl in otherwise healthy pers
benefit of this drug? Can less expensive statin drugs, perhaps at lower doses, provide a similar benefit with less risk? (LOE = 1a)

Reference
Ridker PM, Danielson E, Fonseca FAH, et al. Rosuvastatin to Prevent Vascular Events in Men and Women with Elevated C-Reactive Protein. N Eng

Study design: Randomized controlled trial (double-blinded)

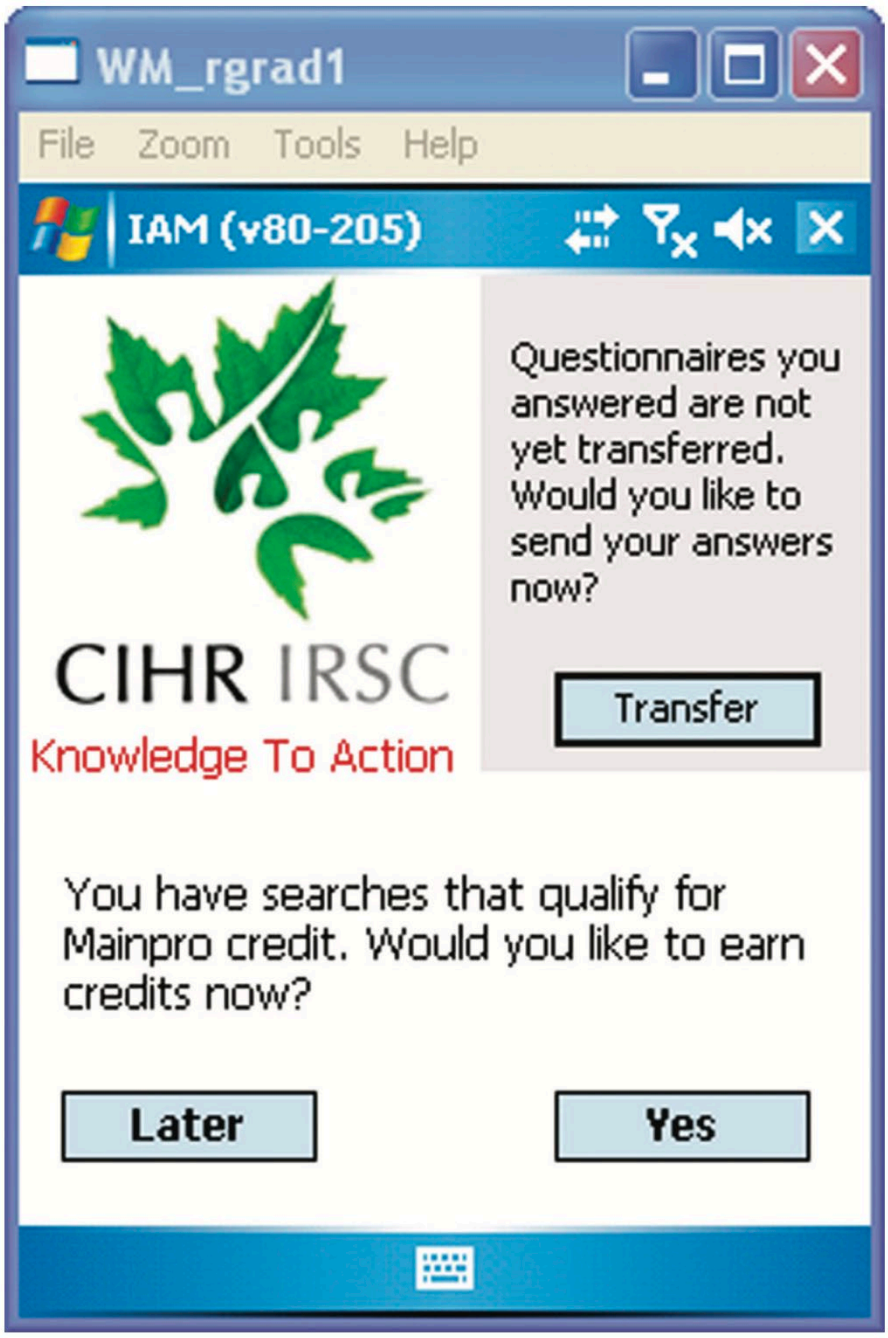
Funding: Industry

Allocation: Concealed

Setting: Outpatient (any)

Synopsis
The Air Force/Texas Coronary Atherosclerosis Prevention Study found that statins may be effective in patients with normal cholesterol but elevated
identified adults with LDL cholesterol < 130 mg/dl and C-reactive protein > 2.0 mg/L. Nearly 90,000 men over age 50 years and women over age 6
excluded due to an elevated LDL (37,611), low CRP (25,993), withdrawal of consent (3948), diabetes (957), hypothyroidism (349), or other reason
hormone replacement therapy were ineligible, as were patients with elevated creatine kinase, creatinine, or hepatic transaminases at baseline. T
those taking less than 80% of the study drug were excluded. This of course has the effect of making the study drug look more effective than it is in
white, mean age 66 years) were randomized to rosuvastatin (Crestor) 20 mg once daily or matching placebo. At each of the annual follow-up visits
group (55 vs 110 mg/dl) and the CRP was also significantly lower (~2.0 vs 3.5 mg/L). The study was terminated early after 1.9 years of median foll
1.25 per 100 patient years, p = 0.02). There was a consistent pattern of fewer cardiovascular events for patients taking rosuvastatin, including fewe
strokes (0.18 vs 0.34 per 100 patient years, p = 0.002). Patients taking rosuvastatin were more likely to be diagnosed with diabetes mellitus, thoug
rhabdomyolysis, which occurred in a patient taking rosuvastatin.

FIG. 3. IAM reminder screen



APPENDIX: IAM 2008

1) Search objective: *Why did you do this search?*
    I. Address a clinical question/problem/decision-making about a specific patient
    II. Fulfill an educational or research objective
    III. Search in general or curiosity
    IV. Look up something I had forgotten
    V. Exchange information with other health professionals
    VI. Share information with patient or caregiver
    VII. Plan, manage, coordinate, delegate, or monitor tasks with other health professionals

2) Situational relevance: *Did this search meet this (these) search objective(s)?*
    I. Yes/No

3) Cognitive Impact: *What was the impact of this item of information on you or your practice?*
    I. My practice will be changed and improved.
    II. I learned something new.
    III. This information confirmed I did (will do) the right thing.
    IV. I was reassured.
    V. I recalled something.
    VI. I was dissatisfied, as this information had no impact on my practice.
    VII. I was dissatisfied, as there was a problem with this information.
    VIII. I disagree with this information.
    IX. I think this information is potentially harmful.

4) Use: Did you/will you use this information for a specific patient?
    I. Yes/No