# THE EFFECT OF RISK ATTITUDE AND UNCERTAINTY COMFORT ON PRIMARY CARE PHYSICIANS' USE OF ELECTRONIC INFORMATION RESOURCES

by

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**Background:** Clinicians use information regularly in clinical care. New electronic information resources provided in push, pull, and prompting formats have potential to improve information support but have not been designed for individualization. Physicians with differing risk status use healthcare resources differently often without an improvement in outcomes.

**Questions:** Do physicians who are risk seeking or risk avoiding and comfortable or uncomfortable with uncertainty use or prefer electronic information resources differently when answering simulated clinical questions and can the processes be modeled with existing theoretical models?

**Design:** Cohort study.

**Methods:** Primary care physicians in Canada and the United States were screened for risk status. Those with high and low scores on 2 validated scales answered 23 multiple-choice questions and searched for information using their own electronic resources for 2 of these questions. They also answered 2 other questions using information from 2 electronic information sources: **PIER©**[1] and **Clinical Evidence©**[2].

**Results:** The physicians did not differ for number of correct answers according to risk status although the number of correct answers was low and not substantially higher than chance. Their searching process was consistent with 2 information-seeking models from information science (modified Wilson Problem Solving and Card/Pirolli Information Foraging/Information Scent models). Few differences were seen for any electronic searching or

[1] **PIER** is copyrighted © 2005 by the American College of Physicians, 190 North Independence Mall West, Philadelphia, PA 19106-1572, USA. (http://pier.acponline.org/index.html?chapinc). Accessed July 12, 2005.

[2] **Clinical Evidence** is copyrighted © by the BMJ Publishing Group Limited, London, England, UK. 2005. (http://www.clinicalevidence.com/ceweb/conditions/index.jsp). Accessed July 12, 2005.

information use outcome based on risk status although those physicians who were comfortable with uncertainty used more searching heuristics and spent less effort on direct searching. More than 20% of answers were changed after searching—almost the same number going from incorrect to correct and from correct to incorrect. These changes from a correct to incorrect answer indicate that some electronic information resources may not be ideal for direct clinical care or integration into electronic medical record systems.

**Conclusions:** Risk status may not be a major factor in the design of electronic information resources for primary care physicians. More research needs to be done to determine which computerized information resources and which features of these resources are associated with obtaining and maintaining correct answers to clinical questions.

## EXECUTIVE SUMMARY

Clinicians use external information regularly to support their clinical decisions and have traditionally consulted books and people. New computerized information resources such as electronic textbooks are available that provide push, pull, and prompting information support. We do not know if these electronic resources, and in which format, are effective; which ones are best implemented into electronic medical record systems; or if they need to be personalized to provide effective support for clinicians based on individual characteristics or specifications. One major way physicians differ is how they view risk and uncertainty. Risk-avoiding physicians and those uncomfortable with uncertainty use more healthcare resources and incur more care costs than their peers, often without improvement in outcomes. Risk and uncertainty affect all health care decisions and therefore are important issues in understanding health care and building effective computer-based systems. Risk and uncertainty also guide information seeking and use of external information. Design is important in computer systems because huge differences in productivity occur across users, often in the range of 20:1. Good design, understanding user needs, and training can mitigate this difference in computer productivity. This dissertation was designed to determine if primary care physicians use electronic information resources differently according to their attitude towards risk (risk seeking or avoiding) and comfort with uncertainty (low or high levels). Canadian and US physicians with different risk status answered 23 multiple-choice questions and searched for information using their own and provided electronic information resources in an hour-long interview. Quantitative methods and think-aloud protocol analyses showed small differences in searching outcomes and processes when using their own computer resources. Design may not need to factor in risk status for production of effective electronic information resources. However the use of some electronic information resources was associated with answers changing from an initially correct answer to being wrong. Further research must determine what features of a resource, and which electronic resources are associated with obtaining and maintaining initially correct answers to their clinical questions.

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## PREFACE

I wish to thank all the members of my committee for their belief in my ability to obtain a medical informatics PhD. At various times each of them with their belief in my abilities have kept me going and headed towards completion. My journey started with Brian Haynes' encouragement. I have learned much from him about research and development and life in an academic setting. Chuck Friedman believed in me and accepted me into the CBMI program despite funding complications. He often steered me in toward success, especially early in my student career. Ellen Detelefsen as a fellow librarian has also been influential in my career: She is the first person whom I told about my desire for a PhD. Lunches and time with Ellen were invaluable and I will miss them—I have never come away from time with Ellen without being ready and eager to move on. Rebecca Crowley has been a real role model in helping with my project at some very crucial times. I learned much from her both in and out of class. Doug Fridsma deserves huge thanks for the encouragement and belief in me during the whole dissertation process—he often saw things that I missed and gently showed them to me and I was off and running again. Without any of my committee members I would not have completed this degree. Thank you to all of you.

George and Helyn, this dissertation is dedicated to both of you. Without you keeping my “home fires burning” in Hamilton and Pittsburgh I would not have been able to finish. You will never know how much you both mean to me. Thank you.

I also want to thank my adult children Nathan, Meghan, and Emily. They too deserve thanks for the things they gladly gave up to enable me to go back to school at this stage in my life.

My friends, family, and colleagues in Hamilton and Pittsburgh also have a special place in my heart for all that they have given me emotionally, physically, intellectually, and spirituality. I hold Liz Bayley and George in high regard and gratitude as they have helped me immeasurably especially as I near the finish line.

Many other people helped with this dissertation at various times. I especially thank statisticians Dr. John Wilson, James McKinlay, and Dr. Stephen Werre. My medical librarian peers have encouraged and cheered me on at many points in this journey. I especially thank Liz Bayley (again), Neera Bhatnagar, Pat Weiss, and Andrea Ketchum for special help in several sections of this dissertation.

This completes the list of people who have believed in me all along the way and been beacons on the road to completion. Thank you again.

# 1 HOW PRIMARY CARE PHYSICIANS USE INFORMATION RESOURCES AND CHALLENGES TO FIND AND IMPLEMENT THE BEST

This first chapter of my dissertation outlines briefly the document describing the background of my project, lists the questions to be addressed, summarizes the methods used and results found, and discusses implications of the findings and directions for further research. Each section is more fully addressed in succeeding chapters. I have included the first chapter to orient readers to the full document and to provide a short summary for those who do not wish to read the full report.

## 1.1 THE NEED FOR GOOD INFORMATION RESOURCES

Clinicians have always used information resources to help them care for their patients. Books and colleagues have traditionally been the main sources of this information. With the increased pace of healthcare research and the introduction of computer capacity and the Internet many new electronic information resources and systems are available. Some hold the promise of being more effective than traditional resources. Formats of the resources differ in the electronic setting although many pull resources are still available—ones that a healthcare professional goes to in search of specific information. Electronic resources can also automatically push information to people to make them aware of advances or changes in knowledge. Some systems are also available that prompt users without being asked with information that they might find beneficial in their current situation. Examples of these prompt systems

are Amazon.com that suggests additional titles that others like you have bought through to physician order entry systems that alert healthcare providers to initiate specific monitoring or consider possible harmful drug interactions.

In addition to the proliferation of electronic information resources and formats, researchers such as Cimino and colleagues (1) have worked to incorporate computerized information resources into electronic medical record and hospital information systems. Integration of accurate and useful information resources into effective patient care systems is one of the major challenges in medical informatics. One of the first steps in this successful integration of information resources into patient care systems is to understand how clinicians use electronic information resources and to determine if the systems need to be tailored or individualized to accommodate individual physicians and situations. Domains outside of medicine have found that many individual differences of users (e.g., computer expertise, intelligence, and baseline knowledge) have consequences for the effectiveness of computer systems and electronic information resources.

My research efforts have been directed at primary care physicians who differ in how they view risk (risk seeking or risk avoiding and comfortable and uncomfortable with uncertainty) to determine if they use electronic information resources differently across risk and uncertainty groups. Physicians' views of risk and uncertainty substantially affect how they use a wide range of healthcare resources (e.g., admissions, diagnostic tests, and antibiotics) that in turn affects care costs. The following scenario highlights some of these differences in resource use across individual physicians and provides a concrete example of how individualized information resources might improve outcomes.

## 1.2 CLINICAL STORY—RESIDENT WOES

It was January and the senior residents had just finished their weekly meeting with the Residency Director, Dr. Lakeland. With 15 minutes left he ended the meeting and asked Bailey, one of the more thoughtful residents who had appeared troubled during the meeting, to join him for coffee. He asked her how she was doing. She was soon describing how being on call with Dr. Fairfield was often difficult as he seemed to admit more patients than other attendings and order many diagnostic procedures, referrals, and antibiotics. It seemed to her that he was pushing the

system to its limits and overworking the residents in general and her specifically. She felt that it was easier for the housestaff to work with Dr. Jolliette as she did not make as much use of people or resources as did Dr. Fairfield. Consequently when Dr. Joliette was on call, things seemed to get done more quickly and efficiently. Bailey stated that both physicians were good doctors, well liked by patients and respected by nurses and other staff on the wards. She said Dr. Fairfield seemed to be uncomfortable with situations that were uncertain and often ordered tests and procedures or admitted patients just to make sure. Dr. Jolliette on the other hand seemed more comfortable in uncertain situations. Bailey summed it up: "They just seem to have a different way of approaching risk and uncertain situations. If only we could give Dr. Fairfield some sort of support or backup to make him more sure of his actions it would make our lives easier—and probably make the administrators happier too."

Dr. Lakeland knew exactly what Bailey described and had had some of the same thoughts—good physicians with different patterns of resource utilization. He also thought back on his career and realized that he had seen physicians and residents in other settings who practiced using the same patterns. He liked Bailey's idea of some sort of decision support. Based on his work with the Electronic Medical Record System Implementation Group and the Library Advisory Committee he wondered about incorporating more guidelines, electronic resources, or clinical decision aids that the information technology staff and the librarians had suggested. If physicians had the decision support or electronic information resources they felt enhanced and strengthened their care decisions, maybe they would reduce their rate of ordering tests or referrals or admitting or prescribing to make sure. But what is the best informational/decision support for physicians and is it same for all physicians?

Although this is a hypothetical example, according to story-telling tradition, "it is true, and might have even happened". The scenario illustrates some important and very real issues in healthcare delivery:

- Clinical care involves making many decisions related to diagnosis, treatment, and prognosis. Clinicians making the decisions function in uncertain situations and almost all decisions have varying risks associated with the options.
- Clinicians vary in their use of healthcare resources and this variation is often linked to their attitude towards risk and stress from uncertainty.
- The variation in resource use is not directly linked to better care—more is not necessarily better.

A logical extension of these issues leads to questions of identifying and installing information resources or support that would provide the same reassurance that comes from using substantial or excessive resources to back difficult decisions or complex situations. Before turning to this ideal electronic information support, several other areas of medical informatics and information science need to be invoked. I describe each in the following sections. I end the chapter with my dissertation questions, my work plan, a general summary of my findings, and a brief outline of the rest of the dissertation.

## 1.3 INFORMATION IS CRITICAL TO EFFECTIVE PATIENT CARE

Physicians and other health care professionals report the need of, and are observed to use information frequently in outpatient and inpatient settings (2-5). This was true in the early 1970s and current studies report similar findings (6, 7). Many, but not all, of these information needs are pursued by using a wide variety of sources despite difficulties in using many of the resources. Combining findings across studies, countries, disciplines, and decades, information is sought approximately once for every 10 patients in outpatient settings or in the range of 2 to 4 times per clinic day with higher rates for inpatient settings. Studies show that when questions are pursued, the care process, and likely patient outcomes, improve (6). Physicians face many obstacles to finding the information they seek quickly and efficiently. Ely and colleagues (8) report 59 obstacles collected during a qualitative study of physician use of information resources. Many relate to practice constraints (e.g., time) and the resources themselves.

Because of the large numbers of information needs, the multiplicity of sources, difficulties looking for answers, and the time pressures clinicians face, as well as the potential to improve outcomes (6), I feel that research and development to improve the effectiveness and usability of electronic information resources is a vital area of study in medical informatics, both on broad theoretical and practical levels. Optimizing design and improving existing resources could lead to more effective and efficient computerized information resources. Many researchers are addressing the goal of high-quality electronic information resources both as stand-alone entities and those that

are integrated into large electronic medical record or clinical information systems although more work needs to be done especially in determining if personalization of the electronic systems is appropriate or warranted.

## 1.4 USER CHARACTERISTCS AFFECT HOW INFORMATION IS SOUGHT AND USED

Information science provides evidence (9) that almost all individual characteristics related to general intelligence, personality, cognitive styles, and psychomotor differences are linked to a greater or lesser degree with success using computer systems. The literature on individual differences and human computer interactions shows variations in efficiencies across people in tasks such as text editing, programming, information retrieval, and database usability (9). People completing computer tasks, especially those related to information finding and use, vary in their productivity by a factor of 20:1 (10). This means that a very productive user can complete a task 20 times faster than can a less productive peer. These variations in efficiencies or productivities are especially startling in that the differences can often be mitigated or even eliminated by good design, adequate training, and tailoring of the system for special needs (e.g., adjustment of text size for people with visual problems). With the increasing time pressures, the ever changing knowledge base of medicine, and importance of low tolerance of mistakes in health care, designers and implementers of electronic information resources need to know their users and how best to optimize computerized resources. Little research in medical informatics has addressed these issues of user characteristics and how they affect resource use efficiencies.

## 1.5 PHYSICIAN RESPONSE TO RISK AND UNCERTAINTY AFFECTS PROCESS OF CARE AND RESOURCE USE

Risk and uncertainty play major roles in healthcare decisions. All options for every decision have associated risks and benefits. Decisions are made in a climate of uncertainty and often with the added pressures of time, resource

limitations, and patient preferences and situations. How one views risk is a basic personality construct and has been studied for almost 100 years. Many scales exist that measure certain aspects of risk taking and stress from uncertainty. In the medical domain, several scales related to risk and uncertainty have been developed and validated. One measures how an individual physician compares with his or her peers on the continuum of risk seeking through risk avoiding. Developed by Pearson and colleagues (11), the scale has shown associations between risk attitude and healthcare resource use and costs: Risk-seeking physicians have lower rates of referrals (12), a lower likelihood of hospitalizing patients with chest pain (11), and lower patient care costs (13, 14). Gerrity and colleagues developed and validated a second scale that measures a physician's stress or comfort with uncertainty. Physicians who are comfortable with uncertainty show similar differences in resource use and costs that risk-seeking and risk-avoiding physicians exhibit (14) with those who are comfortable with uncertainty using fewer resources and incurring lower costs. Studies that include both scales show that in some instances one of the scales is more predictive of resource use and costs. The studies that include data from both scales do not provide sufficient data to determine which scale is more predictive.

I have chosen to use both the Pearson and Gerrity scales to ascertain if how a physician's view of risk and uncertainty affects electronic information resource use. The scales show differences across individuals for healthcare resource use and costs in many settings and several disciplines. These scales are readily available, easy to administer, and have been validated in some settings. Scores on the scales remain constant over time with just a bit of movement towards more risk avoidance with increased age. In addition, both risk and uncertainty play a major role in the use of information—physicians look up or ask for peer help to determine risk information (harms and benefits) and use the information to resolve uncertainties around specific clinical decisions.

## 1.6 NEW RESOURCES PROLIFERATE IN OUR ELECTRONIC ERA

Books have provided clinical decision support for generations. They have become less important in the past decade partly because the pace of healthcare research renders them out of date relatively quickly. With the advent of personal computers and the Internet many new electronic information resources are now available. Electronic

textbooks can be updated frequently and are readily available in multiple locations. The Internet and search engines like **Google™**[3] link healthcare professionals to almost limitless resources such as individual web pages, other searching services such as **PubMED®**[4]**,** and comprehensive web sites such as **MEDLINE Plus®**[5] or US **National Guidelines Clearinghouse**[6]. Evidence-based medicine (EBM) has supplied physicians with a respect for and the ability to use clinical research as a basis for care decisions (15). EBM has also been a factor in the development of national and local clinical practice guidelines. Researchers, clinicians, administrators, associations, and governments have put tremendous amounts of resources into developing these guidelines (content) and how best to implement them. Researchers and developers have also produced new electronic information resources (16). For example, the BMJ publication, **Clinical Evidence** endeavors to provide clinicians with the harms and benefits related to specific clinical questions; the American College of Physicians has developed their **Physician Information and Education Resource (PIER)** that is a hybrid between a textbook and a set of guidelines and provides directed care options; and the **Cochrane Collaboration©**[7] and **Campbell Collaboration©**[8] strive to collect and synthesize high-quality evidence on healthcare and mental health interventions.

New computer technology has also enabled development of pull, push, and prompting electronic information systems. Pull resources are those that are used by a searcher as he or she seeks to answer a specific question—the traditional way of using information resources such as a book. Push systems are those that alert physicians of advances in health care. The alerts arrive often in email format without being sought once the searcher has invoked the push system. An example of a push system is the **bmjupdates+©**[9] service. The prompting systems work to supply a clinician with information to address an unspoken (or unknown) need such as a suggestion to start an ACE-inhibitor for a patient with newly diagnosed diabetic retinopathy or the need for tetanus or influenza vaccinations. These multiple formats add complexity to the choice of which electronic information resources to use.

All of these new electronic resources are still being developed and thus are amenable to improvement. In addition, we do not know if individual electronic resources are useful for all clinicians or if they are useful for some

[3] **Google** is a trademark of Google, Inc., Mountainview, CA, USA. (http://www.google). Accessed July 6, 2005.
[4] **PUBMED** is a registered trademark of the U.S. National Library of Medicine, National Institutes of Health, Health and Human Services, 8600 Rockville Pike, Bethesda, MD, USA.
[5] **MedlinePlus** is a registered trademark of the U.S. National Library of Medicine, National Institutes of Health, Health and Human Services, 8600 Rockville Pike, Bethesda, MD, USA
[6] **National Guidelines Clearinghouse**. http://www.guideline.gov/. Accessed July 6, 2005.
[7] **Cochrane Collaboration**. (http://www.cochrane.org/index0.htm). Accessed July 6, 2005.
[8] **Campbell Collaboration**. (http://www.campbellcollaboration.org/). Accessed July 6, 2005.
[9] **Bmjupdates+.** Copyright the Health Information Research Unit, McMaster University, Hamilton, Ontario. Canada. (http://bmjupdates.mcmaster.ca/index.asp). Accessed July 10, 2005

but not others. We also do not know if tailoring or personalization of electronic resources based on individual characteristics is warranted (17). This dissertation seeks to provide answers to these questions.

## 1.7 INFORMATION RESROUCES ARE BEING INTEGRATED INTO ELECTRONIC MEDICAL RECORD SYSTEMS

Information resources are also being integrated into large electronic medical record and clinician information systems. Cimino and colleagues (18-24) as well as others have done substantial work in the integration of electronic information systems into larger systems using all 3 formats (pull, push, and prompt). These researchers have shown how difficult it is to bring needed information effectively to healthcare professionals when and where they need it and in a timely manner and a useable and useful format. The task of providing useful electronic information requires substantial investments of time and resources as well as expertise from clinicians, information and computer scientists, medical informaticians, resource suppliers, and administrators. Resource constraints limit the number of electronic information resources that will be integrated into the large systems. We need to know which electronic information resources provide the most effective and efficient support for healthcare professionals. We also need to know if multiple resources are needed to support clinicians with varying needs and characteristics and to determine if tailoring of the electronic resources is warranted. Very little evidence exists on what constitutes effective computerized clinical information resources, desired features, or the need for individualization.

## 1.8 QUESTIONS TO ANSWER

To summarize, in the previous sections I have outlined briefly several areas of complex and important knowledge and how each has implications for design and use of electronic clinical information resources. Clinicians need external information to provide quality care to patients. They use a variety of resources to answer questions despite

problems with usability, accessibility, and content. Physicians pursue answers on average 2 to 3 times per day in clinics and more often for hospitalized patients. Individual characteristics are associated with differences in a person's effectiveness of finding and using information from electronic resources. In particular, risk profiles seem to affect the way in which people find and use that information outside the domain of health care (25). Careful design and attention to training can, however, often make computerized systems equally effective for users with varying backgrounds and characteristics. Physicians who are uncomfortable with uncertainty or are risk avoiding are prone to use a higher proportion of healthcare resources than their risk seeking peers or those who are more comfortable with uncertainty, potentially stressing already overloaded healthcare systems. The extra tests, referrals, and interventions these risk seeking and high-stress physicians use are not necessarily associated with improved patient outcomes. Clinicians may be able to provide care more effectively with individualized electronic resources or tools that support decisions they find difficult to make.

New technologies hold the promise of integrating electronic information resources into the care process by linking them directly into computerized medical record or clinical information systems. However this dream of integrated, effective, and timely information is not realized. New technology has brought us new electronic resources and formats but we have not yet optimized their presentation and integration nor have we determined if tailoring these resources based on individual differences of clinicians or their preferences is warranted.

By pulling these ideas together, I have developed the following fundamental dissertation statement and 3 questions that I use to address it:

**Statement:** I contend that clinicians with varying attitudes toward risk and levels of stress from uncertainty employ different approaches to seek information while using electronic information resources and have different outcomes. I can represent the similarities and differences in electronic information seeking behavior and use with theoretical models from information science and cognitive science/human computer interaction. By using the outcome and process data, the models, and clinician preference data for electronic information resources and specific features, I will determine whether designers of computerized information resources should use risk attitude and comfort with uncertainty or other related factors to tailor or personalize the resources. Computerized information resources, whether they are stand-alone resources or integrated into

electronic medical record systems must effectively and efficiently support decision-making regardless of physician risk attitude or level of stress from uncertainty.

1. How are primary care physicians' attitude toward risk (risk seeking and risk avoiding) and comfort with uncertainty associated with outcomes of searching for evidence (e.g., correctness and certainty of answer, time to decision, number of resources used) when using electronic information resources to answer simulated clinical questions?
2. What electronic information seeking and use processes do primary care physicians employ when answering simulated clinical questions and are the processes associated with risk attitudes (risk seeking and risk avoiding) and levels of stress from uncertainty. Can the processes and their differences be modeled by using the modified Wilson Problem-Solving Model (from information science) and the Information Foraging/ Information Scent Model built by Card and Pirolli (from information processing and human computer interaction domains)?
3. What are physician preferences for specific electronic information resources (**Clinical Evidence** and **PIER**) when answering simulated clinical questions and are the preferences for resources and features associated with physician risk attitudes and levels of stress from uncertainty?

## 1.9 WORK PROCESS

With these 3 questions, I have taken concepts from information science, computer science, and cognitive psychology and applied them in medical and medical informatics realms to determine if for primary care physicians an association exists between attitude toward risk and comfort with uncertainty and outcomes and processes of using electronic information resources to answer simulated clinical questions. To answer the questions, I carried out the following tasks:

- Using email and the Internet I screened primary care physicians in Canada and the United States with the Pearson Risk Attitude Scale to ascertain risk seeking and risk avoiding status and the Gerrity Physician Reaction to Uncertainty (PRU) scale which measures perception of level of stress from uncertainty.
- I Interviewed physicians from 4 cohorts (risk seeking, risk avoiding, and comfortable and uncomfortable with uncertainty) in their offices and watched them search for information.
- During these interviews the physicians performed the following tasks:
    - Provided information on computer use and skills
    - Answered 23 multiple-choice questions
    - Selected 2 questions from the list and looked up answers by using their own computerized information resources while thinking aloud
    - For 2 of the 23 questions, which I assigned, used pages from electronic information resources I provided to answer the questions.

## 1.10 MAIN FINDINGS

Scores for the Pearson Risk Attitude Scale and the Gerrity Stress from Uncertianty Scale were consistent in spread and central tendency with scores found in other studies. I found low numbers of correct answers to the clinical questions. The rates of correct answers did not differ across cohorts of physicians based on risk attitude and stress from uncertainty. I had postulated that I would find no difference in scores, which validated findings from other studies. Although I expected to find differences in outcomes and performance with computerized information resources, few differences were apparent despite multiple outcome variables. No difference was found for time spent for completing all of the tasks or individual tasks, the resources used, or the searching techniques used. The main difference identified in the study was the fact that physicians who report high levels of stress from uncertainty used fewer searching heuristics and spent more of their search efforts doing direct searching and assessment of the results

than their peers who were comfortable with uncertainty. This difference in process was not found when comparing physicians who were risk seeking and risk avoiding.

The study physicians had strong preferences for the electronic resources and individual features but these preferences were not associated with either risk attitude or level of stress from uncertainty. In addition to preferences clinicians also listed many criticisms of features. Some features were both criticized and favored by clinicians. The searching behaviors I found were easily integrated into the modified Wilson Problem Solving and Card/Pirolli Information Foraging/Information Scent models. I also discovered new insights. The most significant is that electronic information resources, like other medical informatics applications may not be only neutral or positive in their effect on clinical knowledge. In some circumstances physicians were led away from correct answers by an electronic information resource that provided an incorrect answer or by information in that electronic resource that the clinician applied inappropriately. Some data were found that provide direction for further studies that look at specific resources and features of resources that are associated with obtaining and maintaining correct answers. Some evidence was also found that individualization or personalization of electronic information resources is important for optimizing use of these resources by clinicians when answering clinical questions.

## 1.11 GUIDE TO THE READER

In this chapter I have provided a scenario familiar to many healthcare professionals—how to make the best use of scarce resources while at the same balancing the need for some physicians to order more tests, procedures and referrals than do his or her peers. I have looked at the number of information needs physicians have and how they currently find information. I have also shown the importance of good and flexible design for computer systems and the substantial effects that design, training, and tailoring can have at optimizing effectiveness. Both technical and cultural factors have contributed to the development of many new or modified electronic information resources. Some of these new computerized information resources are being integrated into new and planned electronic medical record and clinical information systems. Only some of the existing electronic information systems will be integrated, however, because of the costs and effort needed to produce truly useful and effective information

resources and integrate them into the electronic care process in push, pull, and prompting formats. Research is needed to optimize the best choices of computerized resources for integration. I end the chapter with my research theme and 3 questions as well as a brief description of my results. The rest of this chapter describes the content of the dissertation to give the reader direction and context.

Chapter 2 builds the historical, theoretical, and practical basis for my dissertation around information needs, individual differences and computer systems, models of information seeking and use, recent developments in providing electronic information to clinicians, and integration of computerized information resources into electronic medical record systems.

Chapter 3 describes the formal methods of my dissertation project as well as the challenges I faced in carrying out the project. I have included a full description of the challenges and how I addressed each one so that my experiences may benefit those who pursue similar work.

Chapter 4 provides the findings of my dissertation. It starts with data on recruitment and the physicians in the study and continues with reporting of the data to answer the 3 dissertation questions. I end the chapter with a summary of the main findings.

In Chapter 5 I outline the findings of the dissertation in relation to expected and unexpected results. I indicate how my findings support existing theory in medical informatics and other domains and I delineate where my findings extend or build new theory. Finally, I summarize the theoretical and practical contributions to information science, medical informatics, and library science and describe extensions of this study and other plans for pursing additional knowledge related to the use of electronic information resources that stand alone or are integrated into electronic medical record systems, preferences for features and products of electronic information resources, the need for computerized personalization, and predictors of successful systems that promote and maintain correct answers to clinical questions.

# 2 REVIEW OF THE THEORETICAL BASIS OF INFORMATON RESOURCES AND HOW PHSICIANS USE THEM IN CLINICAL CARE

## 2.1 QUESTIONS AND SUMMARY OF DISSERTATION

In the first chapter I briefly described 7 areas of knowledge with important implications for the design and use of computerized clinical information resources. In this chapter I review and summarize the theoretical basis of these and several other content areas in medical informatics and related domains important to my dissertation. I briefly describe the areas that I will be summarizing:

1. Clinicians often need information from external resources to provide quality care to patients. Clinicians use a variety of resources to answer questions despite problems with time pressures, usability, accessibility, quality, and content. Across studies, disciplines, decades, and nationalities they have been shown to look up information often in the range of 2 to 3 times per clinic day with higher rates for hospital settings.
2. Individual characteristics of people are often associated with substantial differences in the effectiveness of using computerized programs and systems including electronic information resources. In particular, risk profiles may be associated the way in which people find and use information the retrieved information. Careful design, attention to user needs, and consideration of training issues can, however, make electronic systems equally effective for users with varying backgrounds and characteristics.
3. Although a substantial number of cognitive models have been applied to information seeking and use across disciplines, only a few consider risk profiles, and none appear to target the unique challenge of

uncertainty and risk in medical domains. Cognitive models are important to the theoretical basis of any domain and we need more validated models in medical informatics to help direct research and development.

4. Physicians with varying responses to risk approach care and use healthcare resources differently, potentially putting excessive stress on already overloaded healthcare systems. Physicians who are uncomfortable with uncertainty or who are risk avoiding are likely to order extra tests, interventions, and referrals to deal with their desire for more certainty, less risk, or both. This excessive use of healthcare resources is not necessarily associated with improved patient outcomes although studies of resource use and risk profiles are often underpowered to sufficiently determine if the extra use of healthcare resources improves clinical care or outcomes. Clinicians may be able to provide care more effectively with resources or tools that support decisions they find difficult to make.
5. New information technologies (e.g., the Internet) and more powerful and readily available computer equipment and services have provided the framework and impetus to build electronic information resources and enhance existing resources.
6. Changes in the culture of medicine (e.g., managed care and evidence-based medicine) have influenced the development of new and different information resources (e.g., clinical practice guidelines) as well as directed modification of existing resources (e.g., textbooks). However, we have not optimized the presentation of clinical evidence/information to individual users and its integration into electronic medical record or clinical information systems. We have also not determined if tailoring these new electronic resources based on individual differences of clinicians or their preferences is warranted.
7. Many researchers and developers are working to intelligently integrate electronic information resources into the care process by using electronic medical record and clinical information systems. This dream of integrated, effective, efficient, and individualized information availability that supports real-time clinical care is still not realized. Before we have full and useful integration of information resources we need more research looking at how clinicians actually use information resources, if individual characteristics such as risk attitude and level of stress from uncertainty affect patterns of use or processes of care, and what features of resources or specific resources they value. We also need to know the resources and features of resources that are associated with improved answers to real questions.

Before I start the background to this dissertation, I reiterate the fundamental statement of intent for my dissertation: I contend that clinicians with varying attitudes toward risk and levels of stress from uncertainty employ different approaches to seek information and use electronic information resources to address clinical questions. I can represent the similarities and differences in electronic information behavior and use with theoretical models from information science and cognitive science/human computer interaction. By using these models, as well as clinician preference data for electronic information resources and specific features, I will determine whether risk status or other related factors should be used by designers of computerized information resources. Computerized information resources must effectively and efficiently support clinical decision-making regardless of individual physician characteristics including risk attitude or level of stress from uncertainty.

## 2.2 INFORMATION IS CRITICAL TO EFFECTIVE PATIENT CARE

Formal evidence on the quantity and type of information needs that healthcare professionals have and how the needs are met has accumulated over many years. Some of the first reports came from Canadian researchers in the early 1970s (3, 26, 27). The Medical Information Network in Ontario survey showed that physicians did not use libraries because of time constraints but used colleagues and their own print resources (26) to address information needs, a finding that remains true more than 30 years later. One of the first studies done in the United States found that physicians used information with small differences based on specialty, age of the physician, and practice type (4). Important observational studies in outpatient settings were done by Covell and colleagues in 1985 (28, 29) and Williamson and colleagues in 1989 (30). Osheroff et al. extended the research into clinical information needs in inpatient settings in 1991 (5). Outpatient information needs were in the range of approximately 2 questions for every 3 patients and inpatient needs were up to 5 per patient per hospital day. Research into information seeking patterns and information needs continues today by such researchers as Ely and colleagues who have done considerable research into clinician questions and the answering processes (31, 32).

The rate of information needs or questions has changed little since the original surveys and studies were done and it does not substantially vary across disciplines or countries. In 2003, Ramos and colleagues (7) found that family practice residents had an average of 1.8 information needs per patient visit while the attending staff averaged 0.8 questions per patient visit, very similar to the rate found by Covell and colleagues 20 years before. Currie and colleagues, also in 2003 (33) found an average of 11 information events per hour from an analysis of videotape of 35 clinicians working with an electronic medical record system in a hospital setting—again similar to the inpatient information need rates found by Osheroff and colleagues in 1991. Dawes and Sampson (6) completed a systematic review of 19 studies of information needs and behaviors. They also found substantial variation in the number of questions provided by each physician. The results of their systematic review, combined with work done by Ely and colleagues (8, 31, 34), shows that although clinicians consistently report recurring information needs, the multiplicity of potential sources, time pressures, and lack of knowledge of the best potential sources to answer questions hinder the physician's ability and desire to seek answers.

Despite difficulties associated with existing resources in real-time clinical care, clinicians use information sources to answer many of the questions they encounter in direct patient care situations—studies show that clinicians sought answers for approximately 20% (35) to 30% (34) of their questions. In a 2005 report, Ely and colleagues (32) report a higher rate of 55% of questions pursued. The same authors also found that questions were answered without difficulty (41%), answered with difficulty (31%), or not answered at all (28%). Across all studies, the most used sources were ones that were readily available; easy and fast to access; and familiar as well as having, or perceived to have, high quality—peers, textbooks, previously helpful resources, and more recently, electronic resources (36).

Consolidating the data for clinic and hospitalized patients and assuming conservative estimates that an information need arises for every 2 patients and that 20% of these questions are pursued we can assume that information is sought in various sources once for every 10 patients in routine clinical care. In the outpatient setting where a physicians sees approximately 3 patients per hour this translates to 2 to 3 questions being pursued per day per physician or more if one accounts for patient encounters via telephone calls and emails. Other data also hint at the magnitude of information resource use in healthcare. The U.S. **National Library of Medicine ®** (37) estimates that approximately 60 million **MEDLINE** searches are done each month and although it is difficult to determine

how many of these are done by health professionals, many of the searches are thought to be done by physicians for direct patient care.

This means that research into optimizing electronic information resources is not only a rich and important research area for medical informaticians but also one that has the potential to affect many clinical encounters. What is lacking in the studies described above is the effect of these information resources on actual patient care. Little evidence is available on this aspect of information seeking behaviors. Some published evidence does, however, show that use of information resources improves the patient care process and potentially, outcomes. Haynes and colleagues (38) showed that when **MEDLINE** searching was done in clinical settings, the process of care was reported as altered—decisions were changed or spawned as well as confirmed, based on citations. In a study reported in 2005, Magrabi and colleagues (36) found that 1 physician in 4 reported improvements in patient care during a 4-week trial of an electronic information resource in Australia and 83% of the users felt that the system had potential to improve patient care. Their online system, **Quick Clinical** is built around **MEDLINE** Clinical Queries in **PubMED**, a pharmaceutical and government-funded database, and the **Merck Manual©**[10]. Hersh and colleagues (39) studied medical students and nurse practitioner students. Medical students improved their ability to answer simulated clinical questions correctly when they used **MEDLINE** to support their answers. Taken together, these studies show that the care process is likely improved with the use of **MEDLINE.** The most compelling evidence of the usefulness of electronic information resources to improve patient outcomes comes from a critical incident study commissioned by the U.S. **National Library of Medicine** (40). In a series of interviews, clinicians reported that **MEDLINE** had a substantial effect on health care including changing diagnostic processes and treatment regimens plus substantially reducing morbidity and mortality. Even though these studies evaluated **MEDLINE-**based services, the contribution of other electronic information resources is likely the same—physicians would not continue to use information resources if they were not satisfied with the information they obtain. Information resources can improve care and outcomes, even though we do not know the entire extent of their effect.

In summary, information needs are common in outpatient and inpatient settings and a substantial number of these needs are pursued in a wide variety of sources despite many difficulties in using the resources. Information is sought approximately once for every 10 patients in outpatient settings or in the range of 2 to 4 times per clinic day. When questions are pursued the care process, and likely patient outcomes, improve. Because of the large numbers of

[10] **Merck Manual** copyright 199-2005 by Merck & Company.
http://www.merck.com/mrkshared/mmanual/home.jsp). Accessed July 10, 2005

information needs, the multiplicity of sources, difficulties looking for answers, time pressures clinicians face, and the potential to improve outcomes, I feel that research and development to improve the effectiveness and usability of electronic information resources is an important, if not vital, area of study in medical informatics. Dawson and Sampson concur with this assertion (6) as they close their 2003 systematic review by stating that further research is needed beyond the descriptive and observational studies of use to more fully understand information needs in the clinical context. My research will provide data on outcomes and process of searching that can be used to build a theoretical basis for information seeking and use in an electronic age. This theoretical basis can then drive the optimizing process to design and build effective and efficient electronic information resources. With a fuller understanding of the role that risk attitude and stress from uncertainty play and how each affects electronic information resource processes and outcomes we will also will know if tailoring the electronic resources is needed to provide the best clinical information support possible.

## 2.3 USER CHARACTERISTICS AND INFORMATION SOURCES AND SEARCHING

As stated above, a clear need exists for effective electronic information resources in clinical care. To optimize these resources and evaluate the need for tailoring, we need to start the process by looking at research in medical informatics and other domains that have studied whether individual characteristics of users affect searching process or outcomes. In this section, I will briefly describe published studies and show why research into optimizing electronic information resources is important for their acceptability and effectiveness. Most of this research has been done outside the domain of medicine although some important preliminary work into individual differences and searching process and outcomes has been done in health care.

The most compelling data on the need for research into optimizing electronic information resources comes from work done in the domain of human computer interaction. Dillon and Watson (41) summarize research related to individual differences and performance over the past 100 years. Of special note is the work started by Hull in 1928 (42) that compiles ratios for worker productivity comparing high performers with low performers (best-to-worst

ratios). Usually these productivity ratios across disciplines, domains, and time show ratios in the range of 1.4:1 to 5:1 are common. This means that one's best workers produce anywhere from 1.4 to 5 times more output than a less than average worker. Most differences in performance for non-computer tasks are in the range of about 2:1 for 95% of the human population (ascribed to Salvendy and Knight (43) by Curl and colleagues (44)) However for computer-related tasks such as programming and text editing, the ratio is consistently in the range of 20:1 (45) (interquartile ratios span 2:1 to 4:1) with some studies showing differences in productivity up to 50:1 (44)—a tremendous difference. What adds to the importance of this 20:1 ratio is that the huge differences in computer productivity can be understood and predicted as well as mitigated through careful design (45) and attention to user needs and training issues. In some situations, the difference can be almost entirely eliminated.

An example of the mitigation of difference in performance is a randomized controlled trial by Stanney and Salvendy in 1995 (46), which studied students with varying levels of spatial abilities. The study coordinator asked the students to perform computer-based information retrieval tasks. The students with low spatial abilities performed more slowly than with their peers with higher spatial abilities until both groups used an interface that provided an easy to use visualization of the data. The differences in performance then disappeared.

The 20:1 performance ratio for computer applications, which is readily and easily modifiable, shows why designing electronic systems for optimal use by clinicians in seeking answers to questions and making clinical decisions, is vital.

Research into specific individual differences and their impact on searching and information use efficiency and outcomes has been done in many domains. Some examples of the individual differences that can direct design of computer resources follow. Designers need to provide rank-ordered rather than non-ranked ordered output for users with low logical reasoning ability (47). Users with high scores on visual ability scales learn almost all systems quickly. Those people with low visual ability scores profit by extra training with direct manipulation interfaces that help users visualize the system and its activities (48). People with differing levels of spatial visualization adopt different search strategies and perform differently using various computer systems (44, 49-53). Cognitive style, defined as an individual's characteristic manner of organizing and processing information (54) also has been shown to affect searching process and information use. People who are able to distinguish items as separate and discrete from their background are able to function better in a hypermedia system and find information more accurately and efficiently. In a web environment they find information more efficiently, with shorter search time and fewer search

steps. In addition to differences in steps taken, they also differ on process (more nonlinear searching strategies) although the outcomes of content and decisions are not appreciably different than for their peers who have different cognitive styles.

Problem-solving style also affects searching. Problem-focused style, as compared to emotional-focused style, is associated with breadth-first searching and better overall performance in searching and outcomes. Emotion-focused individuals use a more linear approach to searching (depth first) and follow embedded links more often. Ford and colleagues (55) showed that students with a "holist" learning style do more exploring while searching and the students who were more "serialist" in their approach to information searching built search strategies in a more narrow, stepwise fashion.

Heinstöm studied personality in her 2002 dissertation (56, 57): All 5 of her personality dimensions influenced information behavior of students. Neuroticism was related to the need for confirming information and feeling of time pressures. Extraversion was related to informal information retrieval and preference for thought-provoking documents rather than confirming previous ideas. Openness to experience was associated with broad information seeking, incidental information acquisition, and critical information judgment with a preference for a wide range of related documents. Competiveness was linked to feelings of time pressure and problems with assessing relevance and critical analysis. Conscientious students were willing to work harder at finding and applying relevant information than less conscientious students. These examples in preceding several paragraphs are just a small sample of the research done on individual differences—many more examples exist and additional factors that affect productivity will likely be found.

Dillon and Watson (41) sum up their review of individual differences by stating:

> "Suffice it to say that for most components of information processing that have been subjected to differential investigations, individual differences have been observed".

Studies of individual differences should play a major role in the design of medical informatics projects and applications. Borgman (58) only strengthens this need to study individual differences. He contends that differences are most important when users of computerized systems are nontechnical people who perform tasks that depend heavily on the ability to reason abstractly—both factors describe healthcare professionals working with electronic resources.

Parallel to the work in individual differences in informatics is work done on individualization. Most of the development work in individualization or personalization has been done in commercial sites and we can learn much from observing their successes. Wu and colleagues (17) define personalization as information systems that change configurations based on each user's needs and preferences. These configuration changes can relate to content, display, passage through the system, and provision of links. Cimino and colleagues provide some of these changes in their recent work (59, 60) of integration of electronic information resources into electronic medical record systems. For example they provide links to external resources that will provide an answer to the context specific question or situation based on discipline of the user or the resources to which an individual hospital has access.

In commercial and medical sites personalization has been done with cookies, profile-based changes (e.g., pediatricians would get different tools than an internist), personal choices (e.g., I want to go to **Clinical Evidence** for all my questions and not **UpToDate©**[11], and rules triggered by specific current actions or consistent previous actions. These personalization techniques work well in commerce settings and medical informatics designers and implementers could benefit from their experience and examples of successful projects and methods.

Substantial research has been done on information seeking behaviors of various health professionals. Detlefsen (61) reviews some of important studies and many were described in the previous section on information needs of health professionals. Hersh and colleagues (39, 62) have produced some initial and valuable data in a study of medical and nurse practitioner students and how they use **MEDLINE** to answer assigned clinical questions. Medical students used **MEDLINE** more effectively. Other predictors of various outcomes that were identified in the study show that searching quality and question answering correctness were associated with basic intelligence measured by standardized tests (**Graduate Record Examination©**[12] and **Medical College Admission Test®**[13]), being male, previous knowledge of the correct answer, searching experience, and spatial visualization (validation of previous work (44, 49-53)), with trends seen for verbal reasoning, and the thinking/feeling axes of the **Myers Briggs Type Indicator®**[14]. Staggers and Mills (63) have also shown that in nurses differences in spatial visualization are associated with information retrieval performance. Aydin and Rice (64) studied individual differences in health professionals but in the context of implementation of a medical records system: The authors did not find that

[11] **UpToDate.** Copyright 2005. (http://www.uptodate.com/service/index.asp). Accessed July 10. 2005.
[12] **Graduate Record Examination.** Copyright ETS 2005. (http://www.gre.org/**).** Accessed July 10, 2005.
[13] **Medical College Admission Test.** Copyright AAMC 1995-2005. (http://www.aamc.org/students/mcat/start.htm). Accessed July 10, 2005.
[14] **Myers Brigg Type Indicator.** Registered trademarks or trademarks of the Myers-Briggs Type Indicator Trust in the United States and other countries (http://www.myersbriggs.org/). Accessed July 10, 2005.

attitudes toward the implementation differed based on individual differences of cognitive style, previous computer use, and age. They did not assess the effectiveness of use of the system based on individual differences. Despite the studies just described, little research has been done in the domain of health care on individual differences and their association with searching process or outcomes.

In summary, individual differences of people who perform computer-related tasks are associated with differences in performance, especially retrieval process and for some tasks, outcomes. Limited data suggest that individual differences in clinicians may be important for designing and implementing effective electronic information resources and other computer systems. Although large variations in performance exist among users, sometimes in the range of 20:1 or even higher, good design, attention to the user needs and background, and targeted training can minimize or eliminate these differences. To obtain data to drive design of electronic information systems in health care, we need to identify and quantify differences in individual characteristics, use these differences to build models of information seeking in populations, and then to design systems and resources based on these models. The next step in the process is to target the individual characteristics of physicians that are most likely to affect use.

## 2.4 PHYSICIAN RESPONSE TO RISK AND UNCERTAINTY AFFECTS PROCESS AND RESOURCE USE

In previous sections I have shown that clinicians have many information needs during practice. Clinicians use information resources to answer these questions despite problems with access, use, and content. I have also shown that research into individual differences and use of computer systems has produced evidence that individuals use systems differently, have a wide range of performance abilities, and often have different outcomes. The variations in productivity can be in the range of 20-fold differences when comparing best and worst users. Good design and training can reduce or eliminate this large difference in productivity. Therefore care must be taken in developing computer resources to appropriately address user needs and characteristics. Because design and training can mitigate the differences in performance we need to know what user characteristics merit attention for medical informatics

applications. In this section I describe and justify the individual differences that I chose to study in this dissertation—physician attitudes toward uncertainty and risk.

Uncertainty in medicine arises from 3 different aspects of knowledge that physicians learn in medical school: uncertainty about one's one skills and knowledge in an era of expanding and changing knowledge and skills, uncertainty that surrounds the existing set of skills and knowledge, and uncertainty on how to distinguish between the first 2 (Fox (65) as reported by Gerrity and colleagues (66)). In clinical care, uncertainty surrounding the medical problem and patient situation and characteristics contributes to the total uncertainty in a given clinical encounter. Eddy (67) succinctly summarizes the role of uncertainty in medicine:

> "Uncertainty seeps into medical practice through every pore. Whether a physician is defining a disease, making a diagnosis, selecting a procedure, observing outcomes, assessing probabilities, assigning preference, or putting it all together, he is walking on very slippery terrain."

In addition to uncertainty, risk is inherent in all medical decisions. All clinical decisions, including the choice to do nothing carry both benefits and harms that a physician must assess and balance with consideration of issues related to the patient, setting, culture, and resource. Uncertainty and concern about risk have been considered to increase resource use for many years (68).

Researchers have looked at several overlapping psychological constructs that measure various aspects of risk and uncertainty. Several medical researchers had used the findings with regard to risk and uncertainty to look at resource use and decision-making.

Figure 2-1[15] is a pictorial representation from Gerrity and colleagues (66) showing how uncertainty in clinical settings accumulates and influences physician decision-making.

Closely linked with uncertainty is ambiguity—some researchers consider ambiguity and uncertainty to be interchangeable and other researchers such as Geller et al (69) keep the 2 aspects separate. Risk attitude has often been seen as somewhat different from uncertainty. In many studies people are classified as falling along a continuum from risk seeking (someone who enjoys adventures and is unconcerned with danger) to risk avoiding (being cautious, hesitant, and security-minded).

[15] Permission received to include this figure from the University of Chicago Press, June 8, 2005. Gerrity MS, Earp J, De Villis RF, Light DW. Uncertainty and professional work.: Perceptions of physicians in clinical practice. American Journal of Sociology. 1992;97(4): 1022-51. Figure 1. Page 1030.

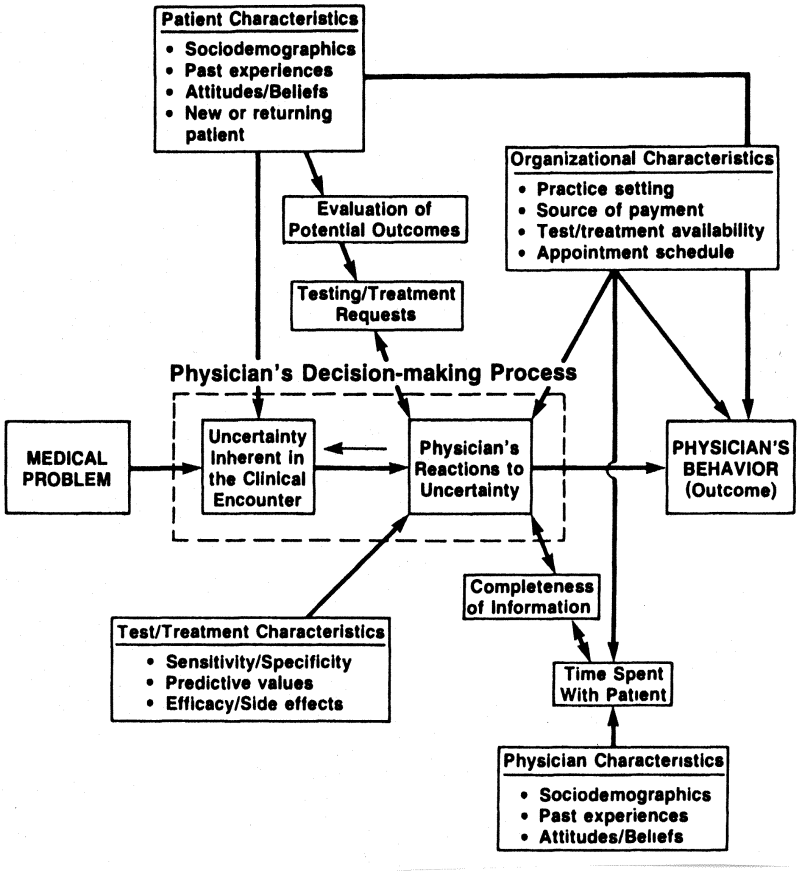


**Figure 2-1. Gerrity Conception of Physicians' Reaction to Uncertainty.** This model shows how uncertainty in a given clinical situation "accumulates" for a physician. The sources are varied and include his or her own characteristics, the organizational and setting, the medical problem and its treatment/diagnostic challenges, the patient, and the clinical encounter itself. Because uncertainty comes from so many different aspects of clinical care, how the physician views or deals with uncertainty has many implications for optimizing processes.

Attitudes toward uncertainty and risk are important for several reasons: Individual physicians vary to a considerable degree on how they compare with their peers for both. In addition, attitudes toward risk and uncertainty have been shown to be associated with many measures of practice patterns and resource use. Even more important for this dissertation, individual response to uncertainty and risk drive question-asking and information-seeking processes. Although data on physician use of information resources based on stress from uncertainty or risk attitude are sparse,

in the discipline of environmental sciences, attitude towards risk affects how professionals and lay people look for information and how they process the information they find (25). Further evidence on this association between risk or uncertainty with information seeking behaviors comes from Ford (54) in a review of cognitive models of information seeking. He states:

> "The need to resolve such states of uncertainty is considered here to be what drives information seeking behavior".

If we could understand how people with varying responses to risk and uncertainty use information in electronic formats, and if the uses are different across physicians based on risk attitude and uncertainty categories, we could potentially build computerized information resources that might be better able to support care decisions than existing electronic information resources.

What are attitudes toward uncertainty and risk and how are they measured? In applied psychology and outcomes research both are considered to be constructs rather than a personality trait (70). Constructs are usually thought of as being relatively stable over time and not amenable to easy modification—much like being left or right handed. Research about, and scales to measure, uncertainty and risk attitude were developed and evaluated in the early 1970s although both have been studied since the 1930s (66). The Jackson Personality Index (71) was one of the first to quantify risk-taking, a broader categorization that includes both risk attitude and comfort with uncertainty. In this index, risk taking was 1 of 16 subscales that included such areas of self-esteem, innovation, social participation, and tolerance. Since the development and modification of the Jackson Personality Index many groups have studied attitudes toward risk and uncertainty. Rohrmann (72), a psychologist, describes risk attitude and lists 15 measurement scales associated with it in a broad, multi-domain review. In the medical domain several methods of assessing attitudes toward risk and uncertainty have been used. These methods include utility functions, standard gambles which are often used in formal decision-making[16], and several statement-based scoring systems. Gerrity (66, 73, 74), Pearson (11), Geller (69, 75, 76) and their colleagues developed 3 of the major risk and uncertainty instruments in medicine. These 3 scales and standard gamble methods of determining attitude towards

[16]A method of assessing preferences for a given health state. The respondent is asked to compare life in a given health state with a gamble between two outcomes, usually a certain amount of life in perfect health and immediate painless death. The probability in the gamble is varied systematically until the respondent is indifferent between the certain health state and the gamble between perfect health and death.
www.hsph.harvard.edu/cearegistry/glossary.html

risk and comfort with uncertainty have been shown to be associated with healthcare resource use and some outcomes. In addition, these methods are also the most commonly used risk assessment techniques.

### 2.4.1 Standard gambles to assess attitude toward uncertainty and their association with process and outcomes

Nightingale (77-79) used standard gambles in situations of possible gain and threatened loss to determine risk avoidance/risk seeking. He found that his scale predicted a substantial amount of the variation in laboratory ordering by US primary care physicians. Physicians who were risk avoiding ordered more diagnostic tests. In the critical care setting, Nightingale (78) used his gambles to assess risk seeking/avoiding in a simulation of an intubation and resuscitation case. Physicians who were risk seeking stated they would prefer intubation and longer duration of resuscitation—one of the few studies that shows that physicians who are risk seeking would use more resources than their risk-avoiding colleagues. Zaat (80) used Nightingale's gambles as well as a scale developed by Grol (81) that measured risk and degree of self-reproach related to missed diagnoses. Both the gamble method and Grol's scale predicted a substantial amount of the variation found in laboratory test ordering among general practitioners in the Netherlands.

I have chosen not to use standard gambles because they are time consuming to implement and not easy for some participants to understand. As shown by Nightingale's studies, they are not consistently associated with increased resource use in those physicians who are risk avoiding. I also did not choose to use the Grol scale. It has not been carefully developed or validated. It has also only been used in a few studies in the early 1990s and its use has mainly been in physicians in the Netherlands.

### 2.4.2 Geller Tolerance for Ambiguity Scale

Geller and colleagues have developed a scale that measures tolerance for ambiguity. It is a 7-item scale with acceptable reliability (Crohnbach's alpha of 0.75) (69) designed to assess aspects of uncertainty rather than risk taking. The scale has been used in 2 general situations: testing and counseling related to medical genetics and career choices of medical students (67, 69, 75, 76). Some differences in scores on the Geller scales are associated with

resource use across disciplines and specialties. Physicians with a lower tolerance for ambiguity are more likely to refer patients for genetic counseling after positive test results while those with a higher tolerance are more like to counsel the patients themselves. Medical students who have a low tolerance for ambiguity do not want to deal with situations such as alcoholism that include a high degree of ambiguity. Geller and colleagues (76) end their paper on medical students, career choices, and tolerance of ambiguity by suggesting that admission to medical school based on tolerance of ambiguity might lead to graduation of more physicians who are better able to deal with the ambiguities of modern medicine.

Few studies have used Geller's tolerance for ambiguity scale and most of them were conducted in simulated settings or studied medical students and not practicing physicians. For these reasons I have not chosen to include the Geller tolerance for ambiguity scale in my dissertation study.

I have chosen to use the Gerrity PRU and Pearson Risk-Attitude scales as they have good reliability (although validity data are less strong), are easy and quick to administer, and are the most studied scales related to risk and uncertainty in healthcare settings. Both show strong, but different potentially associations with many aspects of practice patterns and resource use. In addition they are only moderately correlated indicating that they might be measuring different aspects of risk (correlation coefficient of 0.36 (P = 0.001)). I further discuss these scales in the next 2 sections.

### 2.4.3 Pearson's Risk Taking Scale—description, reliability, and association with practice patterns and resource use

Pearson and colleagues developed their Risk-Attitude Scale (11) based on work associated with the Jackson Personality Index. Although risk taking is only 1 of 16 personality aspects, Jackson and colleagues carefully studied risk taking and validated the risk-taking aspects of their index in the early 1970s (70). They found that risk taking has at least 4 facets (Monetary, Physical, Social, and Ethical risk taking) with strong evidence of a generalized risk-taking aspect. Pearson and colleagues adapted the Jackson questions and derived a short scale designed to divide physicians into 3 groups: risk avoiding (defined as the tendency to avoid options associated with uncertain outcomes), risk neutral, and risk seeking (tendency to be comfortable when options are associated with uncertain outcomes). A few studies use 2 categories only: risk avoiding and risk seeking. The original Jackson Personality

Index had 20 questions related to risk taking. Pearson and colleagues deleted questions related to fiscal, financial, and physical risk taking attitudes and used the remaining 6 statements.

The 6 statements in the Pearson Risk-Attitude Scale follow. Response to each item is made on a 6-point Likert scale. The scale has only the 2 ends anchored at strongly agree for a score of 6 and strongly disagree for a score of 1. The other scores including the neutral center are not marked or given titles or anchors. Scores for statements 2, 4, and 6 are reversed to make a higher score for each statement indicate more risk seeking rather than risk avoiding. Scores for each statement are summed and to give a final score. Scores range from 6 to 36 with mean and median values in the range of 16 to 20 with some variation based on gender, discipline, and country.

**Pearson Risk Attitude Scale**

- I enjoy taking risks.
- I try to avoid situations that have uncertain outcomes (reverse scored).
- Taking risks does not bother me if the gains involved are high.
- I consider security an important element in every aspect of my life (reverse scored).
- People have told me that I seem to enjoy taking risks.
- I rarely, if ever, take risks when there is an alternative (reverse scored).

Crohnbach's alpha for internal validity ranges from 0.72 to 0.84 (11, 14, 82). Level of training was not associated with differences in risk attitude and score are relatively consistent over time with some minor drift towards being slightly more risk avoiding with age. Fiscella and colleagues (82) showed that US internists are more risk avoiding (mean 20.0, S.D. 5.0, n = 112) than their family medicine colleagues (mean 17.0, S.D. 5.3, n = 61)[17].

Primary care physicians in a US Health Maintenance Organization (HMO) who were more risk seeking had lower rates of referrals (12). Emergency physicians who were risk seeking showed a lower likelihood of hospitalizing patients with chest pain (11) with no differences in patient outcomes. Two studies also showed lower patient care costs (14, 82) for risk-seeking physicians. As an example of cost, for every decrease in risk attitude (more comfort with risk) score of 1 SD, the total cost of care for each patient in an HMO fell by 3% (95% CI, 1% to 5%) (82). Neurologists who were risk seeking ordered fewer neuroimaging tests when working with simulated cases

on Parkinson Disease (83). However not all studies showed changes in resource use in association with risk attitude. For example, in a 2005-reported study, risk attitude was not associated with hospitalization of infants with bronchiolitis by pediatric emergency physicians in Arkansas (84). Risk seeking/avoiding is also associated with learning styles (85). I included the Pearson scale in this dissertation project. The second scale I used measures a different aspect of risk—uncertainty.

### 2.4.4 Physicians' Reaction to Uncertainty Scale—description, reliability, and association with practice patterns and resource use

The other scale that I used is the Gerrity PRU scale. It comes out of medical sociology and has been carefully developed over several years under the direction of physicians and researchers from other disciplines. Building on their model (66, 73) Gerrity and colleagues defined the construct physicians' reaction to uncertainty as

> "(a) the emotional reactions and concerns engendered in physicians who face clinical situation that are unfamiliar or not easily resolved and (b) the behaviors used by physicians to cope with those emotions and concerns".

The original scale development included 61 items that reduced to 2 constructs: Stress under Uncertainty (13 items) and Reluctance to Disclose Uncertainty to Others (9 items). Further work led to the modification of the scales (74). Currently the scale has 2 parts: Stress under Uncertainty (5 items on Anxiety Due to Uncertainty and 3 items on Concern about Bad Outcomes) and Reluctance to Disclose Uncertainty and Mistakes (5 items on Reluctance to Disclose Uncertainty to Patients and 2 items on Reluctance to Disclose Mistakes to Physicians). Crohnbach's alpha for internal validity of the 4 subscales are 0.86, 0.73, 0.79, and 0.72). I have chosen to use the SUS scale collapsing the Anxiety Due to Uncertainty and Concern about Bad Outcomes into a single scale for data collection. The scales and subscales were used in the analyses although most of the analyses used the combined score rather than the subscales.

The PRU scale was designed to study the relation between uncertainty and physician decisions. Like the Pearson Scale, the SUS is also a series of statements with 6-point Likert scoring. The scoring ends are anchored at

strongly agree for a score of 6 and strongly disagree for a score of 1. The score for one of the statements is reversed to make higher scores indicate more stress from uncertainty. All scores are summed to give a final score.

**SUS Scale**

**Anxiety Due to Uncertainty Subscale**

- I usually feel anxious when I am not sure of a diagnosis.
- I find the uncertainty involved with patient care disconcerting.
- Uncertainty in patient care makes me uneasy.
- I am comfortable with the uncertainty in patient care (reverse scored).
- The uncertainty of patient care often troubles me.

**Concern about Bad Outcomes Subscale**

- When I am uncertain of a diagnosis, I imagine all sorts of bad scenarios: patient dies, sues, etc.
- I fear being held accountable for the limits of my knowledge.
- I worry about malpractice when I do not know a patient's diagnosis.

The Gerrity SUS in its various forms has been studied more often than the Pearson Risk Attitude Scale. Gifford and colleagues studied simulated cases of diagnosis of Parkinson's disease. Those physicians who had high scores on the uncertainty scales ordered more neuroimaging studies (83). Hickman and colleagues found higher prescribing rates in a Veterans Affairs Hospital by physicians with higher scores on the Gerrity subscale of discomfort in disclosing uncertainty to others (86). Bachman and Freeborn found that primary care physicians in a US HMO who showed more stress from uncertainty had higher self-reported rates of referrals. They found that high stress from uncertainty was also associated with increased rates of physician burnout (87). Primary care residents who showed less stress from uncertainty made better decisions when working with simulated cases in Indianapolis (88) and Taiwan (89) than did their peers. Family medicine residents who were more comfortable with uncertainty reported they were more comfortable dealing with dying patients and their families, had a more positive attitude towards death and dying, and reported less Death Anxiety (90). Allison and colleagues (14) found that for primary care internists, each SD increase in scores on stress from uncertainty was associated with a 17% increase in mean costs per patient.

Other studies have shown inconsistent or conflicting associations for stress from uncertainty scores with resource use and care process. For example, ordering cardiac tests was not associated with SUS scores (91) at another Veterans Affairs Hospital. SUS scores were also not associated with radiologist interpretive performance (92) or admissions of children with bronchiolitis by pediatric emergency physicians (84).

In summary, the Pearson and Gerrity scales have been used to show differences in patient care processes, resource use, and healthcare costs for physicians who are risk seeking or risk avoiding and also for physicians who are comfortable and uncomfortable with uncertainty. Although several of the studies assessed outcomes related to these differences in care, no differences in outcomes were found. For example, Pearson showed that although patients with chest pain were hospitalized more often by physicians who were risk avoiding, the number of deaths in the groups (1 vs 0) could not be used to show differences in outcomes (11) because of the small numbers of events (deaths). The scales have good internal reliability and are easy to administer. In addition, they measure slightly different aspects of risk-taking.

I used both scales in my analysis of process and outcomes of searching and question answering and how they differ depending on individual differences in risk attitude and comfort with uncertainty. I chose both scales because they seem to be measuring slightly different aspects of risk taking. In addition, they have often shown different patterns of association with resource utilization and other outcomes in studies that used both scales. My research sought to show how the scales are associated with process and outcomes and which scale is more strongly associated with differences in process and outcomes of searching and using information. As well as using the data from both scales in descriptive and inferential statistical analyses, I used these scales to provide the “backbone” of validating and building models to portray information seeking and use differences and similarities for physicians with ranges of response to risk taking and uncertainty. I describe the information models in the next section.

## 2.5 MODELS OF SEARCH BEHAVIOR AND NEED FOR MODELS IN MEDICAL DOMAIN

In section 2.2 I argued that clinicians regularly have questions in practice. One of the reasons that many questions arise in clinical care is clinician uncertainty surrounding decisions related to patients and the risks associated with

options—physicians routinely work in settings and situations rife with risk and uncertain outcomes. Risk and uncertainty drive questions and answer seeking, which is consistent with the modified Wilson Problem Solving model. The Card/Pirolli Information Foraging model of information seeking and sense making considers both but to a lesser degree. If information systems or resources could be developed that provide strong and effective support for **individual** clinical decisions made by a **specific** health professional (e.g., guidelines that delineate best practices, the evidence to support the decisions), we could potentially improve decision-making. Systems may be enhanced by attention to individual differences in users and modification to suit both needs and desires. This dissertation will help determine if redesign or tailoring of content or presentation is needed to match user needs based on risk attitude or stress from uncertainty. To provide data that will be most useful in a broad range of situations, I have chosen to ground the results of my work in 2 information seeking/use models from outside the domain of medical informatics, thus adding to the theoretical base of medical informatics.

Models are important to a domain because they synthesize knowledge by integrating formerly disparate sets of knowledge, generalize lower levels of knowledge to larger views of a domain, explain sets of data or findings, and increase knowledge by potentially expanding beyond the model. Models also guide research by providing testable hypotheses, directing new routes for data collection, and suggesting novel approaches to problems as well as new mappings for sets of items and processes within a domain. The modified Wilson Problem Solving and the Card/Pirolli Information Foraging models are described below as well as the reasons why I have chosen them.

### 2.5.1 Wilson Problem Solving Model concentrates on reducing uncertainty

The Wilson Problem Solving Model comes from the domain of information science and was developed by Wilson and colleagues in the late 1980s (54, 93) with updates in 1999 (94) and 2003 (95). A strength of this model for my dissertation work is that it is based on the assumption that the person searching for information is in some state of uncertainty. Acquiring and processing new information may resolve this uncertainty. The need to resolve these states of uncertainty drives the information-seeking behavior through various stages: problem identification, problem definition, problem resolution (the main information seeking stage where an answer is sought or one finds enough information to cope with the problem), and solution statement in which an answer or approach is formulated. When the attempt to reduce uncertainty at a given stage is not successful, one can stay in that stage or revisit

previous stages until the searcher/seeker is satisfied that he or she has enough information to solve the initial problem and cycles out of the model. Wilson and colleagues postulated that a gradual reduction in uncertainty occurs across all stages. Figure 2-2 is a pictorial representation of the modified Wilson Problem Solving Model (54, 93, 95).

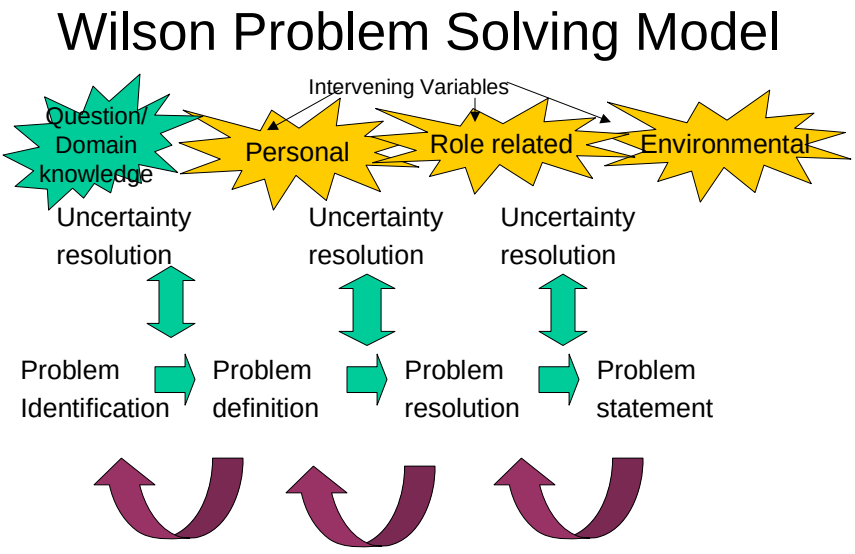


**Figure 2-2. Wilson Problem Solving Model.** This model shows how uncertainty drives the task of seeking information to resolve a problem. The process is cyclic with movement between the stages of problem identification, definition, resolution, and final statement guided by increasing or decreasing levels of uncertainty. The overarching aspects of domain knowledge and intervening variables of personal, role-related, and environmental factors affect the problem-solving process. Pearson and Gerrity aspects of risk attitude and levels of comfort with uncertainty affect the process through the "personal" intervening variable. This model was drawn taking into account data from Ford and Niedzwiedzka (54, 95).

In the modified Wilson model uncertainty is related to the problem and domain knowledge along with intervening variables or activating mechanisms related to the user and his or her psychological state and demographics (individual characteristics), role (social characteristics), environmental conditions, and information resource characteristics. Risk/reward theory and social learning theory also affect the stages and cycling as the search is completed and an answer obtained. The sources of uncertainty in the Wilson model almost exactly parallel the sources of uncertainty from Gerrity and colleagues (66) who model uncertainties (See Section 2.4) as coming from patient characteristics and the medical problem (problem), the clinician (individual and social (role) characteristics),

evidence such as diagnosis and treatment (domain knowledge), and the setting (environmental conditions). The risk/reward aspects of the Wilson model also parallels with aspects of the Pearson Risk Attitude scale (risk seeking/risk avoiding).

Little research has been done with Wilson's model in the domain of health care although many examples have been published in the library and information sciences domains. One example in health care is a PhD dissertation whose author studied hospital administrators in Poland. Niedzwiedzka (95) took Wilson's theory and produced a more general model of information behavior that matched her observations of the administrators in their workplaces. The main changes she has suggested for the model are to take the personal (individual characteristics), role-related, and environmental factors out of the 2 middle stages (problem identification and problem resolution) and acknowledge that they affect the whole 4-step cyclic process. I have reflected this change in Figure 2-2 and use the modifications in modeling the findings of my dissertation.

For my dissertation I will concentrate on the final 3 stages of the modified Wilson model because questions were given to the study participants. The model provides a functional framework to embed the risk-taking aspects of the dissertation as well as being able to validate codes created during the analysis of the think-aloud data collected during the time the participants searched to solve clinical problems. The Card/Pirolli Information Foraging model also provides useful opportunities for modeling risk and uncertainty and evaluating codes but from a different perspective and domain.

### 2.5.2 Card/Pirolli Information Foraging/Information Scent Model

Card and Pirolli (96-98) have developed a theoretical model of information seeking and sense-making based on food foraging strategies from anthropology and behavioral ecology (99, 100). Their work is in the domain of human computer interaction/information processing and builds on the work done in cognitive sciences by Simon and Newell and colleagues as well as animal and social models of foraging. According to Card and Pirolli, providing people with improved abilities to access and understand information has been a social aim of society since the Enlightenment. Technology, from the printing press on, has increased explosively the amount of available information and has been both a blessing and curse—the information one wants is now more likely to be available while at the same time being much more difficult to find, both because of the huge increase in available information.

Information Foraging Theory states that people need external information to help them with daily tasks. To get this information they go through an integrative process of information seeking and sense making. This process is often a task embedded within the original and larger task (e.g., How do I pick a graduate school vs what are the costs and employment opportunities for a graduate with an MSc in medical informatics from the University of Pittsburgh). The value of the information can be measured in improved outcomes for the task at hand and is different for each user and each task and over time.

The information seeking and integration process just described is similar to an animal's need for food, energy, or shelter to sustain its main task of survival. Individual foraging tasks change over time but the general processes are always the same—we need food and information continuously, and to be successful both animals and humans adapt their individual foraging methods to changing needs and circumstances.

Just as food is often found in patches (e.g., berry bushes on a specific hill or prairie dog communities), information may be seen as clumped in patches or other locations. These patches can be such things as **MEDLINE**, an online or print encyclopedia, a telephone book, an Internet site, or a document. The patch's usefulness is measured by how well it provides data or information that produce outcomes in comparison with the costs of getting the information (time, resources, and opportunity). These costs of retrieval are weighed against the rate at which useful information is being obtained in that patch. The user with the information need stays in the patch until the production costs are higher than the potential to get more information or when the information is enough to complete the task. Satisficing and bounded rationality principles come into play as people know when enough information is enough for their present situation rather then feeling the need to find and process everything ever produced. This process is consistent with the animal model of foraging where the animal stays in the patch until hunger is gone (need met) or when continued foraging consumes more energy than is being gained in that patch. I have portrayed these concepts in a diagrammatic manner in Figure 2-3.

An animal leaves his or her current patch to move to another patch if it is still hungry and has picked up a scent or intuition that another patch might be more productive. With no scent, the search for another patch is reduced to random walking (animal) or surfing blind (human information seeker using the Internet). An information user moves to a new patch when the scent of another site seems to indicate that the new site might be more productive than the current site or patch. Information scent is a proximal clue or hint of the content of the next (distal) site and can be

such things as a listing in an index, title, link, icon, thumbnail, comment, or abstract all pointing or leading (or enticing) to the next electronic foraging site.

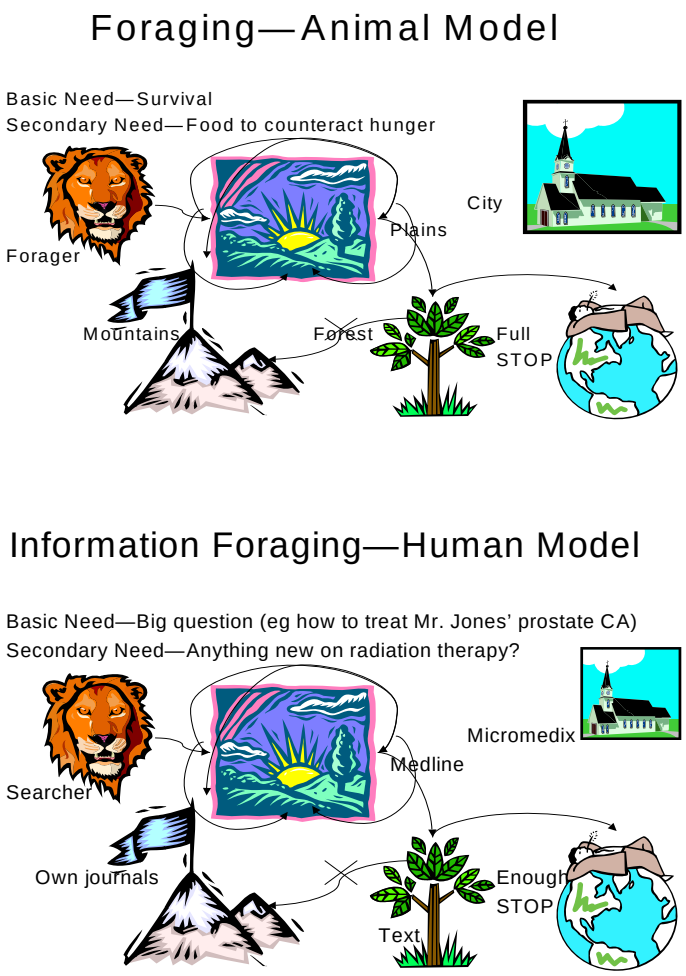


**Figure 2-3. Comparison of Animal Foraging and Human Information Foraging.** These 2 pictures represent the similarities between the animal model of foraging for food and survival with the human need for information to "be successful. A searcher goes from "information patch" to information patch as he or she needs more or different information. The "scent" of good information (e.g., a citation in **MEDLINE**) leads the searcher and once enough information is obtained, the foraging process stops. Just as animals have characteristics that guide food gathering, physicians also have characteristics that guide their information foraging. This dissertation will determine if risk status is one of these driving characteristics. Drawing of this figure is based on (96, 97).

Three sets of assumptions are built into applications of Information Foraging/Information Scent models: decision, currency, and constraint assumptions. Decision assumptions deal with which of the aspects of a task to pursue, how to pursue, which resources to pursue, how much time to spend on each resource, and when to stop. Currency assumptions deal with the value that the information holds for the user's task completion. These currency assumptions are often based on principles of maximization, minimization, and stability. Constraint assumptions deal with the relations between the decision assumptions and currency assumptions and are related to aspects such as task structure, interface issues, and individual characteristics including knowledge and abilities.

Card and Pirolli have applied their theory to interface design and browsing systems such as their Scatter/Gather system. They showed that their foraging model can predict an individual's processes of using electronic information resources (97). Others have used the Information Foraging model to describe Internet behavior and even in some cases computationally predict individual and group use of sites. An example of group searching using the theory that takes advantage of similar foragers using the same patches and paths is **Amazon.com©**[18]. One sees this application when the computer indicates people like you are reading… or people who bought that book also bought…..

Very little has been done, however, in looking at this model in the medical domain. I have used the Information Foraging model to analyze think-aloud data obtained from the physician searchers and to verify that the model fits clinical searching processes and electronic information resources. This pairing of think-aloud protocols and the Information Foraging Model has produced research into information scent and web behavior by Card and Pirolli and their colleagues (101). This combination of methods worked very well and is consistent with my research agenda. The data from clinicians with differing risk attitudes and levels of stress from uncertainty fit the Information Foraging model and its sets of assumptions. The range in risk attitude was accounted for in the constraint assumptions (individual characteristics) as well as the currency assumptions (value of the information in relation to the task at hand). Similar to the modified Wilson Problem Solving Model, I predicted that clinicians with high levels of stress from uncertainty and risk aversion would stay in a patch longer, go to more patches, or return to previous patches more often while searching to find information to answer the questions in the study.

In summary, research based models can consolidate knowledge in a domain as well as explain and integrate seeming disparate areas of knowledge. They can also be used to guide tool development as well as validate previous findings, direct research into new directions, and contribute to the theoretical base of a domain. I have chosen 2

[18] Amazon.com. Copyright 1996-2005. (http://www.amazon.com/exec/obidos/subst/home/home.html/104-9289040-3145555). Accessed July 11, 2005.

information seeking and use models—the modified Wilson Problem Solving Model from library and information sciences and the Information Foraging/Information Scent developed by Card and Pirolli in cognitive sciences/human computer interaction domains. Both provided a framework to analyze and understand the think-aloud data from the study participants as well as the structure to determine whether differences in process exist for clinicians with differing responses to risk taking (risk attitude and stress from uncertainty). The data and the models can provide guidance to help design effective computerized information resources or plan for their implementation into electronic medical record or clinical information systems and add to the theoretical base of medical informatics.

## 2.6 NEW RESOURCES PROLIFERATE IN AN ELECTRONIC ERA

One final body of literature needs to be incorporated into this proposal—the electronic information resources themselves. I mention the resources in Section 2.2 on clinician information needs and how they are used when questions are pursued and also in Section 2.5 on information seeking models. The electronic information resources form the patches in the Information Foraging model and are one of the main components used in the problem-resolution stage of the modified Wilson Problem Solving model. Implicitly, information resources and how they are searched and used are the main thrust of Section 2.3 on user characteristics and information resources. Using the risk attitudes and uncertainty stress information in Section 2.4, I feel that design changes and a personalized approach to electronic information resources may be necessary to support clinicians who are risk avoiding or uncomfortable with uncertainty. In this and the following sections I briefly describe 2 areas of research and development that center on electronic information resources and my dissertation work.

First, I want to briefly describe the plethora of electronic information resources now available for clinician use. Although the Internet has provided an astonishing number of information sources, I have concentrated on resources designed for or used by clinicians: textbook-like sources, clinical practice guidelines, systematic review articles, journal article summaries in secondary journals developed based on principles from the EBM movement, and **MEDLINE**. All resources are not equal in their ability to quickly and efficiently supply answers to a clinical

need. Haynes has provided a useful classification of existing resources that he calls the 4S Pyramid (16) and is shown in  His pyramid represents both the volume of available resources in the 4 categories of studies, syntheses, synopses, and systems and their relative clinical usefulness. The most valuable level of resources is the systems. They represent the dream of integration of truly useful information resources with specific patient needs, characteristics, and preferences. Resources in the systems level would effectively prompt a clinician when appropriate actions are needed or supply the answer, not just something vaguely about the issue when asked by the clinician. Few of these systems exist and the ones that do need additional work to make them clinically useful. I discuss these in Section 2.7. Synopses of original studies and systematic reviews are the next level. Several examples of these exit (e.g., *ACP Journal Club*) and will be discussed in following sections. The synopses summarize studies and reviews and provide a clinical bottom line. Syntheses are considered, careful compilations of original studies (systematic reviews and meta-analyses) to provide a synthesis of existing knowledge on a specific clinical topic. More of these exist than synopses and systems and examples are reviews from the **Cochrane and Campbell Collaborations**. They are discussed in later sections as well as the studies, the final S in the pyramid. The studies category is large as it includes all studies and trials with clinical applicability.

Supplementing the 4S Pyramid classification, new information resources are also available in push, pull, and prompt formats. Push resources supply clinicians with notice of important advances in health care. Often the choice of what sort of information is received is tailored for the individual or class of individuals (e.g., **bmjupdates**+ discussed below). Pull resources are the more traditional format where a clinician goes to a resource with a specific question and actively seeks the answer. Prompt systems are those discussed above in the systems level of the 4S Pyramid—the clinician is prompted with evidence in regard to an action that needs to be done or reconsidered.  The following sections describe some of the new information resources and classify each using the 4S Pyramid and the 3P's—push, pull, and prompt designations.

In addition to the categories and formats of information resources, Ely and Osheroff and colleagues (35) continue their long-standing research into questions and  information seeking in clinical settings. They summarized qualitative (subjectivist) data from clinicians who describe the characteristics of ideal information resources they feel would best support their clinical care (32). I used data from this article to show how several popular information resources meet these suggested criteria.

The second area I want to address is the integration of computerized information resources into electronic medical record systems or other large clinical information systems (Systems level on the 4S Pyramid and prompt format). This integration task is a complex, vital, timely mission for medical informatics. Researchers and developers have been working on this integration for many years and some progress has been made (21). We need to know however, which electronic resource or resources to integrate and if we need to tailor the resources based on clinician characteristics. I continue this chapter by describing examples of information resources that typify these new types and formats of resources and if their features are in the list of desired features provided by Ely and Osheroff (32).

### 2.6.1 Textbooks evolve to better support clinical care

Books have been integral to clinical care for several centuries and are considered to be the first, and probably the most used decision support tools (6). With the electronic age, publishers have started to make books available online and in CD-ROM format. This allows quick searching; linkage of content to similar ideas, additional resources, or the evidence for that topic; improved access at multiple locations; and enhanced possibilities for rapid updating and integration into other computerized systems such as electronic medical record systems.

The first medical books published as an electronic resource had little change of format or presentation from the paper versions—long, broad-coverage chapters laid out in a sequential manner. Searching used a table of contents and index, which took a user only to the "right" page or chapter but not to the appropriate paragraph or sentence level. Clinical answers were available although the clinical uses still had to ascertain if the answer applied to a given patient and his or her condition and situation. Early electronic resources did not include linkages to evidential documents or related content areas. These electronic books, such as early versions of **Harrison's Online©**[19] were not used heavily. The books that provided good searching including synonyms and combining of terms with smaller chunks of presentation, often in a question-and-answer format and laid out in a more logical order for clinical use, were used more heavily.

The changes in design of the electronic resources to meet individual physicians' desires for smaller chunks of information that were clinically usable, became a defacto standard of presenting clinical content to health

[19] Harrison's Online. Copyright 2004-2005 McGraw Hill companies. (http://www.accessmedicine.com/resourceTOC.aspx?resourceID=4). Accessed July 11, 2005.

professionals. (This format and structure was also a tremendous benefit for those who sought to integrate computerized texts into electronic medical record systems or other electronic services.) Textbooks that provide these features of small and quickly and efficiently retrievable pockets of knowledge such as **Clinical Evidence** and **UpToDate**, have prospered. This prospering provides anecdotal evidence that format and presentation of content are important design features for electronic information resources in clinical care. Books are in the syntheses or synopses levels and are most often provided in the pull format although they can function as a push resource by providing sending notice of updated chapters or sections to interested clinicians. Electronic tests also hold promise for effective movement to a prompting system.

### 2.6.2 MEDLINE is not a heavily used electronic information resource in clinical practice

Clinicians and researchers have been interested in using **MEDLINE** for clinical support since the late 1980s and early 1990s (102). According to the 4S/3P classifications, **MEDLINE** provides studies and reviews (synthesis) and can be in the pull or push (traditional SDI programs), but not prompt format. The spread of computers and the Internet; the evolution of EBM; readily available, no-cost access to **MEDLINE**; and improved and simplified access (e.g., **Grateful Med®**[20] and **PubMED**) have driven this interest. Studies of making **MEDLINE** available on the wards and in the clinics (103, 104) in the early 1990s showed very little use (< once per week per physician). Similar findings of low, but increasing, use of **MEDLINE** in clinical situations are still being found 10 years later for access to electronic information resources, including **MEDLINE** (105). Even research done to make clinical searching easier and more efficient, for example with the PubMED® clinical queries http://www.ncbi.nlm.nih.gov/entrez/query/static/clinical.html) has failed to encourage substantial **MEDLINE** use for clinical decision support (106, 107). Ely and colleagues (8, 31, 34) confirm this nonuse as they report that clinicians use **MEDLINE** to answer clinical questions only 2% of the time when a question arises in patient care.

Therefore, although **MEDLINE** is readily available and can be used for clinical decision-making, it is not a system that is preferred by clinicians. Use statistics and observational studies indicate that other information resources likely provide better, or at least preferred, support than **MEDLINE** (6, 105). Part of this non-use is the

[20] Grateful Med was a stand-alone and Internet based MEDLINE® searching program from the US National Library of Medicine. It was replaced by PubMED in the late 1990s and was heavily used by those interested in doing their own MEDLINE® searching.

issue of content of the **MEDLINE** database. The foundation of this database was the provision of access to journal articles to multiple audiences such as researchers and administrators as well as clinicians—the content is not designed primarily for clinical use. In addition, the information in the articles must be evaluated and synthesized before it can be applied to a given clinical situation. Searching for the right information is difficult partly because **MEDLINE** now holds almost 15 million citations spanning almost 40 years (or more if one counts **OLDMEDLINE®**[21] citations).

### 2.6.3 EBM contributes to the development of systematic reviews and journal summary compilations to support clinical care

The EBM movement started 1980s with attention given to critical appraisal of journal articles—reading an article to ascertain its important to clinical decision making. With more emphasis on finding articles and implementation EBM gained momentum in the 1990s with the publication of the *JAMA* series produced by the Evidence Based Medicine Working Group (108)[22]. EBM grew quickly with maturation in the mid to late 1990s. Dawes and colleagues (15) provide a succinct summary of what EBM is and the skills one needs to practice using its principles. The practice of EBM recognizes that clinicians base their care on the best available evidence and be willing and ready to change the care process as new evidence becomes known. Clinicians need to consciously and deliberately integrate research findings from original studies and systematic reviews into their care process on an ongoing basis. This practice of using evidence to direct care affects information needs, numbers of questions asked and pursued, resources used, and ultimately, resource design.

With the advent of EBM, journal articles are now more desirable as sources of potential evidence for action for practicing clinicians. The articles (bottom level of the 4S Pyramid) are not perfect information resources, however, because data from articles may be difficult to apply quickly to individual patients and clinical situations without training and practice in using health care research at the bedside. Several innovations have been developed to make original articles easier to identify and use in clinical decision-making.

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[21] OLDMEDLINE includes the citations in Index Medicus from 1951 to 1965 inclusive that have been added to MEDLINE®. The project was completed in September 2004.
(http://www.nlm.nih.gov/databases/databases_oldmedline.html). Accessed July 11, 2005.
[22] Citations to the whole series are available at http://www.ebmny.org/ebmbib.html. Accessed July 11, 2005.

First, systematic review articles (synthesis level) have become a popular method to summarize and present data across studies. This development of systematic reviews has led to the publication of many high-quality and clinically relevant reviews. It also contributed to the development of the **Cochrane Collaboration** and **Campbell Collaboration** and York University's Database of Reviews of Effects (**DARE**[23]) (synopses level). The **Cochrane Collaboration** oversees production of many systematic reviews. They, along with the **Campbell Collaboration**, collect original studies of interventions to produce and distribute systematic reviews. Systematic review production also fueled, and was fueled by, clinical guideline development. Production methods of high-quality guidelines dictate that evidence from the literature be collected and synthesized form the foundation of any recommendations. Guideline developers often publish their evidence as a separate systematic review article (often done by the **American College of Physicians**[24]) or embedded in a guideline (often done by groups such as the **American Academy of Neurology**[25]). Although the reviews in their full format are readily available to clinicians, they are not used heavily in practice. The systematic review process is however being used as the background of several textbook-like resources that provide clinical content in the smaller chunks described above. For example, **Clinical Evidence** uses already-prepared systematic reviews or completes their own to provide the evidence on benefits and harms of therapeutic interventions that form the basis of their information resource.

Second, clinicians and publishers have established secondary journals that provide summaries of high-quality and clinically important articles for clinician use (e.g., *ACP Journal Club*. These secondary journals (synopses level) were started in the early 1990s and approximately 15 to 20 now exist. High-quality and clinically important studies and reviews are screened, clinically relevant abstracts are prepared, and often each abstract often includes a commentary on the study or review and its implications. Each issue of the summary journal provides a current awareness service for readers—listings of the new and important advances in health care in a given discipline or content area (push format). A substantial number of the abstracts and commentaries now exist so that collections of the abstracts are able to provide clinical support—and also to be integrated into electronic medical record systems (pull format). An example of a collection of abstracts and commentaries is InfoPOEMs™[26].

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[23] DARE. Produced by the Centre for Reviews and Dissemination, York University, York, UK. (http://www.york.ac.uk/inst/crd/darehp.htm). Accessed July 11, 2005.
[24] American College of Physicians. (http://www.acponline.org/). Accessed July 11, 2005.
[25] American Academy of Neurology. (http://www.aan.com/professionals/). Accessed July 11, 2005.
[26] **InfoPOEMS: The Clinical Awareness System™**. (http://www.infopoems.com/). Accessed July 11, 2005.

In summary, the EBM movement has helped establish a culture in health care that promotes the use of the best available evidence by clinicians. This cultural shift has encouraged physicians to learn how to understand and apply evidence from healthcare research in their own clinical work. It has also contributed to the development of new electronic information resources and encouraged the established electronic information resources to rely on and present the evidential basis to support their content. All of this adds to the pressure for system developers of finding the most effective computerized information resources and studying how best to implement them into large clinical information systems. One additional set of information resources still remains to be discussed before I move to specific features and products—clinical practice guidelines.

### 2.6.4 Managed care and evidence-based medicine helped clinical practice guidelines mature and assume a role in clinical care support

The guidelines movement started in the late 1980s and grew steadily over the next 20 years—a very similar time frame to the development of EBM. Clinical practice guidelines have been defined as "systematically developed statements to assist practitioner and patient decisions about appropriate healthcare for specific clinical circumstances" (109). Professional associations such as the **American College of Physicians**, government organizations (e.g., the **Canadian Task Force for the Preventive Health Care**[27] and the **US Preventive Services Task Force**[28]) as well as local institutions and organizations produce and support guideline development and use. Guidelines are important in clinical care for many reasons: They address specific clinical situations and offer direct recommendations related to that situation, include citations or links to evidence that supports the recommendations, and are often vetted and endorsed by clinical experts and professional organizations.

Guidelines can be considered to be synopses on the 4S scale and they can be harnessed in all formats: push, pull, and prompt. Guidelines and their production methods have matured to the point that compilations or collections are now available that address most, if not all of the more common healthcare situations with which physicians deal. Because of their nature of addressing a carefully defined clinical situation they are often used in decision making

[27] **The Canadian Task Force for Preventive Healthcare** is the new name for the Canadian Task Force on the Periodic Health Examination©. (http://www.ctfphc.org/). Accessed July 11, 2005.

[28] **US Preventive Services Task Force** was convened by the US Public Health Service (USPSTF) to rigorously evaluate clinical research to assess the merits of preventive measures, including screening tests, counseling, immunization, and preventive medications. (http://www.ahrq.gov/clinic/cps3dix.htm) Accessed July 11, 2005.

and have been integrated, with some initial but limited success, into electronic medical record systems (110, 111). Not every integration, however, has been positive for clinicians or clinical care (112).

As guidelines have matured, computerized compilations of individual guidelines are starting to become similar to current electronic textbooks in that they are composed of short entries or modules that address a single disease or disorder and specific diagnosis and treatments (e.g., drug and nondrug therapies for left ventricular heart failure), provide the evidence for action and decisions, and are readily available in electronic and paper formats with potential to be integrated into electronic medical record systems. Some information resources such as **PIER** (Physician Information and Education Resource) from the **American College of Physicians** cannot be easily classified as a text or a collection of guidelines. The choice of a single, or several best electronic information resources, for individual use or system integration is becoming more difficult.

## 2.7 INFORMATION RESOURCES ARE BEING INTEGRATED INTO ELECTRONIC MEDICAL RECORD SYSTEMS

The idea of intelligently matching clinical data and healthcare information/evidence to aid clinical decision-making using electronic methods at the point of care has been studied since the late 1980s (e.g., Medical Desktop (113), Meta-1 Front End (114), Hepatopix (115), Psychotopix (116), Chartline (117), IQW (118), EON (119), **MEDLINE** Buttons (102), and **Infobuttons**[29] (120)). Much progress has been made (120) from a technical perspective and promising results have been shown in small domains and local settings. Cimino was one of the prime innovators for embedding traditional information resources into electronic medical record systems. He started with what he called **MEDLINE** buttons and worked hard to put question architecture under buttons into logical question-answering opportunity points in specific patient records.

An example of a **MEDLINE** button would be an embedded search that leads to a randomized controlled trial of a specific diabetic medication for a patient with diabetes who would be a candidate for that medication (121). The clinician could see the button while working within the medical records system if a rule triggered the button to be

[29] Infobuttons and Infobuttons Manager are copyright of Columbia University. (http://www.ahrq.gov/clinic/cps3dix.htm). Accessed July 11, 2005.

turned on or activated. The clinician then chooses to search or not. After much work on this question architecture to link patient information needs to information in **MEDLINE**, Cimino moved on to what he called **InfoButtons**© (59, 60). These InfoButtons link from a specific location in a chart (e.g., an abnormal laboratory value or the order screen for the class of antibiotics in a physician order entry system) to a specific information resource (e.g., a text on laboratory tests or a specific drug in Micromedix) via an external, online database system called the Infobutton Manager. This system also does some limited personalization for users as links for physicians and nurses often go to different information resources and links from a hospital go to their licensed and available resources (59, 60).

This database format in **Infobutton Manager**© is quite like the EON system for guidelines listed above (109). The knowledge or information is stored outside the main electronic medical record system so that it can be quickly updated, modified for an individual site (e.g., based on hospital formulary specifications) or a user class (e.g., nurses and physicians), and provided to many users at multiple sites. The Cimino Infobuttons approach is not perfect but has gone a long way to provide patient-specific and situation-specific information resources as part of an electronic medical record system. His system can also be taken one step further to provide computerized information resource material that takes into account physician preferences and individual characteristics.

Little work has been done to determine the best electronic information resources to integrate, what features to emphasize, how to present information based on physician differences or preferences for content, searching, and presentation. Clinicians may prefer textbook-like resources although clinical practice guidelines often have more electronic structure and therefore may be easier to integrate. Researchers who advocate the use of evidence for care may feel that journal article summaries are truer to the original research than textbook summaries or guidelines. However, individual studies and possibly review articles, and hence **MEDLINE**, do not provide direct answers—the answers to specific questions must be determined using data from a study or systematic review. **MEDLINE**'s relative low use attests to its perceived limited effectiveness.

The best resources to integrate are likely to be a textbook or a compilation of guidelines, analogous to the higher levels of the 4S Pyramid (syntheses and systems). The choice is absolutely vital because of the large number of clinical information needs and the fact that developers spend huge amounts of time and money integrating information resources into electronic medical record systems. Only a select few information resources will be integrated. We must carefully find the best resources to integrate so that the most accurate and appropriate support is

given to those who make clinical decisions. Ely and Osheroff and colleagues provide some direction on how best to sort out ideal resources or set of features for electronic and other information resources to support clinical care (35).

## 2.8 CLINICIANS LIST DESIRED CHARACTERISTICS OF GOOD INFORMATION SUPPORT RESOURCES

What do physicians want in an ideal information resource? We know clinicians use information resources and often express frustration with them (8, 122). We have little knowledge beyond anecdotal or observational evidence that these resources are optimized to match clinicians' needs or if they improve care. Ely and Osheroff (32) provide valuable data on physicians preferences in a qualitative study of the obstacles 48 clinicians perceived in using information resources to answer clinical questions. After interviewing physicians about obstacles, Ely and Osheroff asked the physicians to describe the features they felt were important to them in using electronic information resources. These features center on issues of

- Comprehensiveness
    - Comprehensive topic coverage by anticipating and answering clinical questions
    - Direct answers to clinical questions
    - Treatment details provided fully-including prescribing information
    - Summary and bottom line recommendations
    - Specific information so that one does not need to go elsewhere if unfamiliar area
    - Tell the physician exactly what to do
- Trust
    - Evidence—provide rationale for evidence including citations—summaries of research not just listings of studies
    - Authority of source
- Clinical Organization

- Concise, succinct, and to the point and good clear writing
- Clinical findings presented from clinician perspective
- Algorithms presented that take into account many features of care
- Rapid information access—tables, lists, headings

## 2.9 EXAMPLES OF IMPORTANT INFORMATION RESOURCES IN PRIMARY CARE: UPTODATE, CLINICAL EVIDENCE, AND PIER

As discussed in Section 2.6, a wide variety of different electronic resources exist to support clinical care. Ideally I would have liked to produce prototypes of computerized information resources and vary crucial features for evaluation among clinicians with varying levels of risk attitude and stress from uncertainty. I could not produce these electronic prototypes within the scope of this dissertation and therefore I designed the dissertation to evaluate 2 electronic information resources that represent a wide range of the ideal features listed in the previous section. Three important information resources in primary care are **UpToDate**, **Clinical Evidence**, and **PIER**. According to the 4S Pyramid they are syntheses as the authors endeavor to consolidate clinical information in topic or question format. All 3 resources have a strong reliance on evidence (**UpToDate** to a lesser degree) and provide information in small chunks on clinical issues that reflect the nature of clinical practice. They are almost exclusively electronic products, have been recently developed, and are to a varying degree being used by primary care clinicians.

### 2.9.1 UpToDate is a popular information resource favored by primary care physicians

**UpToDate** is a popular information resource that presents its content in small specific disease and condition topic reviews. Because the topic reviews are simple and easy to read with a predictable format as well as the company's aggressive marketing practices in residency programs it is heavily used by primary care physicians. It is designed to "get physicians the concise, practical answers they need when they need them the most—at the point of care" and presents disease manifestations and options for diagnosis, management, therapy, screening, and prevention.

**UpToDate** is available only in electronic format, being too large to have a print equivalent. Major criticisms of **UpToDate** are poor searching features, high costs to libraries, and lack of explicit handling of evidence—much of the evidence is opinion based despite multiple links to external documents and **MEDLINE** abstracts.

### 2.9.2 Clinical Evidence provides evidence for clinical actions and decisions

**Clinical Evidence** is produced by the **BMJ Publishing Group**[30], the commercial publishing arm of the **British Medical Association**[31]. Promotional literature describes its features:

> "**Clinical Evidence** summarizes the current state of knowledge and uncertainty about the prevention and treatment of clinical conditions, based on thorough searches and appraisal of the literature. It is neither a textbook of medicine nor a set of guidelines. It describes the best available evidence from systematic reviews and RCTs, and if there is not good evidence it says so."

Unlike many other information resources, **Clinical Evidence** is **not** designed to provide decisions or decision choices but to provide evidence for users (clinicians and patients) to integrate into the decision-making process. For example, of the 2329 treatments in the 12th issue, 15% are rated as beneficial, 21% are likely to be beneficial, 7% as a tradeoff between benefit and harm, 5% unlikely to be beneficial, 4% likely to be ineffective or harmful, and 48% have unknown effectiveness (123). Although **Clinical Evidence** is produced in the United Kingdom, more than half a million copies are distributed in the United States (United Health Foundation). It is available online without cost to all physicians in many countries including all developing ones. Neither Canada nor the United States has negotiated access for all physicians. Because **Clinical Evidence** does not direct care but just lists benefits and harms around a specific clinical situation, it scores low on the Ely/Osheroff scale of ideal characteristics.

### 2.9.3 Physicians Information And Education Resource (PIER) directs care decisions

**PIER** comes from the **American College of Physicians** and is a relatively new information resource. It grew out of the College's desire to provide general internists with an outline of the knowledge essential for their practices and

[30] BMJ Publishing Group. Copyright 2005. (http://www.bmjpg.com/). Accessed July 12, 2005.
[31] British Medical Association. Tavistock Square, London UK. (http://www.bma.org.uk/ap.nsf/Content/Home). Accessed July 12, 2005.

accreditation. Its structure is based on the College's own internal list of diseases, conditions, and competencies. Modules are divided into 5 topic areas: diseases and conditions, screening and prevention, complementary and alternative medicine, ethical and legal issues, and procedures. Diseases are further broken down into categories of prevention, screening, diagnosis, consultation for diagnosis, drug therapy, non-drug therapy, patient education, consultation for management, and follow-up. Each section includes guidance statements and lists of recommendations with the associated strengths of evidence for clinical usefulness based on literature. Authors are sent important advances in their topic areas and they are encouraged to use them in deciding on the need for updating their chapter or section. Searching and integration into electronic medical record systems is enhanced by a strong commitment to electronic markup of the content. **PIER** provides direction for specific clinical situations along with evidence to support these directions, it adheres more closely to the favored features listed above.

To summarize this section on electronic and other information resources, many more are now available, made possible by computerization, expansion of knowledge, and the evolution of clinical practice guidelines and EBM. The resources can be categorized by using the 4S Pyramid as being studies, syntheses, synopses, or systems and provided in push, pull, and prompt format. Textbooks and compilations of clinical practice guidelines are becoming more alike by providing their content in smaller modules or topics rather than the traditional larger chapter format and aligning their content with the current best evidence for clinical practice. These synopses hold promise to be used in information systems. In addition to texts and guideline collections, many high-quality, clinically relevant systematic review articles are available to support clinical care. Compilations of summaries and commentaries on high-quality, clinically relevant original studies and systematic review articles are also available and being used in push and pull formats. **MEDLINE** and original research articles are difficult to apply to clinical practice—synopses and summaries are easier to use.

This is the last knowledge area I present. The next section summarizes briefly the basic areas I have addressed and presents my dissertation topic. Chapter 3 expands on the research questions and describes my methods. The Chapter 4 contains results. Chapter 5 discusses the results and finishes with potential contributions of this research.

## 2.10 SUMMARY OF PROPOSAL AND STATEMENT OF DISSERTATION STUDY

In the previous sections I have described several areas of knowledge and how each area is complex and important with implications for design and use of clinical information resources. I have shown that information needs are numerous and a substantial number must be answered to enable clinicians to provide quality care for patients. Clinicians use a variety of resources to answer questions despite problems with usability, accessibility, currency, and content. They often look up information 2 to 3 times per clinic day. In addition, individual characteristics of searchers are often associated with substantial differences on the effectiveness of finding and using electronic information resources. In particular, aspects of risk and uncertainty seem to affect the way in which people find and use that information. Careful design and attention to training can make systems equally effective for users with varying backgrounds and characteristics. Although a substantial number of cognitive models have been applied to information seeking and use across disciplines, only a few consider risk profiles, and none appear to target the unique challenge of uncertainty and risk in medical domains. Cognitive models are important to the theoretical basis of any domain and we need more validated models in medical informatics to help direct research and development.

Physicians with varying responses to risk approach care and use health care resources differently, potentially putting excessive stress on healthcare systems. Physicians who are uncomfortable with uncertainty or are risk avoiding are prone to order more tests, interventions, referrals, and admissions, and incur more costs than their risk seeking or low-stress from uncertainty peers. This increased use of healthcare resources is not necessarily associated with improved patient outcomes. Clinicians may be able to provide care more effectively with electronic resources or tools that support decisions they find difficult to make.

New technologies hold the promise of integrating computerized information resources into the care process by using electronic medical record systems and other types of clinical information systems. However this dream of integrated, effective, and efficient information availability is still not realized. New technology has brought us new resources but we have not yet optimized their presentation and integration nor have we determined if tailoring these resources based on individual differences of clinicians or their preferences is warranted.

To address the concerns about how information resources are used and differences based on risk attitude and comfort from uncertainty I expanded my research statement (Section 1.8) into 3 more specific research questions that provided data to address these concerns. These 3 questions are listed at the start of Chapter 3 which

describes the methods and design issues I implemented to gather data to answer them. My results and their implications follow.

## 2.11 DISSERTATION STATEMENT

By addressing the 7 areas of research in the previous sections of Chapter 2 I developed the following research statement.

> **Statement:** I contend that clinicians with varying attitudes toward risk and levels of stress from uncertainty employ different approaches to seek information while using electronic information resources and have different outcomes. I can represent the similarities and differences in electronic information seeking behavior and use with theoretical models from information science and cognitive science/human computer interaction. By using the outcome and process data, the models, and clinician preference data for electronic information resources and specific features, I will determine whether designers of computerized information resources should use risk attitude and comfort with uncertainty or other related factors to tailor or personalize the resources. Computerized information resources, whether they are stand-alone resources or integrated into electronic medical record systems must effectively and efficiently support decision-making regardless of physician risk attitude or level of stress from uncertainty.

I used 3 dissertation questions to address this statement. They are listed in Chapter 3 along with the methods I used to answer the questions. Answers to these questions provide insight for 5 groups of people: First, those people who design, develop, and produce electronic information resources for clinicians; second, researchers and developers who are interested in integrating information resources into electronic medical record and clinical information systems; third, purchasers of information resources for clinicians; fourth, users of the systems, and fifth, those who study information seeking behaviors of health professionals. This study is centered in the discipline of medical informatics and draws on research and ideas from information sciences, medical librarianship, human computer

interactions, EBM, and information processing/cognitive sciences, with some research from applied psychology and medical decision-making.

# 3 METHODS TO ASSESS EFFECTS OF RESPONSE TO RISK AND UNCERTAINTY ON PHYSICIAN INFORMATION RESOURCE PROCESS AND USE

## 3.1 STUDY QUESTIONS

This dissertation is designed to answer 3 specific questions. Each question addresses the association between physicians risk attitude (risk seeking or risk avoiding) and comfort from uncertainty (high and low levels) with electronic information resource use. The first one determines if an association between risk status and outcomes of searching for information using electronic information resources. The second assesses the processes of using the resources in relation to risk status and includes modeling of the processes using existing frameworks. The third addresses preferences for electronic resources and specific features of the resources in association with risk status. The formal questions follow:

1. *How are primary care physicians' attitude toward risk (risk seeking or risk avoiding) and comfort with uncertainty associated with outcomes of searching for evidence (e.g., correctness and certainty of answer, time to decision, number of resources used) when using electronic information resources of their choice to answer simulated clinical questions?*

2. *What electronic information seeking and use processes do primary care physicians employ when answering simulated clinical questions and are the processes associated with their risk attitude (risk seeking or risk avoiding) and levels of stress from uncertainty? Can the processes and their differences be modeled by using the modified Wilson Problem-Solving Model (from information science) and the*

*Information Foraging/ Information Scent Model built by Card and Pirolli (from information processing and human computer interaction domains)?*

3. *What are physician preferences for specific electronic information resources (**Clinical Evidence** and **PIER**) when answering simulated clinical questions and are the preferences for resources and features associated with physician risk attitude (risk seeking or risk avoiding) and levels of stress from uncertainty?*

## 3.2 OVERVIEW OF STUDY DESIGN

This dissertation is a cohort study of US and Canadian primary care physicians who used electronic information resources to answer simulated clinical questions to determine if their information seeking and use of resources are associated with their attitude towards risk or comfort with uncertainty. Recruitment was done in southern Ontario, western New York, and western Pennsylvania. An influential peer used email to introduce the project to individuals or groups. Once physician indicated they were interested in being part of the study they completed the Pearson Risk Attitude and Gerrity SUS scales by using the Internet or paper versions. Physicians who scored high or low on the 2 scales were invited to be interviewed in their offices (45 minutes to 1 hour). At the interview, after signing consent documents each participant completed 3 sets of tasks. I collected baseline data on information resource use and familiarity. For the first of 3 tasks, physicians answered 23 multiple-choice questions from a previous study by Hersh and colleagues (39) in a paper format. The clinicians provided answers as well as their certainty of the answers and noted if they would look up the information if the issue came up in their care of patients. Second, the physicians chose 2 questions from the first 20 questions and used their own electronic information resources to answer them. They searched and described their processes by using think-aloud protocol methods according to the procedures of Ericsson and Simon (29). Third, for 2 questions I gave each physician pages from 2 different electronic information resources (**Clinical Evidence** and **PIER**) and asked them to use the pages to help answer the questions and to determine how helpful each of the resources had been. These 2 resources represent very different

approaches to presenting clinical information for use in patient-care settings. **PIER** provides directed care actions (in this situation do this….) and **Clinical Evidence** provides a summary of the evidence for benefits and harms related to a specific clinical question. For the second and third tasks the physicians were also asked for their answer to the question and their certainty after they completed their searching or use of the print materials. The think-aloud data from the second task as well as the verbal data from the third task were captured and transcribed.

The study is designed as 2 independent substudies with participants contributing data to both. For the first substudy, physicians were included if they were assessed to be risk seeking or risk avoiding by their scores on the Person Risk Attitude Scale. For the second substudy, physicians were included if they reported low or high levels of stress from uncertainty as scored by the Gerrity SUS Scale. Physicians who were risk neutral or reported moderate levels of stress from uncertainty were not included in the analyses.

## 3.3 ARCHITECTURE IS A COHORT STUDY

This study is designed as a cohort analytic study. I ascertained physician risk attitude and stress from uncertainty attributes at baseline and subsequently assessed the association of these attributes with outcomes and processes related to information seeking and application when the physicians used electronic information resources to address simulated clinical questions. I could not be blinded to risk status during the interviews. I remained blinded to the correct answers to the multiple-choice questions until completion of the interviews.

## 3.4 PARTICIPANTS AND RECRUITMENT

I included family physicians from both Canada and the United States and general internists from the United States if they saw patients on a regular basis in clinic settings. Therefore emergency physicians, hospitalists, intensivists, and most specialists were not eligible for participation. Residents were not included as some research indicates that the

Gerrity scale may be influenced by residency training under the supervision of a more senior clinician. Other inclusion criteria were having a computer with Internet access in their office and being willing to spend 45 minutes completing the study tasks.

I used standard recruitment procedures of asking an influential person or peer to introduce the project by letter or email. Both groups of physicians and individuals were thus invited to participate. The following approaches provided a list of physicians who were interested in volunteering for the study:

1. Email to the **MORE**[32] raters who rate journal articles for Dr. Haynes' research group. This undertaking is composed of a large group of volunteer physicians who rate clinically important articles for clinical relevance and newsworthiness. Their ratings are provided to their discipline peers in several electronic information (push and pull) systems such as **bmjupdates+.** Although the physicians who rate articles are located in many countries, I elected to screen primary care physicians in southern Ontario, western New York State, and western Pennsylvania. Staff working on the **MORE** project sent an electronic invitation to primary care physicians in these selected geographic areas. I obtained the names and emails of the physicians only after they agreed to be part of the study and take part in the selection process.

2. Departments of Family Medicine. I attended a meeting of the Department of Family Medicine at McMaster University in September after meeting with several of the faculty members responsible for departmental research and education department. The Chair of Family Medicine at the University of Pittsburgh emailed a letter of request to all of the faculty members asking for volunteers.

3. Contact by individuals to known colleagues. Drs. Haynes, Detlefsen, and Fridsma, as well as several physicians and administrators not associated with my project, provided names and contacted individuals. I also directly approached colleagues in Family Medicine at McMaster University and other primary care physicians who I had worked with in previous studies.

[32] MORE. McMaster Online Rating System. (http://hiru.mcmaster.ca/more/AboutMORE.htm). Accessed July 13, 2005.

Physicians who volunteered received an email with an electronic link to the screening questionnaires. I sent only 1a single request for participation to each physician and did not follow up on those who volunteered but did not complete the screening questionnaire. Filling in the electronic questionnaires took 1 to 2 minutes. I employed electronic data scoring and all scores and results were automatically entered into an Access database. All methods of recruitment were effective with the **MORE** raters being the most productive. All participants who filled in the screening questionnaires were given a $5 coffee card.

## 3.5 DOMAIN AND SETTING IS PRIMARY CARE

My domain is primary care in Canada (family physicians) and the United States (family physicians and general internists). While most physicians studied were allied with a teaching hospital or university medical center, this was not a requirement of my study. Although primary care physicians are well studied, they have special information needs—they need to be able to identify and deal with a very broad range of patients, diseases and conditions, and settings. The integration of information resources into electronic medical record or clinical information systems will only be deemed to be successful if the systems can meet the information needs of primary care physicians, a more difficult task than meeting information needs of specialists.

## 3.6 METHODS TO ADDRESS SPECIFIC STUDY QUESTIONS

The study included several steps. Data to answer each of the 3 questions often came from more than 1 step. The steps in the study were:

- Baseline data collection
    - From outside resources

    - From the participants themselves (questionnaires filled in during the interview)
- Answering 23 multiple choice questions along with certainty of answer and potential to look up the answer if it arose in the clinicians practice
- Using their own electronic resources, look up data to answer 2 questions of their choice from the multiple-choice questions
- Using pages from the electronic information resources (**PIER** and **Clinical Evidence**) which I provided, answer 2 additional questions from the multiple-choice questions
- For these final 2 tasks physicians were asked to think aloud, describing what they were doing while working with the electronic information resources to address the simulated clinical questions. The verbal data were audio taped and transcribed.
- Physicians received $50 at the end of the interview.

### 3.6.1 Baseline data collection

After a physician volunteered for the study I collected baseline data on discipline, certification, gender, year of graduation from medical school, and medical school attended. Each physician filled in the Pearson Risk Attitude Scale and Gerrity SUS Scale (online or in paper format). I received formal permission Dr. Pearson[33] on April 23, 2004 and from Dr. Gerrity[34] on July 28, 2004. Once I ascertained if a participant had high or low scores on either scale I obtained additional information to determine if they met the inclusion criteria (current clinical practice, computer and Internet access in their office, and willingness to be interviewed).

At the start of the interview and after the physician had signed the consent letter, I used paper forms to ascertain familiarity and sophistication as well as their use of computers, the Internet, and several electronic information resources.

Statistical analysis issues are discussed in Section 3.10. Information on the dependent variables and how they were measured in section 3.7. Similar information on the independent variables is in section 3.7.4.

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### 3.6.2 Question 1—Outcomes of information seeking and use

Question 1 centers on the outcomes of the searching and the answers to the 2 questions that each physician chose to look up using electronic information resources of their choice. The formal question follows.

> *How are primary care physicians' attitude toward risk (risk seeking or risk avoiding) and comfort with uncertainty associated with outcomes of searching for evidence (e.g., correctness and certainty of answer, time to decision, number of resources used) when using electronic information resources of their choice to answer simulated clinical questions?*

I collected quantitative data from the multiple-choice question answers on:

- Questions correctly answered
- Certainties associated with each answer
- Number and proportion of questions that the clinician reported that he or she would have searched if that question came up in practice.

For the 2 questions that were searched by the physicians using their electronic information resources of choice, I used the think aloud protocols and derived the following quantitative data:

- Number of sites visited
- Which sites/resources were visited
- Number of searching cycles (new terms within a resource or movement to another resource)
- Number and type of search methods used (e.g., textwords, limits to English language)
- Total time spent searching as well as times for each task and task group

I did not look at precision and recall for the searches as these traditional ways to measure searching performance are not always linked to correct answers for clinical questions (39).

### 3.6.3 Question 2—Process and models of information seeking and use methods and outcomes

Question 2 deals with describing and modeling the information seeking and use process of the study physicians to determine if their attitude to risk or levels of uncertainty are associated with differences in processes and to elucidate any differences found. The process of searching for and using computerized information resources in clinical situations must be understood to optimize resources and their implementation into electronic medical record systems and other clinical information systems. The second formal question is as follows:

> *What electronic information seeking and use processes do primary care physicians employ when answering simulated clinical questions and are the processes associated with their risk attitude (risk seeking or risk avoiding) and levels of stress from uncertainty? Can the processes and their differences be modeled by using the modified Wilson Problem-Solving Model (from information science) and the Information Foraging/ Information Scent Model built by Card and Pirolli (from information processing and human computer interaction domains)?*

Data gathering and analysis for this question are based on standard methods of think aloud protocol collection developed by Erickson and Simon and their colleagues at Carnegie Mellon University (29). These methods have been widely used in many contexts. Both the theoretical basis and how to apply the methods are well established. The foundation of the method is that people can describe what they are doing as they do it—verbalizing the internal dialogue that often happens during task performance. These verbalizations of process are accurate reflections of the steps involved in the task. The think-aloud process does not substantially affect the processes themselves although it may take longer to complete the task than if the participants were not verbalizing their processes.

After obtaining informed consent and baseline data collection, I described the process and gave each participant a training exercise to perform to familiarize him or her with the think-aloud processes using standard procedures. As part of this training, I asked the participants NOT to explain why they are doing the task but just to report what they

were doing and thinking. When a participant stopped talking I urged him or her to keep talking. I also encouraged participants to move from explanations back to verbalizations of the process if needed. Otherwise the process or task went on without prompting.

I initially started using a single training task but it soon became apparent that some physicians were not comfortable with the first task and I switched to a second one. Training tasks are usually chosen to match the type of thinking and processing skills that are to be reflected in the think-aloud tasks but of different content. In consultation with Dr. Crowley we chose a cryptoarithmetic problem. In this type of task a word problem is translated into an equivalent numerical solution. Young children use these problems as secret code exercises and computer science students often learn programming skills by modeling these problems. As an example to show the participants what I was asking them to do, I used the following code phrase

```
  CROSS
+ ROADS
 DANGER
```

The numerical solution of matching letters to digits is:

```
  96233
+ 62513
 158746
```

This is a complex problem that requires pencil and paper or computing resources. For the think-aloud training I used the following more simple example—the solution is provided.

| Problem | Solution | Numerical/Letter Equivalencies |
|---|---|---|
| I | 1 | I = 1 |
| + BB | + 99 | B = 9 |
| ILL | 100 | L = 0 |

For the people who found this cryptoarithmetic problem very difficult, I switched to counting the number of windows in the house in which they grew up—a standard think-aloud training exercise. Training time was in the range of 2 to 4 minutes and most participants became proficient in thinking aloud.

After training I asked the participants to choose 2 questions from the pool of 23 simulated questions that they had previously answered. A fuller description of the questions is included Section 3.10.1. Each question was written on a card and given to the physician at the start of each of the 2 question look-up tasks. I provided the cards for 2 reasons: First, the card helped ensure that the physicians would stay on task in answering the question and second, they did not see the answer or certainty that they had originally recorded. Often the answer and certainty changed after searching for answers.

I asked each physician to answer the questions by using their usual information resources while thinking aloud—all participants used electronic resources exclusively. Once they were finished the searching I asked the clinician what he or she felt was the correct answer along with his or her certainty of the correctness of that answer. I recorded the answer and times and took notes on the searching process. Ideally I would have liked to do screen captures of the searching process but felt that this would have not been feasible giving the time constraints, issues over consent, and the need to download screen capture software on the participant's computer.

After transcription and verification of the accuracy of the tapes I developed coding schemes for the searches done using information resources chosen by the participant and for answering the questions using pages from **PIER** and **Clinical Evidence**. These 2 sets of codes (Appendix D and E) were used to ascertain searching and application processes. A further description of code development and review follow in Section 3.7.4.

### 3.6.4 Question 3—Preferences for electronic information resources and outcomes

Describing the process of searching and information use and knowing the outcomes (e.g., time and accuracy of answers) are important. Preferences for resources and resource features are also important in optimizing and choosing from among established information resources. The third question provides data on physician preferences for information resources or specific aspects of resources regardless of risk attitude or stress from uncertainty or if any preferences are related to the physicians' risk/uncertainty levels. I also collected data to determine why

physicians prefer a resource. Data to answer these aspects of Question 3 came from analysis of the second sets of questions that physicians were given—the ones for which I supplied information from specific information resources. The third question follows.

> *What are physician preferences for specific electronic information resources (**Clinical Evidence** and **PIER**) when answering simulated clinical questions and are the preferences for resources and features associated with physician risk attitude (risk seeking or risk avoiding) and levels of stress from uncertainty?*

As in Question 1, I analyzed the data using risk attitude and stress from uncertainty groups as the independent variables looking at the following analyses and specific dependent variables. I also analyzed the data on outcomes related only to the difference between the 2 resources initially ignoring the risk/uncertainty data and then including it. The analyses center on the following areas and were done using per-person analyses.

- Certainty of answers related to the information resources
- Effect of the information resources on correctness of answers
- Preference for the information resources

I used qualitative (subjectivist) and quantitative (objectivist) methods to analyze the data explaining why a resource is preferred regardless of risk/uncertainty levels and also taking into account risk/uncertainty levels. I also compared these reasons with Ely and Osheroff's list (32).

Addressing these 3 questions gave me data on the process that clinicians with different levels of risk attitude and stress from uncertainty employ in searching for information and using it to answer simulated clinical questions. Integration of the outcomes from all 3 study questions provides design directions for computerized information resources and electronic medical record systems and model building in medical informatics.

## 3.7 DEPENDENT VARIABLES

Section 3.7 provides information on the dependent variables in the study and how they were measured. Section 3.8 provides similar information on the independent variables.

### 3.7.1 Baseline information on the participant physicians

I collected the following information on each participant (Table 3-1). Each variable is also listed as to how it was measured or identified and if it was analyzed as being categorical or continuous. Table 3-2 contains the variables collected on computer sophistication, information resource familiarity, and use of both computers and resources. Physicians filled out a paper questionnaire at the start of their interview and after they had signed consent forms.

**Table 3-1. Dependent Variables Collected at Baseline.** The table includes all of the basic information that I collected on each physician, how I collected or measured it, and how each was used in the analyses.

| Variable | How collected | How analyzed |
|---|---|---|
| **Name and contact information** | Provided by influential person who nominated the physician after the physician volunteered for the study | Not used in analyses |
| **Gender** | From physician name or state/provincial databases | Categorical |
| **Discipline** | From state/provincial databases (general internist or family physician) | Categorical |
| **Certification** | From state/provincial databases (yes/no) | Categorical |
| **Country** | From state/provincial databases (US or Canada) | Categorical |
| **Year of graduation from medical school** | From state/provincial databases (decade: 160s or before, 1970s, 1980s, 1999s) | Categorical |
| **Medical school attended** | From state/provincial databases (problem based education—yes/no) | Categorical |

**Table 3-2. Sophistication with Computers, Familiarity with Information Resources, and Use of Computers and Information Resources.** A questionnaire in paper format gathered information on how much physicians used computers and information resources and how sophisticated/familiar they were with the resources.

| Variable | Scale | How analyzed |
|---|---|---|
| **Computer sophistication** | Very sophisticated<br>Sophisticated<br>Neither sophisticated or unsophisticated<br>Unsophisticated<br>Very unsophisticated | Scales were given scores of 1-5 and analyzed as continuous data |
| **Familiarity with**<br>• **The Internet**<br>• **MEDLINE**<br>• **UpToDate**<br>• **Clinical Evidence**<br>• **PIER** | Very familiar<br>Familiar<br>Neither familiar or unfamiliar<br>Unfamiliar<br>Very unfamiliar | Scales were given scores of 1-5 and analyzed as continuous data |
| **Use**<br>• **Computers**<br>• **The Internet**<br>• **MEDLINE**<br>• **UpToDate**<br>• **Clinical Evidence**<br>• **PIER** | At least hourly<br>At least daily<br>At least weekly<br>At least monthly<br>Very seldom<br>Never | Scales were given scores of 1-6 and analyzed as continuous data |

### 3.7.2 Study questions from previous studies

One of the most crucial issues of a study of this sort is the choice of questions. Study questions in a project such as this should be clinically important to primary care physicians, have answers that not readily known by practicing clinicians, have a definite clinical answer (yes with evidence, no with evidence, and cannot tell based on evidence), and have been pretested. Hersh and colleagues have recently completed 2 high-quality studies of medical students and nurse practitioners and their searching abilities. The studies also looked at individual differences of the searchers and related these to searching outcomes (39, 62). Hersh's most recent study (39) used 20 questions that match my requirements. Ten come from a study by Gorman and colleagues (122) that collected questions from primary care physicians and 10 come from the **American College of Physicians Medical Knowledge Self-Assessment (MKSAP) Program©[35].** They are relatively difficult: 51.6% of the medical students and 34.7% of the nurse

[35] **Medical Knowledge Self-Assessment Program.** Copyright 1995-2005 American College of Physicians.

practitioners got the correct answer with the use of **MEDLINE**. Dr. Hersh[36] gave me permission to use his questions and answers in this dissertation (email dated June 4, 2004).

After review by an expert clinician I deleted 1 question that was no longer valid and added a substitute. I checked the answers using compiled information resources and original studies. For those questions that I was unsure of the answers, I checked with the expert clinician. One question had a changed answer. I also added 3 questions that were used in the final task set of the interview on choice of resource. Questions and answers are in Appendix B.

Initially I proposed choosing pages from both **PIER** and **Clinical Evidence** resources that provided answers to some or most of the multiple-choice questions to use for the final task of using resources that I provided instead of the participants own resources. The 20 Hersh questions include content that deals with therapy, diagnosis, etiology/causation, and prognosis and are generally quite specific. None of the questions were addressed in both **PIER** and **Clinical Evidence**. I developed 3 additional questions using the list of new topics from each of the information resources. The questions were based on the use of:

- Acetazolamide for high altitude illness—a topic that few primary care physicians deal with but could be asked to address.
- Antidepressants for irritable bowel syndrome—a topic that is quite common in primary care and often a complex condition with which to deal. One Canadian family physician stated that she saw patients with irritable bowel syndrome every day in her clinic.
- Empowering techniques to help women to be able to leave an abusive situation—again a very common and complex issue.

These final 3 questions brought the total questions to 23: 19 from the Hersh study, 1 replacement question, and 3 for use in the final task of the study. I asked participants to choose which questions they wanted to address from these 3. No one chose the third question and therefore my analysis is based on the first 2. I presented the questions in random order and asked them to think aloud as they looked at the pages and addressed the questions. Because they often told

[36] William Hersh, MD. Department of Medical Informatics and Clinical Epidemiology. Oregon Health Sciences University. hersh@ohsu.edu. www.billhersh.info

me why they were doing things, the think-aloud data from these analyses are not true think-aloud data. At the end of their deliberation on each question, I again asked for the correct answer and accompanying decision certainty. The pages of the multiple choice questions were stored so that the physician could not easily check back to verify what he or she had initially indicated as the correct answer and certainty. I also asked the clinicians if they had a preference, what features of the resource they liked, and to explain why a resource was favored.

### 3.7.3 Information resources studied—Pier and Clinical Evidence

I took the features listed as desired by physicians in the study by Ely and Osheroff (32) and asked 5 medical librarians to score 3 frequently used clinical information resources (**UpToDate, Clinical Evidence,** and **PIER**) using these features. Scoring was based on 2 points if the feature was present in the resource and 1 point if the feature was partially implemented. All 5 medical librarians were experienced reference and collection development librarians who also had extensive training experience in clinical medicine. They also worked closely with residents and faculty and provide classes on information seeking and resources. Three librarians were from McMaster University and 2 from the University of Pittsburgh. Individual scores were obtained blinded to other scores. The individual scores for each feature were summed using data from all 5 librarians are in Table 3-3 which includes total scores for all 5 librarians for each feature as well as totals for feature groups and for each information resource.

Each of the 3 information resources (**UpToDate, Clinical Evidence,** and **PIER**) is designed for primary care physicians and places a high value on evidence to support their content. I wanted to use 2 information resources in this study to determine if features of resources or resources themselves were preferred differentially based on clinician attitude toward risk and stress from uncertainty. A description of each of these resources follows as well as an explanation of why they were chosen for further study.

As part of this dissertation, I contend that those clinicians who are risk avoiding or uncomfortable with uncertainty will prefer sources that provide direct clinical action steps along with strength of evidence. As well those physicians who are risk seeking or comfortable with uncertainty will likely prefer resources that provide evidence which they then use to make their own decisions. I designed this study to determine resource and feature preferences and sought to have 2 respected resources that showed differences in style and features.

**Table 3-3. Desirable Aspects of Information Resources and Presence of Features in UpToDate, Clinical Evidence, and PIER.** Ely and colleagues (35) provide a set of desired features for the ideal information resource. Five health sciences librarians have given scores based on this list to 3 commonly used clinical information resources designed for primary care physicians. **PIER** and **Clinical Evidence** represent different scoring on this scale. Both are studied in this dissertation in relation to preferences for answering clinical questions.

| Feature | UpToDate | Clinical Evidence | PIER |
|---|---|---|---|
| **Comprehensiveness** | | | |
| Comprehensive topic coverage by anticipating and answering clinical questions | 7 | 6 | 7 |
| Direct answers to clinical questions—answers clinical question directly | 7 | 5 | 8 |
| Treatment details provided fully-including prescribing information | 7 | 2 | 8 |
| Summary and bottom line recommendations | 7 | 5 | 7 |
| Specific information so that one does not need to go elsewhere if unfamiliar area | 8 | 5 | 9 |
| Avoid vague statements | 8 | 8 | 9 |
| Tell the physician exactly what to do | 6 | 2 | 10 |
| Summary score for comprehensiveness | 50 | 31 | 58 |
| **Trust** | | | |
| Evidence—provide rationale for evidence including citations—summaries of research not just listings of studies | 6 | 9 | 10 |
| Practicality | 10 | 5 | 10 |
| Based on clinical experience/"real world" | 8 | 4 | 9 |
| Frequent updates | 6 | 5 | 10 |
| Authority of source | 8 | 10 | 10 |
| Summary score for Trust | 38 | 33 | 49 |
| **Clinical Organization** | | | |
| Concise, succinct, and to the point and good clear writing | 8 | 8 | 10 |
| Clinical findings presented from clinician perspective | 10 | 7 | 10 |
| Algorithms presented that take into account many features of care | 6 | 3 | 4 |
| Rapid information access—tables, lists, headings | 10 | 5 | 10 |
| Links to related topics | 10 | 7 | 8 |
| Links to full text of articles | 1 | 3 | 5 |
| Availability | 9 | 10 | 9 |
| Summary score for Clinical Organization | 54 | 43 | 55 |
| Summary score for all features | 142 | 108 | 162 |

**Score:** 2 points feature present, 1 point partially present, and 0 points not available in resource.

**Clinical Evidence** has a total librarian score of 108 points and **PIER** has 162 points based on scores given by 5 medical librarians. In addition, **PIER** and **Clinical Evidence** differ on the important aspect of providing direct answers to questions. **PIER** gives the answer or provides specific direction on how to proceed in a given clinical situation. **Clinical Evidence** is formatted on a question basis but is very careful only to provide the evidence for benefits and harms related to the issue. The clinician uses this information to come to his or her own decision. The coverage of both resources is similar with an emphasis on primary care preventions and treatments as well as a strong commitment to using and making explicit the evidential base for their content.

I did not chose to include **UpToDate** for several reasons:

- Its evidence base is not as strong as that of **PIER** and **Clinical Evidence**
- Its features' score from the librarians is intermediate between **PIER** and **Clinical Evidence**
- I chose to include only 2 resources in this study.

### 3.7.4 Processes of searching and use from coding the think aloud data

All of the think-aloud protocol data obtained from the participants were transcribed within 24 hours of collection. I reviewed the tapes and transcriptions after at least 2 weeks to check accuracy. I also used the tapes to provide timing for training and the questions. After all of the transcriptions were complete and checked I divided the documents into segments for coding and analysis. These segments for oral reports usually consist of a phrase with a single operator rather than a whole sentence. Verbal pauses, conjunctions, and sentence structure helped with this segmentation. A sample of a segmented protocol is in Appendix C.

Separate coding was done for the 2 tasks: answering questions using their own resources and answering questions using pages from **PIER** and **Clinical Evidence.** I produced a preliminary set of codes after analysis, using data from 4 randomly selected sets of data that represented participants who were risk seeking and risk avoiding and had high and low levels of comfort with uncertainty. I built my coding system working with the data rather than using information from previous studies or the information seeking models. Code building was an iterative process and took approximately 80 hours for the first task and more than 40 hours for the second task. Dr. Crowley provided

valuable insights into coding methods and analyses. The coding was produced in a hierarchical manner. The full code sets are in Appendix D and Appendix E. The first 2 levels of the coding for each set of data follow.

**Searching and Application of Information Using Chosen Information Resources**

1. Attempt
   - 1.1. first
   - 1.2. second
   - 1.3. third…up to 6 attempts
2. General discussions around the issue but not related to the searching for speficic questions
   - 2.1. discuss searching including discuss process
   - 2.2. discuss own knowledge
   - 2.3. discuss training…
3. Resources and search engines
   - 3.1. resources that are used for searching
   - 3.2. search engines that are used for searching
4. Searching itself
   - 4.1. question
   - 4.2. search approaches
   - 4.3. discuss search methods
   - 4.4. search methods
   - 4.5. stop searching
   - 4.6. troubles
   - 4.7. heuristics
   - 4.8. mistake
   - 4.9. modify/verify search strategy
5. Retrieval
6. Documents and web sites and pages
   - 6.1. discuss document
   - 6.2. discuss web site
   - 6.3. discuss web page
   - 6.4 read document (plain)
7. Application
   - 7.1. discuss clinical application including conflicting results
   - 7.2. summarize
   - 7.3. make decision
   - 7.4. certainty
   - 7.5. what l like
   - 7.6. what I dislike
8. Heuristic
   - 8.1. before searching
   - 8.2. choosing document
   - 8.3. decision making
   - 8.4. general
   - 8.5. if my usual
   - 8.6. searching choosing sites
   - 8.7. searching choosing
   - 8.8. retrieval

**Searching and Application of Information Using Provided Information Resources (J and K were codes for PIER and Clinical Evidence)**

1. Discuss
   - 1.1. Discuss question
   - 1.2. Discuss clinical content
   - 1.3. Discuss own knowledge
   - 1.4. Discuss/mention resource besides J and K
   - 1.5. Discuss process and related terms
2. Read
   - 2.1. Read J looking for …
   - 2.2. Read K looking for…
3. Discuss feature-J (see list below for subcategories)
4. Discuss feature-K (see list below for subcategories)
5. Prefer feature-J (see list below for subcategories)
6. Prefer feature-J (see list below for subcategories)
7. Criticism feature-J (see list below for subcategories)
8. Criticism feature-J (see list below for subcategories)
9. Nice feature-J (see list below for subcategories)
10. Nice feature-K (see list below for subcategories)
11. Mistake
12. Preference-J (see list below for subcategories)
    - 12.1. Initial
    - 12.2. Final
13. Preference-K
    - 13.1. Initial
    - 13.2. Final
14. Preference-neither
    - 14.1. Initial
    - 14.2. Final
15. Reason prefer-J
16. Reason prefer-K
17. Clinical Application
18. Decision making
19. Certainty
20. Heuristics
21. Satisfaction

After review of these codes I continued and analyzed the rest of the available data. I revised the codes as necessary and recoded all data sets. I completed an intra-rater reliability study of 5% of my sample with duplicate coding separated by 3 weeks. Codes with poor agreement were dropped or modified for easier application. I did not complete an inter-rater reliability check because I am the only person coding the data. I analyzed the data for the first 2 questions and the second 2 questions as separate sets of data.

Analysis of the think-aloud and other process data and differences across participants with varying levels of risk attitude and comfort with uncertainty follow in Chapter 4, Section 4.8. In addition, the processes found using the codes are compared with the modified Wilson Problem Solving and Card/Pirolli Foraging models.

## 3.8 INDEPENDENT VARIABLES

The independent variables were the scores on the Pearson Risk Attitude Scale and the Gerrity Stress from Uncertainty Scale. The scales are full described in Section 2.4.3 and 2.4.4.

### 3.8.1 Setting Pearson and Gerrity Scale scores to define groups

The data on Pearson and Gerrity scales have been analyzed in 3 ways across studies. I used the most common method of 3 groups split so that approximately one third of the participants are in each group (risk seeking, risk neutral, or risk avoiding and high, moderate, and low levels of stress from uncertainty). I considered, but did not use, 3 groups formed by being above, below, or within 1 SD on for mean score or 2 groups split by using the mean of the total group. For most analyses I used categorical group for analyses although some analyses used scores taken as continuous data. Based on previous studies, I worked with Dr. Friedman and established cut points for the groups.

Pearson scores can range from 6 to 36. For this study risk seekers were defined to have scores from 6 to 17 and risk avoiders have scores 21 or above. Gerrity scores can range from 8 to 48. For this study participants considered to be comfortable with uncertainty were defined to have scores from 8 to 15 and participants who were uncomfortable with uncertainty have scores 19 and above. In retrospect these cut points were set low for the participants and did not accurately reflect a split of the participants into 3 equal sized groups for either scale.

## 3.9 MATERIALS WERE PRETESTED

The screening questionnaires in both paper and electronic format were pretested for usability and technical problems by sending them to physicians and research staff. The other study materials were pretested by using physicians

associated with the University of Pittsburgh Center for Biomedical Informatics program and a study participant in a full interview session. Dr. Crowley oversaw this step. This pretesting and oversight of the process was invaluable for fine tuning the steps and ensuring that the materials, sequences, and process worked well. I made only minor adjustments to the materials and some more major changes to my processes.

## 3.10 DATA ANALYSES

I used Stata version 7.0 for descriptive and inferential statistics. Statistical significance was set at 0.05. I used Student's t-tests using the participant as the unit of analysis as well as exact methods of Fisher's exact tests and McNemar change tests in various analyzes because of the small numbers of participants and events in each group. I used pairwise correlational analyses to determine the association between the Pearson Risk Attitude Scale and the Gerrity Stress from Uncertainty Subscale. I did not combine the Pearson and Gerrity scores further as they are moderately correlated with a high degree of significance (correlational coefficient 0.37, P = 0.007). Analyses of the searching heuristics used qualitative (subjectivist) methods and therefore did not require inferential statistical tests. Some counting and grouping of like concepts were done using these data. Further information on specific tests in various data sets is included in the analysis chapter and its subsections.

Because this study was done as an early exploratory project, I chose not to include participants who were "in the middle" of the spectrum—risk neutral attitude and moderate stress from uncertainty. I have included these middle people up to now in my baseline analyses. For the rest of the analyses that look at differences in process and outcomes based on risk status, I will exclude the people with mid-range scores. For some analyses at the end of this dissertation and where I discuss next steps in the research process, I will reintroduce these participants and their outcomes.

Dr. John Wilson, School of Public Health, University of Pittsburgh provided initial assistance with data and statistical analyses. I consulted with James McKinlay and Dr. Stephen Werre of McMaster University on final analysis issues.

### 3.10.1 Sample size calculations indicate that 40 data sets are needed

Traditional sample size calculations are difficult to do for studies that use think-aloud protocol methods. The Eriksson/Simon coding scheme is built around operators and is developed while working with the transcribed verbal data. The procedures have many similarities with qualitative (subjectivist) methods. Therefore *a priori* sample size calculations built on the number and frequencies of operators are not accurate reflections of what is often found during analysis. Crowley (124, 125) found substantial differences among 3 groups (experts, intermediates, and novices) in a study of expertise in microscopic diagnosis of breast cancer with 14 participants per group. Hersh and colleagues (62) found statistical differences in the number of correct answers to clinical questions as well as identifying individual factors associated with improved process and outcomes after searching by studying 29 medical and nurse practitioner students who used **MEDLINE**. Taking these studies into account, I interviewed enough physicians to have

10 physicians with low Pearson scale scores (risk seeking)

10 physicians with high Pearson scale scores (risk avoiding)

10 physicians with low Gerrity scale scores (comfortable with uncertainty)

10 physicians with high Gerrity scale scores (uncomfortable with uncertainty)

I was conscious of trying to balance for gender, country, and discipline but did not limit my inclusion of participants based on these factors. My data were stratified for participants across the Pearson and Gerrity groups. This balance accounted for potential counfounding of the scale scores for each other. Recruitment stopped when I had the 40 spots filled. I interviewed 25 physicians to fill the 40 analysis slots.

In the analyses sections, I show that my choice of numbers was associated with very low power to detect the differences I sought. Generally at the end of the study I found that my power was in the range of 10% to 20% to detect the differences I sought. With methods and statistical issues decided I next sought ethics and institutional review approval for the study.

## 3.11 ETHICS AND INSTITUTIONAL REVIEW BOARD APPROVAL

Because my participants were Canadian and US physicians, I obtained Institutional Review Board approval from the University of Pittsburgh and Ethics Review Board approval from McMaster University. The University of Pittsburgh required an expedited review rather than an exempt review because one question on the Pearson scale (I enjoy taking risks) was considered to have employment implications. This expedited review required that participants were told of confidentiality measures in the email request form for the screening part of the study. Assumed consent was allowed for the email/Internet questionnaires as their consent was given when they chose to respond and provide data. The interview part of the study required a full, signed consent letter for US participants. I have signed copies for all US and Canadian participants on file as well as signed approval forms from both institutions. I left a copy of the signed consent letter with each participant.

The Ethics Review Board at McMaster University meets once a month with the requirement that forms be handed in 2 weeks in advance of the meeting. Therefore Institutional Review Board approval was obtained from University of Pittsburgh first. (Of note, each institution preferred that the other institution provide approval first and it was the timing issues at McMaster that allowed the University of Pittsburgh requirement to have approval first from the Canadian site waived.) Renewal of the approvals was sought to complete the second year of the project—further analyses and writing up the results. I did not go back to the participants for additional information after the interviews were complete.

## 3.12 SUMMARY OF METHODS

This dissertation is a cohort study designed to elucidate the process and outcomes for clinicians who search for and use electronic information resources to help answer simulated clinical questions. These processes and outcomes were assessed to determine associations with physician attitude towards risk and relative levels of stress from uncertainty. The steps in my study were:

- Study recruitment with data gathering on baseline characteristics and scores for Pearson Risk Attitude and Gerrity Stress from Uncertainty Scales
- Interviews with 25 primary care physicians obtaining baseline information on computer and information resource familiarity and use
- Answers and certainty of the answer for 23 multiple-choice clinical questions
- Physicians were observed while answering 2 questions using their own information resources using think-aloud protocol procedures developed by Eriksson and Simon
- Physicians were again observed while answering 2 questions using provided print pages from 2 electronic information resources (**Clinical Evidence** and **PIER**)

Chapter 4 describes the results of recruitment, interviews, and analyses of the data. I end the chapter with a summary of important findings and proceed to Chapter 5 for discussion, conclusion, implications, and future research.

# 4 RESULTS OF STUDY OF PHYSICIAN USE OF INFORMATION REOURCES

The data gathering process proceeded on schedule and was done in September, October, and November 2004. This chapter starts with an assessment of the characteristics of those physicians who were screened for inclusion and baseline characteristics of the participants as well as descriptive analyses of answers to the clinical questions and the searching processes. I then provide the inferential statistical analyses and results based on my study questions. At the end of the chapter I show that risk seeking/avoiding are not strongly related to searching behaviors or outcomes while some differences were apparent for physicians with high and low levels of stress from uncertainty I end the chapter showing some unexpected results related to the success of searching for and application of information with the use of electronic information resources. I then do some further analyses looking at these findings before closing with conclusions and future directions in Chapter 5.

## 4.1 BASELINE DATA ON ALL VOLUNTEERS AND THOSE WHO WERE INTERVIEWED

More than 260 physicians were invited to volunteer for the study. The numbers of physicians who volunteered, were screened, and had interviews are in Table 4-1 by method of recruitment. By far the most productive group for identifying study volunteers was the **MORE** rater pool. The **MORE** project is a volunteer group of practicing physicians who receive notification of new studies and systematic reviews in their discipline. They provide clinical relevance and newsworthiness ratings for new studies and systematic reviews for their peers. Over 2000 physicians from many countries and disciplines are part of this group.

Physicians readily volunteered and supplied baseline data in a timely manner after initial contact. All the physicians who agreed to be part of the full study found completed the interview except for 1 family physician who chose not to look up answers using his own resources. The physicians wanted to find out how their attitude towards risk and comfort with uncertainty compared with their peers. For those physicians that I did not interview, I sent scores as soon as they were excluded from the study. I gave the interviewed physicians their scores on the Pearson and Gerrity scales at the end of the interview session. One Canadian family physician used the paper version of the scale at a departmental meeting[37] and after checking his perceptions of his scores at the end of the interview we determined that he had filled in the questions incorrectly. Instead of having the highest scores on both scales (very risk avoiding and uncomfortable with uncertainty) he had the lowest scores. Without this check I would have had him in the wrong groups. Although the MORE raters comprised the majority of the study participants, I also recruited through colleagues and the Departments of Family Medicine at both study universities.

**Table 4-1. Participant Recruitment.** Number of physicians invited to be part of the study and those who were screened and included according to the source of the participants.

| Recruitment Step | MORE raters | Recruited by peers | Family Medicine (McMaster) | Family Medicine (Pittsburgh) |
|---|---|---|---|---|
| **Invited** | 102 | 26 | ~40 | ~100 |
| **Volunteered** | 48 | 16 | 2 | 2 |
| **Completed Screening** | 43 | 13 | 2 | 2 |
| **Ineligible** | 10 | 0 | 0 | 0 |
| **In study—interviewed** | 22 | 1 | 2 | 0 |
| **In study—not interviewed** | 11 | 12 | 2 | 2 |

The 10 people who were ineligible after screening were in disciplines outside primary care (n = 6), did not have a computer (n = 2), or refused to be interviewed (n = 2). I have only an approximate count of the number of physicians at the Family Medicine departmental meeting or the number of emails that were sent to the department of Family Medicine at the University of Pittsburgh. I did not contact the members of the departments of Medicine at either McMaster University or the University of Pittsburgh.

[37] Only 2 physicians used the paper version and it was somewhat more confusing than the computer version.

## 4.2 BASELINE CHARACTERISTICS OF PARTICIPANTS

Data on 52 participants screened and found eligible are included in this section—25 who had interviews and 27 who did not. Baseline characteristics of the groups of participants are in Table 4-2. A baseline description of the participants and their risk groups follows. Looking at the baseline characteristics of the study participants in the risk groups, no statistically significant differences were found (Fisher's Exact test). The next step in the process was a descriptive summary of the independent variables (Pearson and Gerrity scores) of the physicians who were screened and those who went on to be interviewed. Table 4-3). Individuals who were interviewed were different from those who were not interviewed in that they were more likely to:

- be a family physician rather than a general internist
- be certified as a family physician or general internist.

**Table 4-2. Baseline Characteristics of the Screened Physicians.** Physicians who met the inclusion criteria and a comparison between those who were interviewed and not interviewed. Student t-tests and Fisher exact tests for statistical significance shows those who were interviewed were more likely to be a family physician and be certified.

| Characteristic | All Participants n =52 (% of 52) | Interviewed N = 25 (% of 25) | Non Interviewed n = 27 (% of 27) |
|---|---|---|---|
| **Men** | 39 (75.0) | 21 (84.0) | 18 (66.7) |
| **Women** | 13 (25.0) | 4 (16.0) | 9 (33.3) |
| **United States** | 23 (44.2) | 8 (32.0) | 15 (55.5) |
| **Canada** | 29 (55.8) | 17 (68.0) | 12 (44.5) |
| **Family Medicine** | 39 (75.0) | 22 (88.0) | 17 (62.9) (P = 0.04) |
| **General Internal Medicine** | 13 (25.0) | 3 (12.0) | 10 (37.1) (P = 0.04) |
| **Decade of Graduation (60s/70s/80s/90s)** | 2/10/28/12 (3.9/19.2/53.8/23.1) | 0/6/12/8 (0/22.2/44.4/33.3) | 2/4/16/4 (8.0/16.0/64.0/16.0) |
| **Certification** | 44 (84.6) | 24 (96.0) | 20 (74.1) (P = 0.05) |

The difference in the number of family physicians is because family physicians were recruited in both countries and general internists were recruited only in the United States. Canada has a 2-tiered healthcare system while the United States has a 3-tiered system. This means that Canada has few general internists and most function as specialists or hospitalists—exclusion criteria for the study. In addition, a nonstatistical trend toward more Canadian physicians was also seen (P = 0.08) in the study groups, probably reflecting my geographic location and my history of contact with Hamilton-area physicians.

**Table 4-3. Baseline Characteristics of the Study Participants.** Assessment of the baseline characteristics of the physicians in the risk groups (Pearson and Gerrity) showed no statistically significant differences between the groups—Risk seeking vs risk avoiding groups and also low-stress and high-stress groups (Student t-test).

| Characteristic | Pearson (Risk Attitude) | | Gerrity (Stress from Uncertainty) | |
|---|---|---|---|---|
| | Risk Seeking (n = 11) | Risk Avoiding (n = 11) | Low Stress (n = 10) | High Stress (n = 11) |
| **Country (Canada)*** | 64% | 64% | 80% | 54.5% |
| **Gender (Women)*** | 9.1% | 9.1% | 30% | 9.1% |
| **Decade graduated** | 0/1/9/1 | 2/2/6/1 | 0/3/6/1 | 1/1/7/2 |
| **Discipline (GIM)*** | 9.1% | 18.2% | 0% | 18.2% |
| **Certification (Yes)*** | 100% | 100% | 90% | 100% |

*I did not include the converse of each category. For example, if a group had 64% Canadian physicians, then by subtraction, 36% were from the United States and if 18.2% were women then 71.8% were men.

## 4.3 PEARSON SCORES ARE CONSISTENT WITH OTHER STUDIES

Pearson scores can range from 6 to 36 (1 to 6 points per statement). My interviewed sample had score ranges of from 10 to 31 (Table 4-4). Taking the Pearson scores as normally distributed, mean scores varied considerably across subgroups for those who were interviewed and not interviewed. The physicians who were interviewed had lower Pearson scores than those who were not interviewed (mean score 19.6 for interviewed vs 24.1 for no interview, P = 0.04 for a difference of 4.4 points). Men (P = 0.02), Canadians (P = 0.003), and family physicians (P = 0.008) that were interviewed had lower Pearson scores than their peers who were not interviewed. This difference between interviewed and not interviewed was not evident for women, US physicians, or general internists.

The mean score of 19.6 for interviewed participants is consistent with the scores set for the study groups (Table 4-5). The Pearson scores for those interviewed (mean 19.6) were similar to those found in other studies including slightly higher scores for general internal medicine than family medicine (tending towards being more risk avoiding in internal medicine).

**Table 4-4. Summary Data on Pearson Scores (Attitude towards Risk).** Pearson data from the 22 study participants who are risk seeking and risk avoiding are in the table. Some differences were seen between those who were interviewed and those who were not (those interviewed and men, Canadians, and family physicians had lower mean Pearson scores than their counterparts who were not interviewed).

| Characteristic | Number | Mean Pearson score | Standard deviation | Range |
|---|---|---|---|---|
| **All participants** | 52 | 21.9 | 5.4 | 10 to 31 |
| Interviewed* | 25 | 19.6 | 6.0 | 10 to 31 |
| Not interviewed* | 27 | 24.1 | 3.8 | 18 to 30 |
| **All women** | 13 | 23.2 | 4.0 | 17 to 29 |
| Women interview | 4 | 20.3 | 4.6 | 17 to 27 |
| Women no interview | 9 | 24.6 | 3.0 | 20 to 29 |
| **All men** | 39 | 21.5 | 5.8 | 10 to 31 |
| Men interview* | 21 | 19.5 | 6.3 | 10 to 31 |
| Men no interview* | 18 | 23.9 | 4.2 | 18 to 30 |
| **All United States** | 23 | 21.9 | 5.6 | 12 to 30 |
| US interview | 8 | 20.1 | 7.5 | 10 to 31 |
| US no interview | 15 | 23.0 | 3.5 | 18 to 30 |
| **All Canada** | 29 | 22.0 | 5.3 | 10 to 31 |
| Canada interview* | 17 | 19.4 | 5.4 | 12 to 28 |
| Canada no interview* | 12 | 25.4 | 3.9 | 19 to 30 |
| **All Family Medicine** | 39 | 21.3 | 5.7 | 10 to 31 |
| FM interview* | 23 | 19.2 | 5.9 | 10 to 31 |
| FM no interview* | 17 | 23.9 | 4.3 | 18 to 30 |
| **All General Internal Medicine** | 13 | 24.0 | 4.0 | 16 to 30 |
| GIM interview | 3 | 22.7 | 7.0 | 16 to 30 |
| GIM no interview | 10 | 24.4 | 3.0 | 20 to 30 |
| Decade 1950s/60s | 2 | 27.5 | 0.7 | 27 to 28 |
| Decade 1970s | 10 | 21.5 | 4.6 | 15 to 30 |
| Decade 1980s | 28 | 21.3 | 6.3 | 10 to 31 |
| Decade 1990s | 12 | 22.8 | 3.7 | 17 to 29 |

* Statistically significant differences when comparing interviewed and not interviewed physicians.

The differences in Pearson and Gerrity baseline scores between those who were interviewed and those not interviewed are important for this study and will likely affect the generalizability of the findings. The large differences in scores are likely because the majority (22 of 25) study participants came from the request to the MORE raters. These raters are a volunteer group of practicing physicians who are heavily involved and committed to EBM principles in their clinical work. Both the volunteerism and the commitment to evidence of these MORE raters likely make them different from their colleagues. This difference in the MORE physicians was also evident in that I needed 7 weeks to identify the final participant with low Pearson scores (risk seeking) once I had contacted all the MORE raters who were interested in being part of the dissertation study. Finding the physicians to fill the other 39 slots (risk avoiding and comfortable and uncomfortable with uncertainty) took less than 3 weeks.

The cut points for the Pearson scales (risk seeking and avoiding) for inclusion into the study are in Table 4-5. The table also includes the mean scores for those who are in each Pearson category and their Gerrity SUS scores. The study groups had a wide range of mean scores for risk attitude. This range was not evident in the Gerrity scores, showing that stratification based on possible confounding between the Pearson and Gerrity scores was effective.

**Table 4-5. Cut Points for Pearson Groups and Mean Scores for Each Group.** Physicians were grouped according to their Pearson scores. The table shows the scores for each group as well as corresponding Gerrity scores. The Gerrity scores did not show the same range across the groups as did the Pearson scores.

| Pearson Group | Number in Group | Cut Point Criterion | Mean Pearson Score (SD) | Pearson Range | Mean Gerrity Score (SD) |
|---|---|---|---|---|---|
| **All** | 25 | n.a. | 19.6 (6.0) | 10 to 31 | 17.0 (5.5) |
| | | | | | |
| **Risk Seeking** | 11 | Less than 18 | 14.2 (2.0) | 10 to 16 | 16.3 (5.2) |
| **Risk Neutral** | 3 | 17 to 19 | 18.7 (0.58) | 18 to 19 | 16.0 (5.6) |
| **Risk Avoiding** | 11 | More than 20 | 25.3 (3.8) | 20 to 31 | 18.1 (6.1) |

## 4.4 GERRITY SCORES ARE CONSISTENT WITH OTHER STUDIES

The Gerrity scores for the groups are in Table 4-6. These scores can vary from 8 to 48 and the participants' scores represented almost the full scale (8 to 46). Men, Canadians, and family physicians had scores at the lowest part of the range (low levels of risk) while women, US physicians, general internists, and those not interviewed had scores in the highest part of the range (high levels of stress).

**Table 4-6. Summary Data on Gerrity Scores (Stress from Uncertainty).** Gerrity data from the 21 study participants. Some differences were seen between all who were interviewed and not interviewed. Men, Canadians, and family physicians had lower mean Pearson scores than their counterparts who were not interviewed).

| Characteristic | Number | Mean Gerrity score | Standard deviation | Range |
|---|---|---|---|---|
| **All participants** | 52 | 21.1 | 8.0 | 8 to 46 |
| Interviewed* | 25 | 17.0 | 5.5 | 8 to 27 |
| Not interviewed* | 27 | 24.9 | 8.4 | 12 to 46 |
| **All women**** | 13 | 26 | 11.9 | 11 to 46 |
| Women interview* | 4 | 13.8 | 5.5 | 11 to 22 |
| Women no interview* | 9 | 32.0 | 9.0 | 23 to 46 |
| **All men**** | 39 | 19.5 | 5.9 | 8 to 38 |
| Men interview* | 21 | 17.7 | 5.4 | 8 to 27 |
| Men no interview* | 18 | 21.7 | 5.9 | 12 to 38 |
| **All United States**** | 23 | 23.6 | 9.1 | 8 to 46 |
| US interview* | 8 | 18.4 | 5.9 | 8 to 25 |
| US no interview* | 15 | 26.6 | 9.4 | 12 to 46 |
| **All Canada**** | 29 | 19.1 | 6.7 | 8 to 38 |
| Canada interview* | 17 | 16.4 | 5.4 | 8 to 27 |
| Canada no interview* | 12 | 22.9 | 6.8 | 15 to 38 |
| **All Family Medicine**** | 39 | 19.3 | 6.7 | 8 to 38 |
| FM interview* | 22 | 16.5 | 5.5 | 8 to 27 |
| FM no interview* | 17 | 22.9 | 6.4 | 12 to 38 |
| **All General Internal Medicine**** | 13 | 26.8 | 9.8 | 16 to 46 |
| GIM interview | 3 | 21.0 | 3.6 | 18 to 25 |
| GIM no interview | 10 | 28.8 | 10.6 | 16 to 46 |
| Decade 1950s/60s | 2 | 22.0 | 7.1 | 17 to 27 |
| Decade 1970s | 10 | 20.1 | 9.6 | 8 to 40 |
| Decade 1980s | 28 | 20.0 | 7.8 | 8 to 46 |
| Decade 1990s | 12 | 24.5 | 7.7 | 11 to 41 |

* Statistically significant differences in Gerrity scores for interview/no interview.
** Statistically significant differences in Gerrity scores for pairing (e.g., men vs women).

Analysis showed that Canadians had lower levels of stress from uncertainty (19.1 vs 23.6 for US physicians, P = 0.04), men had less stress (19.5 vs 26.0 for women, P = 0.01), and family physicians also had less stress (19.3 vs 26.8 for general internists, P = 0.004). The lower scores for men and family physicians are consistent with other studies. The lower levels of stress in Canadian physicians was likely because the Canadian group did not include general internists—no differences were evident when comparing scores for risk attitude for Canadian family physicians with US family physicians.

When comparing the subgroups of interviewed and not interviewed physicians, lower Gerrity scores were seen for interviewed vs not interviewed physicians for men (P = 0.03), women (P = 0.005), Canadians (p = 0.008), US physicians (0.03), and internists (p = 0.002) but not for family physicians.

**Table 4-7. Cut Points for Gerrity Stress from Uncertainty Groups and Mean Scores for Each Group** Physicians were grouped according to their Gerrity scores. The table shows the scores for each group as well as corresponding Pearson scores. Pearson scores did not show the same range across groups as did Gerrity scores.

| Gerrity Group | Number | Cut Point Criterion | Mean Gerrity Score (SD) | Gerrity Range | Mean Pearson Score (SD) |
|---|---|---|---|---|---|
| **All** | 25 | n.a. | 17.0 (5.5) | 6 to 27 | 19.6 (6.0) |
| | | | | | |
| **Low stress** | 10 | Below 16 | 11.5 (2.4) | 8 to 15 | 17.7 (5.1) |
| **Moderate stress** | 4 | 16 to 18 | 17.0 (0.82) | 16 to 18 | 22.5 (6.9) |
| **High stress** | 11 | Above 18 | 22.1 (2.88) | 19 to 27 | 20.3 (6.4) |

The Gerrity SUS is composed of 2 subscales measuring stress from anxiety and concern with bad outcomes. As expected, progression occurs in the scores as one moves from low to high stress from uncertainty.

**Table 4-8. Gerrity Stress from Uncertainty Subscales: Stress from Anxiety and Concern with Bad Outcomes by Study Group.** The subcategory aspects of Stress From Uncertainty show an increase in both subcategories across the Gerrity groups from low stress through moderate to high stress from uncertainty.

| Gerrity Group | Stress from Anxiety* Mean (SD) | Concern with Bad Outcomes* Mean (SD) |
|---|---|---|
| **All Participants** | 11.5 (4.7) | 5.9 (2.7) |
| | | |
| **Low stress from uncertainty** | 8.3 (4.4) | 3.9 (1.3) |
| **Moderate stress** | 11.0 (2.7) | 6.0 (2.2) |
| **High stress from uncertainty** | 14.6 (3.6) | 7.7 (2.5) |

* Higher scores indicate more stress or concern.

Several of the baseline dependent variables could be potential confounders in this study. The Pearson and Gerrity scores have been stratified so their potential confounding on each other is acknowledged and dealt with. Country, discipline, and gender may also be confounders. I have not adjusted for this potential in any of the analyses.

## 4.5 PEARSON AND GERRITY SCORE OVERLAP FOR PARTICIPANTS

To further understand and describe the physician group that I interviewed, I describe the Pearson and Gerrity scores within and across the study groups. Pearson and colleagues found that risk attitude and stress from uncertainty scores were moderately correlated (Spearman rank correlation 0.36 (P = 0.0001)) with high significance for the 119 physicians in their study (11). Analysis of the data from the 52 participants in the dissertation study showed a very similar result of a moderate correlation with high significance (Spearman rank correlation 0.37 (P = 0.007)).

Normal distributions were expected for both Pearson and Gerrity scores based on previous studies (11, 12). The Kolmogovov-Smirnov test showed a normal distribution for the Gerrity scores (P = 0.007) and a trend towards normalcy for the Pearson scores (P = 0.16). The Shapiro-Wilk test of normalcy showed a stronger tendency towards normal data for the Gerrity scores (P = 0.003) and less normalcy for the Pearson scores (P = 0.4). I used very few analyses using the Pearson and Gerrity scores as continuous variables so this non-normalcy of the Pearson data does not affect my analyses. I indicate in all further analyses when I use continuous data for the independent variables.

The next analysis I looked at was the overlap of categories. Table 4-9 shows that very few physicians were in the middle categories of having moderate stress or being risk neutral. Because I had an almost even distribution of physicians in the combined (overlap) categories of low stress/risk seeking, low stress/risk avoiding, high stress/risk seeking, and high stress/risk avoiding I could assume my sample of 25 were stratified sufficiently so as to cancel out any possibility of one of the scales being a confounder for the other scale. The data were not stratified for other potential counfounders such as discipline, country, or gender.

In summary, the physicians screened had a wide range of risk attitude and uncertainty scores. The scores almost spanned the entire range of scores for both scales. The scores were as expected based on previous studies (e.g., women and internists reported higher levels of stress). The scales had moderate but highly statistically significant correlations. All analyses were done independently based on separate risk attitude and stress from uncertainty groups because of the significant correlation. With the risk groups in place, I moved to data analyses.

**Table 4-9. Overlap of Categories for Interviewed Physicians** The overlap between Pearson and Gerrity scores is consistently moderate as found in previous studies and is reflected above. Of note is the almost equal numbers in the 4 overlap groups (risk seeking/high stress, risk seeking/low stress, risk avoiding/high stress, and risk avoiding/low stress) indicating a stratified sample of physicians based on scores for risk attitude and comfort with uncertainty.

| **Pearson (Risk Attitude)** | **Gerrity (Stress from Uncertainty)** | | | |
|---|---|---|---|---|
| | **Low Stress** | **Moderate Stress** | **High Stress** | **Total** |
| **Risk Seeking** | 5 | 1 | 5 | 11 |
| **Risk Neutral** | 2 | 0 | 1 | 3 |
| **Risk Avoiding** | 3 | 3 | 5 | 11 |
| **Total** | 10 | 4 | 11 | 25 |

## 4.6 PARTICIPANT COMPUTER SKILLS AND FAMILIARITY WITH RESOURCES

Research indicates that previous use of computer resources is associated with performance in other computer tasks in general and to information retrieval specifically (39). Therefore I collected baseline data on participant use and

familiarity of computer systems. I also gathered the same information on the information resources I studied (**PIER** and **Clinical Evidence**) as well as the other commonly used information resources (**MEDLINE**, the Internet, and **UpToDate**). Responses to the questions were anchored, 5-point scales for sophistication (computers in general and the Internet) and familiarity (**MEDLINE**, **PIER**, **Clinical Evidence**, the Internet and **UpToDate**) and a 6-point scale for use.

All participants rated their sophistication with computers very highly—little use was made of the low anchors. All computer questions had responses that were grouped quite tightly together (Table 4-10). Very little range in choices was also seen on the use categories with very high use of computers in general and the Internet, moderate use of **MEDLINE** and **UpToDate,** and very low use of **PIER** and **Clinical Evidence** (Table 4-11). No statistically significant differences were found (t-test using scale designations turned into numerical scores) for familiarity/sophistication or computer use across the risk groups although a few differences in the data appear to be different when looking at the numerical data transferred back to scale anchors in Table 4-10.

**Table 4-10. Computer Sophistication/Familiarity by Risk Status—Mean numerical scores were transferred back to the scale anchor.** Mean numerical scores were transferred back to the scale anchor for presentation in the table. All scoring clustered around similar scores—very little range was seen. No statistically significant differences were found.

| Computer Resources | All participants | Risk Seeking | Risk Avoiding | Low Stress | High Stress |
|---|---|---|---|---|---|
| **All computers** | Sophisticated | Sophisticated | Sophisticated | Neither sophisticated or unsophisticated | Sophisticated |
| **Internet** | Familiar | Familiar | Familiar | Familiar | Somewhat familiar |
| **MEDLINE** | Familiar | Familiar | Familiar | Somewhat familiar | Familiar |
| **PIER** | Unfamiliar | Unfamiliar | Very unfamiliar | Unfamiliar | Unfamiliar |
| **Clinical Evidence** | Very Unfamiliar | Neither familiar or unfamiliar | Unfamiliar | Neither familiar or unfamiliar | Neither familiar or unfamiliar |
| **UpToDate** | Neither familiar or unfamiliar | Neither familiar or unfamiliar | Unfamiliar | Neither familiar or unfamiliar | Neither familiar or unfamiliar |

**Table 4-11. Computer Use by Risk Status—Mean numerical scores were transferred back to the scale anchors.** Mean numerical scores were transferred back to the scale anchor for presentation. Scoring clustered around similar scores—very little range was seen for the groups. No statistically significant differences were found.

| Task | All | Risk Seeking | Risk Avoiding | Low Stress | High Stress |
|---|---|---|---|---|---|
| **All computers** | Hourly | Daily | Daily | Daily | Hourly |
| **Internet** | Daily | Daily | Daily | Daily | Daily |
| **MEDLINE** | Monthly | Monthly | Monthly | Monthly | Monthly |
| **PIER** | Never | Never | Never | Never | Never |
| **Clinical Evidence** | Rarely | Rarely | Rarely | Rarely | Rarely |
| **UpToDate** | Rarely | Rarely | Rarely | Rarely | Rarely |

I end this section by noting that for the groups based on risk attitude and stress from uncertainty, very few differences in baseline characteristics were seen. The data on the Pearson and Gerrity scores of the participants screened and included is comparable with data from other studies and the correlation between the scores is also very similar to previous studies. The next step in the process was to analyze the searching outcomes and processes to ascertain if, and how, they differ based on the physicians' risk attitude (risk seeking and risk avoiding) and stress from uncertainty (low and high levels of stress).

## 4.7 QUESTION 1—OUTCOMES OF INFORMATION SEEKING AND USE

Many of the differences I expected to find in this dissertation study were likely going to be evident after analysis of the data from this second question:

> *What are the outcomes of searching for evidence using electronic resources (e.g., correctness and certainty of answer, time to decision, number of resources used) to answer simulated clinical questions and are they different for clinicians who have varying risk attitudes and levels of stress from uncertainty?*

The methods for Question 1 are described in Section 3.6 and center on the outcomes of answering the multiple-choice questions and searching for information using the physician's own preferred information resources. The first sets of analyses I performed were to ascertain how well clinicians answered the multiple-choice questions and if the use of information resources actually improved question-answering abilities. Hersh and colleagues (39, 62) found an improvement in scores when medical students searched **MEDLINE** and I wanted to determine if this finding carried over to practicing physicians.

Very few of the substantial number of studies of questions that clinicians have and the resources they use to answer them have looked at the issue of the resources providing the correct information. The study by Gorman and colleagues is an excellent exception to this statement (122). I had predicted that the results would show some differences in the risk and uncertainty groups. I predicted, however, that not all the outcomes would show differences. In addition, I expected to find more and bigger differences for the risk attitude analyses than for the stress from uncertainty analyses, which is consistent with studies looking at the scales in different domains. I had expected to find differences among the groups and a few surprises such as resources changing a correct answer to an incorrect one: I found few differences and even more surprises.

### 4.7.1 Total time and time spent on learning and tasks did not differ for risk groups

Because risk-avoiding physicians and those who report stress from uncertainty order more tests and referrals and often admit more patients, I expected this finding of more resource use would extend to the use of information resources. First, I postulated that physicians who were risk seeking and comfortable with uncertainty would spend less time searching for information. I did not discuss exact times when I set up interviews and I did not hurry or limit times for filling out baseline questionnaires, answering the multiple-choice questions, preparing for the think aloud process, or searching. I also was very careful not to look at my watch during the session or mention times to avoid cuing physicians to the timed nature of the study. I relied heavily on data from the audio taping process to time the specific tasks.

The tables that follow show that the times for each task and the total interview session were not different across Pearson risk attitude groups (Table 4-12) or Gerrity Stress from Uncertainty groups (Table 4-13). Although the differences seem to be a bit greater quantitatively in the Gerrity groups, no statistically significant differences

were found for any of the individual times or total time. However, these analyses were not fine grained and other analyses addressing additional potential differences are described in following sections.

**Table 4-12. Time Taken in Minutes (SD) for Tasks by Pearson Group.** Risk seeking and risk avoiding physicians used the same amount of time to complete training in think-aloud protocols and tasks (total and time for individual tasks).

| Task | Time taken in minutes for risk-seeking physicians (n = 11) | Time taken in minutes for risk-avoiding physicians (n = 11) |
|---|---|---|
| **Total time** | 23.6 (6.4) | 24.2 (4.9) |
| **Training time** | 3.4 (1.2) | 4.2 (1.1) |
| **Question 1 (search)** | 7.6 (4.9) | 7.1 (3.5) |
| **Question 2 (search)** | 5.9 (2.7) | 5.6 (4.0) |
| **Question 3 (preference)** | 3.5 (1.0) | 4.4 (1.9) |
| **Question 4 (preference)** | 3.3 (0.85) | 2.8 (1.2) |

**Table 4-13. Time Taken in Minutes (SD) for Tasks by Gerrity Group.** Physicians who report low and high levels of stress from uncertainty used the same amount of time to complete training in think-aloud protocols and tasks (total time and time for individual tasks).

| Task | Time taken in minutes for low-stress physicians (n = 10) | Time taken in minutes for high-stress physicians (n = 11) |
|---|---|---|
| **Total time** | 25.1 (6.4) | 22.9 (4.8) |
| **Training time** | 4.1 (1.5) | 3.3 (0.86) |
| **Question 1 (search)** | 7.7 (5.3) | 6.4 (2.8) |
| **Question 2 (search)** | 5.4 (3.0) | 6.6 (3.9) |
| **Question 3 (preference)** | 4.9 (2.5) | 3.5 (1.6) |
| **Question 4 (preference)** | 3.1 (1.3) | 3.2 (1.1) |

### 4.7.2 The number of correct answers was low and did not differ for risk groups

Pearson and colleagues have shown that although physicians use healthcare resources differently, they do not necessarily have different outcomes (e.g., rate of completed myocardial infarction). Therefore I predicted that I would not find differences in the scores on the multiple-choice questions before searching.

I used 19 of 20 questions from the study by Hersh and colleagues (39). These questions had been shown to be relatively difficult for the students. Medical students correctly answered a mean of 10.3 of the questions (56.5%) with the help of **MEDLINE** and nurse practitioners had fewer correct answers (mean 6.9 questions or 34.5%). Both groups had lower scores before the **MEDLINE** searching (32.3% correct for medical students and 31.7% for the nurse practitioner students)—and not substantially different than by chance alone (33.3%). One question from the original group was no longer relevant and I replaced it with a fairly difficult question provided by an expert physician. I also added 3 more questions that I used for the information preference tasks. These final 3 questions were uniformly well answered. (All of the questions are listed in Appendix B along with their answers.)

Because of the addition of the 3 well-answered questions and because the physicians were no longer students I felt that the physicians in my study would likely obtain similar or better scores than did the medical and nurse practitioner students even though the students had used **MEDLINE** to supplement their own knowledge base. Table 4-14 shows that the mean number of correct answers (10 answers correct or 43.5%) for all of the physicians is lower than the medical students and somewhat higher than the nurse practitioners after their **MEDLINE** use. The scores were somewhat higher than the students' answers without **MEDLINE**. Of note, this rate of 43.5% correct answers is not adjusted for chance. With the possibility of only 3 answers (yes, no, or insufficient data) anyone guessing blindly would be correct approximately 33.3% of the time.

**Table 4-14. Average Number of Correct Answers to 23 Multiple-Choice Questions.** Previous studies showed that although use of healthcare resources differed by risk status, often outcomes did not show differences. Physicians in the different risk attitude and stress from uncertainty categories did not show differences in the number of correct answers to the 23 multiple-choice questions—the rate of correct answers is surprisingly similar.

| Group | Average Number Correct (%) | Standard Deviation | Range |
|---|---|---|---|
| **All Participants** | 10.0 (43.5) | 2.4 | 5 to 14 |
| **Pearson Scores** | | | |
| **Risk Seeking** | 10.1 (43.9) | 1.7 | 8 to 13 |
| **Risk Avoiding** | 9.9 (43.0) | 2.6 | 6 to 14 |
| **Gerrity Scores** | | | |
| **Low Stress** | 10.0 (43.5) | 3.0 | 5 to 14 |
| **High Stress** | 10.2 (44.3) | 2.1 | 7 to 13 |

As predicted, the groups did not differ for their rate of correct answers based on their Pearson or Gerrity scores (p = 0.8 for both)—analogous to finding no differences in the outcomes of care the physicians provided despite differential use of healthcare resources. The scores are surprisingly the same, ranging from 9.9 to 10.2 mean correct answers across all risk/uncertainty groups. Another way of looking at the possibility of differences in scores according to Pearson or Gerrity scores, correlational analyses showed that neither Pearson (coefficient –0.013, p > 0.9) nor Gerrity scores (coefficient -0.05, P = 0.8) were associated with number of correct answers.

**Table 4-15. Proportion of Correct Answers to Questions (mean and standard deviation) by Individual Question and Risk Group for All 23 Questions.** The individual questions varied substantially in how often they were answered correctly, from 0.0 to .91. Of note is the size of the standard deviation, showing a wide range of correct answers. The statistically significant differences are likely obtained by chance alone.

| Question | Type | All Physicians (n = 25) | Risk Seeking (n = 11) | Risk Avoiding (n = 11) | Low Stress (n = 10) | High Stress (n = 11) |
|---|---|---|---|---|---|---|
| 1 | Diagnosis | 0.64 (0.49) | 0.91 (0.30)* | 0.45 (0.52)* | 0.70 (0.48) | 0.55 (0.52) |
| 2 | Prognosis | 0.44 (0.51) | 0.55 (0.52) | 0.36 (0.50) | 0.10 (0.32)* | 0.72 (0.47)* |
| 3 | Treatment | 0.32 (0.48) | 0.45 (0.52) | 0.18 (0.40) | 0.20 (042) | 0.27 (0.47) |
| 4 | Prognosis | 0.08 (0.28) | 0.00 (0.00) | 0.09 (0.30) | 0.10 (0.31) | 0.00 (0.00) |
| 5 | Diagnosis | 0.88 (0.33) | 0.82 (0.40) | 0.91 (0.30) | 0.80 (0.42) | 0.91 (0.30) |
| 6 | Treatment | 0.44 (0.51) | 0.55 (0.52) | 0.27 (0.47) | 0.20 (0.42) | 0.55 (0.52) |
| 7 | Treatment | 0.60 (0.50) | 0.55 (0.52) | 0.55 (0.52) | 0.06 (0.52) | 0.73 (0.47) |
| 8 | Treatment | 0.16 (0.37) | 0.09 (0.30) | 0.18 (0.40) | 0.10 (0.32) | 0.27 (0.47) |
| 9 | Treatment | 0.80 (0.41) | 0.91 (0.30) | 0.73 (0.47) | 0.90 (0.32) | 0.73 (0.47) |
| 10 | Etiology | 0.00 (0.00) | 0.00 (0.00) | 0.00 (0.00) | 0.00 (0.00) | 0.00 (0.00) |
| 11 | Treatment | 0.38 (0.49) | 0.50 (0.53) | 0.27 (0.47) | 0.50 (0.53) | 0.30 (0.48) |
| 12 | Diagnosis | 0.52 (0.51) | 0.45 (0.52) | 0.45 (0.52) | 0.50 (0.53) | 0.55 (0.52) |
| 13 | Treatment | 0.16 (0.37) | 0.00 (0.00) | 0.27 (0.47) | 0.30 (0.48)* | 0.00 (0.00)* |
| 14 | Prognosis | 0.16 (0.37) | 0.18 (0.40) | 0.09 (0.30) | 0.10 (0.32) | 0.18 (0.40) |
| 15 | Etiology | 0.84 (0.37) | 0.73 (0.47) | 0.91 (0.30) | 0.90 (0.32) | 0.82 (0.40) |
| 16 | Etiology | 0.24 (0.44) | 0.09 (0.30) | 0.36 (0.50) | 0.20 (0.42) | 0.18 (0.40) |
| 17 | Etiology | 0.20 (0.41) | 0.00 (0.00)* | 0.36 (0.50)* | 0.30 (0.48) | 0.09 (0.30) |
| 18 | Prognosis | 0.20 (0.41) | 0.18 (0.40) | 0.18 (0.40) | 0.20 (0.42) | 0.18 (0.40) |
| 19 | Treatment | 0.36 (0.49) | 0.36 (0.50) | 0.36 (0.50) | 0.10 (0.32)* | 0.64 (0.50)* |
| 20 | Prognosis | 0.40 (0.50) | 0.45 (0.52) | 0.45 (0.52) | 0.40 (0.52) | 0.36 (0.50) |
| 21 | Treatment | 0.60 (0.50) | 0.73 (0.47) | 0.55 (0.52) | 0.70 (0.48) | 0.54 (0.52) |
| 22 | Treatment | 0.60 (0.50) | 0.55 (0.52) | 0.55 (0.52) | 0.60 (0.52) | 0.45 (0.52) |
| 23 | Treatment | 0.75 (0.44) | 0.91 (0.30) | 0.64 (0.50) | 0.91 (0.30) | 0.64 (0.50) |

* P < 0.05 for the difference between the risk status groups (risk seeking vs risk avoiding or high and low levels of stress from uncertainty).

Breaking the answers down by question (Table 4-15) showed some differences across the risk attitude and stress from uncertainty levels but these were likely due to chance—5 statistically significant differences were seen and by

chance alone, 2 to 3 were predicted. Also the statistically significant differences do not favor the same group, another indication that the observed differences are not likely to be real. Considerable variation in proportion of correct answers was seen across questions. Question 10 was difficult and I checked the answer carefully with the expert physician to make sure the original answer remained correct. No one got a correct answer.

The times and number of correct answers did not differ across the groups based on risk attitude and levels of stress from uncertainty. The next step was to look at more of the processes to determine if differences in other aspects of information seeking and searching based on risk status exist.

### 4.7.3 Increased certainty was associated with correctness of answers but not risk groups

In addition to indicating their answer to the question, physicians also listed their certainty of their answer on a scale of 0% to 100% and whether they would look up the answer to the question if it arose during their clinics. Clinicians who need information must be aware of their need for information or updating before they will pursue answers—they need to know when they truly do not know and this is often difficult to ascertain. As shown by Friedman and colleagues (126), even experienced clinicians may be unaware of the correctness of their decisions. Data from this dissertation adds to that article's findings.

Data in Table 4-16 indicate that the physicians in the study were more certain of their answer when their answers were correct than when the answers were incorrect. This pattern holds for physicians who are risk avoiding and risk seeking as well as those with high and low levels of stress from uncertainty. This difference in certainty associated with incorrect and correct answers is in the range of an absolute difference of 9% to 12%. Although this is substantial and a statistically significant difference, it may actually not be clinically important. Physicians may be less certain of their answers when they are incorrect but this difference in certainty (from approximately 60% to about 70%) may not be large enough to direct the physician to take time from the clinic and proceed to search for the correct answer. Data to support this statistically significant but possibly clinically insignificant finding are in the next section (Section 4.7.4).

A visual assessment of the data shows what could be considered to be a trend towards more certainty if the physician is risk seeking rather than risk avoiding or more comfortable with uncertainty. Statistical analyses do not

support this difference, most likely because of the substantial variation (large SDs) in the data set. Therefore risk attitude and stress from uncertainty do not appear to be associated with differences in perception of certainty when answers to multiple-choice questions are correct or incorrect.

**Table 4-16. Physician Certainty Associated with Correct and Incorrect Answers.** Physicians indicated for each question how certain they were with the answer. They were statistically significantly more certain if the answer was correct than if the answer was incorrect. No statistically significant differences according to risk status were seen. The data showed substantial variability.

| Group | Percent certainty of answer if answer was correct (SD) | Percent certainty of answer if answer was incorrect (SD) | P value for difference comparing incorrect with correct answers |
|---|---|---|---|
| **All Participants** | 70.5 (11.8) | 60.2 (12.3) | 0.0004 |
| **Pearson Scores** | | | |
| **Risk Seeking** | 74.2 (7.9) | 63.1 (10.9) | 0.007 |
| **Risk Avoiding** | 70.2 (10.2) | 57.8 (12.2) | 0.001 |
| **Gerrity Scores** | | | |
| **Low Stress** | 71.7 (10.9) | 61.4 (12.0) | 0.03 |
| **High Stress** | 69.5 (13.6) | 60.4 (14.1) | 0.03 |

### 4.7.4 Choosing to look up an answer was not associated with correct answers or risk groups

Another measure of the ability of physicians to know when they need to look up information is to ask them if they would look up the answer to each of the multiple-choice questions if they would have come up in their daily practices. The data in Table 4-17 show that the participants did not indicate that they would look up the questions that they had answered incorrectly at a different rate than those questions that they answered correctly. The physicians in this study did not know that they did not know the answers to the multiple-choice clinical questions. This finding of seeming inability to know when to look up an answer renders the decreased certainty with incorrect answers, clinically unimportant as postulated in the previous section (Section 4.7.3).

Analysis of the difference in willingness to look up answers across risk groups showed that physicians in the risk/uncertainty groups did not differ for this aspect of information seeking and use. Willingness to look up an answer is not associated with certainty on a per-person basis but is when assessed on a per-question basis it is—

those questions that a physician would look up were given a lower certainty rating (55.6% (SD 25.9) for lookup questions vs. 69.3% (SD 29.9) for non-lookup questions or an absolute difference of 13.7%). Ultimately physicians do not know when they need to look up information—adding more evidence to the need to provide accurate and effective prompting information resources into electronic medical records systems.

**Table 4-17. Willingness to Look Up an Answer for Questions that were Given Correct and Incorrect Answers.** Physicians were not able to determine the questions they needed to follow up with a search for the correct answer. This inability was the same across the risk scales.

| Group | Percentage of questions that would look up if answer was correct | Percentage of questions that would look up if answer was incorrect | P value for difference |
|---|---|---|---|
| **All Participants** | 41.2 | 39.7 | n.s. |
| **Pearson Scores** | | | |
| **Risk Seeking** | 37.6 | 34.4 | n.s. |
| **Risk Avoiding** | 36.4 | 37.0 | n.s. |
| **Gerrity Scores** | | | |
| **Low Stress** | 33.6 | 45.1 | n.s. |
| **High Stress** | 40.6 | 42.1 | n.s. |

In summary, physicians answered only a small number of questions correctly. This rate of correctness did not differ across risk groups as predicted. Other differences in searching for information and use of information were postulated. Using the dissertation data, no differences were found for:

- Time spent in searching for information (total or based on individual tasks)
- Certainties associated with answers were higher for correct answers than for incorrect ones and this difference was the same across risk groups
- Willingness to look up information was not associated with the correctness of the answer or with any risk group although willingness to look up information was associated with certainty assessments given to the answers.

The next section deals with other aspects of the searching and information use process as set out in dissertation question 2. The data are more fine grained, coming from the transcribed and coded think-aloud protocols. If any differences were present across the risk status groups, these analyses would have identified them.

## 4.8 QUESTION 2—PROCESSES OF INFORMATION SEEKING AND USE

Question 2 deals with the process and models of the information searching and use that physicians employ:

> *What electronic information seeking and use processes do primary care physicians with different risk attitudes (risk seeking and risk avoiding) and levels of stress from uncertainty employ when answering simulated clinical questions and how can the processes be modeled by using the modified Wilson Problem-Solving Model (from information science) and the Information Foraging/ Information Scent Model built by Card and Pirolli (from information processing and human computer interaction domains)?*

Section 3.6 describes the methods used to address this question. I expected to see substantial numbers of difference in process for physicians based on their risk attitude and reported stress from uncertainty with those who are risk avoiding and feel stress from uncertainty using more resources or using them longer or more intensively. I also expected to see more or larger differences with analysis of the Pearson Risk Attitude scores rather than the Gerrity SUS scores. I based this prediction on the larger differences observed in care processes and resource use when the 2 scales have been compared in the same studies. I did not see these projected differences in my data analyses. The rest of this section reports on the processes that I investigated. A summary of the findings on these variables is in Section 4.11.

With regard to the modified Wilson Problem Solving Model and the Card/Pirolli Information Foraging Model, I had predicted that the processes I elucidated would fit very nicely into the models with little or no modification. These models have proved to be robust in various other domains and instances and I felt that they would closely describe information seeking and use in medicine as well. In addition, both models can easily account for

uncertainties and need for checking and verification in multiple ways—both features that are present in the risk scales I am using as the basis for this study. The processes that I found did fit both models well despite finding few differences in process based on risk status. A summary of how I developed the coding and implemented full coding is in Section 3.7.4. A summary follows in the next section.

### 4.8.1 Description of coding for searching using the physician's own resources

The methods for the development and formative analyses of the coding for the think-aloud data were described in Section 3.6 and 3.7.4. The full list of the codes I used and an example of a coded session are in Appendix D and F.

### 4.8.2 The number of segments and codes did not differ for risk groups

One area of possible differences in information searching and use across the risk groups is the number of segments in the transcribed documents and codes that are applied to the think-aloud protocol data. As described previously in Section 3.6, a segment is piece of a verbal protocol that has a single operator and idea or theme, often part of a sentence or a single utterance. After the transcriptions were segmented, each segment was assigned codes. Any given segment could have no codes, a single code, or multiple codes. The number of segments and codes for the total searching process (2 searches) and separate tasks follow, broken down by risk status.

Although multiple differences were predicted, only 1 difference was observed across risk groups and tasks: More codes were associated with the low-stress physician group compared with the high-stress group (mean per physician, 219.6 vs 154.4, $P = 0.04$). The few differences could be because of the absence of true differences or because of the large variation in the data and the small sample size of the risk status groups (power issues). Some apparent differences were visually, but not statistically more pronounced for the comparisons of low- and high-stress groups (Gerrity) than for risk seeking/avoiding (Pearson). An example of the visual but not statistically significant differences is that in every case except for 1 (in italics), risk-avoiding and high-stress physicians were assigned fewer segments and fewer codes than the risk-seeking and low-stress physicians.

**Table 4-18. Mean Number of Segments (SD) for the Interview and Each Task per Physician Across 2 Searches.** The number of segments per physician was combined for 2 searches. Only 1 difference was found (total codes for low- and high-stress physicians). For every comparison except 1, risk-avoiding and high-stress physicians have fewer segments. Search 1/2 used chosen resources. Search 3/4 used **PIER** and **Clinical Evidence.**

| Task | All Participants | Risk Seeking Group | Risk Avoiding Group | Low Stress Group | High Stress Group |
|---|---|---|---|---|---|
| **All** | 186.8 (67.0) | 186.4 (53.8) | 164.8 (71.5) | 219.6 (70.1)* | 154.4 (58.2)* |
| **Search 1** | 62.9 (35.7) | *62.2 (32.4)* | *63.8 (42.3)* | 73.0 (45.2) | 51.6 (26.4) |
| **Search 2** | 52.3 (29.0) | 57.0 (30.0) | 46.1 (29.6) | 60.3 (36.1) | 47.9 (23.6) |
| **Search 1&2** | 115.2 (55.4) | 119.2 (45.6) | 109.9 (66.6) | 133.3 (69.5) | 99.4 (42.5) |
| **Search 3** | 42.9 (27.0) | 39.7 (12.8) | 33.1 (16.4) | 54.0 (33.8) | 31.0 (16.6) |
| **Search 4** | 28.1 (14.5) | 27.6 (9.1) | 22.1 (8.2) | 32.3 (19.0) | 24.0 (9.1) |
| **Search 3&4** | 71.0 (39.5) | 67.2 (17.8) | 55.2 (22.1) | 86.3 (51.7) | 55.0 (22.4) |

* P = 0.04 for difference between Low and High Stress Groups

**Table 4-19. Mean Number of Codes for the Interview and Each Task per Physician Across 2 Searches.** The number of codes for each physician was combined for all searches. The data has large standard deviations (substantial variation). No differences were found although all comparisons had fewer codes for risk-avoiding and high-stress physicians. Search 1/2 used selected resources. Questions 3/4 used **PIER** and **Clinical Evidence**.

| Task | All Participants | Risk Seeking Group | Risk Avoiding Group | Low Stress Group | High Stress Group |
|---|---|---|---|---|---|
| **All** | 213.8 (75.6) | 217.1 (61.8) | 177.4 (61.73) | 242.9 (80.3) | 187 (71.5) |
| **Search 1** | 74.8 (41.0) | 77.8 (39.0) | 70.7 (47.2) | 80.4 (51.4) | 66.1 (33.2) |
| **Search 2** | 57.4 (33.0) | 65.3 (39.5) | 46.7 (23.0) | 61.6 (39.3) | 57.8 (31.5) |
| **Search 1&2** | 131.5 (59.7) | 143.1 (58.0) | 117.4 (30.4) | 142.0 (72.6) | 123.9 (27.0) |
| **Search 3** | 47.3 (34.7) | 42.1 (13.6) | 33.3 (18.6) | 60.6 (45.0) | 34.7 (21.1) |
| **Search 4** | 33.7 (21.5) | 32.7 (14.3) | 26.0 (14.3) | 41.3 (29.8) | 29.0 (8.9) |
| **Search 3&4** | 81.0 (53.3) | 74.8 (19.2) | 59.3 (22.3) | 101.9 (71.9) | 63.7 (27.6) |

### 4.8.3 Cycles of searching did not differ for risk groups

I next looked at how many cycles each of the searchers completed within their 2 searching sessions to determine if risk status is associated with differences in the searching process. I defined a cycle as one that involved choosing

and searching a resource (e.g., **MEDLINE**), looking at the retrieval, and possibly a document or article. If the searcher then started a new search in that resource or moved to a new resource, this signaled the end of a cycle and the start of the next. This is analogous to the patches described in the Card/Pirolli model. Cycles of searching have been considered by others researchers such as Wildemuth (127). The data in Table 4-20 show that the average number of cycles per searcher across 2 searches is not associated with risk attitude or levels of uncertainty stress.

My next analysis looked at the proportion of the searching process that was dedicated to active searching and application of new knowledge. During interviews and transcription, I noticed that some of the participants would be more focused on the task than others who would discuss aspects of information use that did not build towards an answer or decision.

**Table 4-20. Average Number of Cycles per Searcher across 2 Searching Sessions.** Cycles within a searching session are an important aspect of searching (Card/Pirolli patches). Neither risk attitude nor stress from uncertainty was associated with the average number of cycles across searches. The data had substantial variation (large SDs).

| Group | Average Number of Cycles per Physician | Standard Deviation | P-value for comparison of risk groups |
|---|---|---|---|
| **All Participants** | 4.0 | 1.9 | n.a. |
| **Pearson Scores** | | | |
| **Risk Seeking** | 4.3 | 2.3 | n.s. |
| **Risk Avoiding** | 3.5 | 1.5 | |
| **Gerrity Scores** | | | |
| **Low Stress** | 3.9 | 2.5 | n.s. |
| **High Stress** | 4.2 | 1.4 | |

### 4.8.4 Proportion of active vs passive time was different for Gerrity but not Pearson risk groups

An aspect that seemed to vary across searchers was the proportion of the searching session spent on actual searching, assessment of the retrievals, and application of the knowledge. I defined active searching as being assigned the following codes:

3.14 Go to resource

3.23 Go to search engine

| | | |
|---|---|---|
| 4.11 to 4.12 | Discuss question/Read question | |
| 4.4 to 4.5 | Search methods/stop searching | |
| 4.9 | modify search strategy | |
| 5 | Work with retrieval | |
| 6 | Work with documents/web pages/web sites | |
| 7.3 | Make decision | (see Appendix D) |

From the data in Table 4-21, physicians with high levels of stress spent the highest proportion of the search process actively searching while those with the lowest levels of stress spent statistically significantly less time. No difference was seen in the proportion of the sessions spent in active searching, assessment and application between risk-seeking and risk-avoiding physicians. The observed difference across the Gerrity groups may be real or just obtained by chance. With the number of comparisons made, several will be found significant by chance alone. However this finding of more active processing is consistent with the trend towards increased numbers of changed decisions for physicians who report high levels of stress from uncertainty (see Section 4.8.6). The next section deals with different aspects (code categories) of the searching process as assessed by the coded protocols.

**Table 4-21. Mean Proportion of Active Searching for Each Searcher during 2 Search Sessions.** Searching sessions included codes related to actively pursuing answers and more general discussions of searching and information use in general. This table assess if the physicians in the risk groups differed on this aspect. High-stress physicians had a higher proportion of codes related to active searching and information application.

| Group | Average Number Correct | Standard Deviation | P-Value for group comparison |
|---|---|---|---|
| **All Participants** | 0.60 | 0.11 | Not applicable |
| **Pearson Scores** | | | |
| **Risk Seeking** | 0.59 | 0.09 | n.s. |
| **Risk Avoiding** | 0.63 | 0.11 | |
| **Gerrity Scores** | | | |
| **Low Stress** | 0.54 | 0.10 | P = 0.03 |
| **High Stress** | 0.64 | 0.09 | |

### 4.8.5 Categories of search process and proportion of the searching process spent on each

The coding scheme broke the searching sessions into different aspects or subcategories. This section describes the subcategories and lists the proportion of the searching processes that physicians in the risk groups spent doing each of the general aspects of searching. These subcategories are fully listed in Appendix D and those that were analyzed follow:

- General discussions around searching and use of information in clinical decision making (Code 2.0)
- Resources and search engines used (Code 3.0)
- Searching methods discussed and used (looking for information) (Code 4.0)
- Dealing with search retrievals (Code 5.0)
- Dealing with documents and web pages (Code 6.0)
- Application of information to the question (Code 7.0)
- Searching heuristics (Code 8.0)

In addition, the table includes the number of searching heuristics that I identified from the searching transcripts. These heuristics are statements related to actions of the participants and can be thought of as being the foundation or internal rules of why and how the physician proceeds as he or she does in an information seeking/decision-making situation. Several examples of these searching heuristics and their subcategories follow. These heuristics are analyzed further in Section 4.8.8.

- Heuristic-trust: I need to know the source of something before I can trust it.
- Heuristic-presentation: I like the numbers to be given in a standard useful format.
- Heuristic-feature: I want more than looks in a resource-content and evidence count more.
- Heuristic-application: I want to make my own decision, not be told by others.
- Heuristic-application: I want a resource that matches the way I practice.
- Heuristic-questions: I spend more time on decisions if the question is important to me.

Statistical analyses showed that the risk groups did not differ for number of codes used in searching either for the total number of codes or the number of subcategory codes devoted to each of the 7 aspects of the searching process. A similar pattern was seen for the proportion of codes for each category compared with the total number of codes for a searcher across the 2 search sessions. No differences were seen when comparing physicians who were risk seeking and risk avoiding except that those physicians who were risk seeking had almost twice as many heuristic codes (16.3 vs 8.4, P = 0.015). When the physicians with low and high levels of stress were compared, those with high stress were coded as having relatively smaller proportion of codes for general discussions (0.8 vs 0.5, P = 0.05) and a trend towards fewer heuristic codes (14.4 vs 9.7, P = 0.1). This finding of fewer heuristic codes contributed to high-stress physicians spent a larger amount of their efforts on more active aspects of searching (Section 4.8.4).

**Table 4-22. Number (SD) of Codes for Each Searching/Information Use Category—Reported per Physician Across 2 Searches.** The number of codes in each category of the searching/information use categories did not differ across the risk status groups except that the number of heuristics was higher for risk seeking physicians and showed a trend for being higher in the low-risk group compared with their counterparts.

| Category | All Participants | Risk Seeking Group | Risk Avoiding Group | Low Stress Group | High Stress Group |
|---|---|---|---|---|---|
| **General discussions** | 7.5 (6.9) | 6.3 (3.4) | 8.5 (9.9) | 10.4 (8.7) | 5.5 (4.2) |
| **Resources** | 13.3 (9.0) | 12.9 (5.9) | 10.1 (3.6) | 11.9 (6.8) | 15.5 (12.3) |
| **Searching** | 29.3 (12.0) | 31.6 (14.0) | 25.1 (11.0) | 29.7 (13.4) | 30.0 (12.1) |
| ***Addressing question**** | *4.2 (2.4)* | *3.4 (1.5)* | *4.6 (2.8)* | *4.1 (2.7)* | *4.7 (2.5)* |
| **Retrievals** | 7.7 (4.7) | 8.6 (6.0) | 7.1 (4.3) | 7.9 (5.7) | 6.9 (4.0) |
| **Documents** | 42.4 (26.9) | 45.7 (31.9) | 39.9 (22.6) | 46.5 (33.6) | 40.3 (22.9) |
| **Application** | 14.0 (9.2) | 14.9 (6.7) | 12.2 (11.5) | 17.0 (11.7) | 12.2 (6.3) |
| | | | | | |
| **Number of Heuristics** | 12.2 (7.8) | 16.3 (9.1)** | 8.4 (5.6)** | 14.4 (6.2)*** | 9.7 (7.28)*** |

* These data for Addressing the question are included in the Searching Category.
** P = 0.015
*** P = 0.1

**Table 4-23. Proportion (SD) of Codes for Each Searching/Information Use Category—Reported per Physician Across 2 Searches.** The proportion of codes in each category did not differ across the groups except that the proportion of general discussion codes was higher for physicians in the low-risk group.

| Category | All Participants | Risk Seeking Group | Risk Avoiding Group | Low Stress Group | High Stress Group |
|---|---|---|---|---|---|
| **General discussions** | 0.07 (0.04) | 0.05 (0.03) | 0.08 (0.06) | 0.08 (0.05)** | 0.05 (0.03)** |
| **Resources** | 0.11 (0.04) | 0.11 (0.03) | 0.11 (0.04) | 0.10 (0.04) | 0.13 (0.04) |
| **Searching** | 0.27 (0.11) | 0.28 (0.14) | 0.25 (0.07) | 0.26 (0.14) | 0.29 (0.09) |
| ***Addressing Question**** | 0.02 (0.01) | 0.02 (0.01) | 0.03 (0.01) | 0.02 (0.01) | 0.03 (0.01) |
| **Retrievals** | 0.07 (0.03) | 0.07 (0.03) | 0.07 (0.03) | 0.06 (0.02) | 0.07 (0.03) |
| **Documents** | 0.35 (0.12) | 0.36 (0.15) | 0.38 (0.01) | 0.35 (0.15) | 0.35 (0.10) |
| **Application** | 0.12 (0.05) | 0.13 (0.04) | 0.12 (0.07) | 0.13 (0.05) | 0.12 (0.06) |

* These data for Addressing the Question are included in the Searching Category.
**P = 0.05 for the comparison of low and high-stress groups.

#### 4.8.5.1 Physicians used many resources during searching.

The study physicians used their preferred information resources to answer clinical questions with no restrictions on choice of resource. I did not restrict them to computerized resources and although several mentioned using books and contacting experts or peers all participants used electronic resources. Because the resources did not improve scores and many answers being changed, it is important to ascertain what resources the physicians used. (This result of unimproved scores has not been described yet—see Section 4.8.6.) In the following table I collapsed data from individual physicians and questions to present the number of times a resource was used in the risk groups. Using Fisher exact tests, no differences were found for the overall comparison of risk-seeking and risk-avoiding physician and low-risk vs high-risk physician groups ($P < 0.5$) for number of resources used. I completed 3 subgroup analyses looking at risk groups and separate groups of resources and the results of these are as follows:

- Strongly evidence-based resources/synopses (**Clinical Evidence**, **Cochrane Database of Systematic Reviews**, and **OVID Evidence Based Medicine Reviews**) vs. other resources—no differences for risk groups ($P = 0.5$)

- Distilled resources or summaries and synopses (**Clinical Evidence**, **Cochrane Database of Systematic Reviews**[38], and **OVID Evidence Based Medicine Reviews©**[39], **UpToDate**, and **InfoPOEMs**) vs. all other resources—no difference except for a trend for more use of the resources for risk-avoiding physicians (P = 0.07)
- **MEDLINE** (**OVID MEDLINE**[40] and PubMED) or studies vs. other resources—no difference in risk-seeking vs. risk-avoiding physicians and a trend for less use of **MEDLINE** in the high-stress physicians (P = 0.07).

**Table 4-24. Number and Percentage of Different Resources Used by Risk Status.** Data were collapsed into one group and analysis was done looking at the number of resources used. No differences were found, especially in the average in question. Some subgroup analyses showed a trend towards different use of resources.

| Resource | All Participants (%) | Risk Seeking Group (%) | Risk Avoiding Group (%) | Low Stress Group (%) | High Stress Group (%) |
|---|---|---|---|---|---|
| **Clinical Evidence** | 2 (2.4) | 0 (0) | 0 (0) | 2 (5.9) | 0 (0) |
| **Cochrane** | 8 (9.8) | 1 (2.9) | 5 (13.5) | 2 (5.9) | 3 (8.8) |
| **InfoPOEMs** | 4 (4.9) | 1 (2.9) | 4 (10.8) | 1 (2.9) | 4 (11.8) |
| **Lancet ©**[41] | 2 (2.4) | 1 (2.9) | 1 (2.7) | 1 (2.9) | 1 (2.9) |
| **MD Consult©**[42] | 7 (8.5) | 3 (8.6) | 4 (10.8) | 2 (5.9) | 5 (14.7) |
| **OVID EBMR** | 7 (8.5) | 4 (11.4) | 3 (8.1) | 4 (11.8) | 3 (8.8) |
| **OVID MEDLINE** | 19 (22.3) | 11 (31.4) | 8 (21.6) | 8 (21.6) | 6 (17.6) |
| **PubMED** | 11 (13.4) | 5 (14.3) | 3 (8.1) | 6 (17.6) | 1 (2.9) |
| **UpToDate** | 5 (6.1) | 3 (8.6) | 2 (5.4) | 1 (2.9) | 4 (11.8) |
| **Google** | 17 (19.5) | 7 (17.1) | 7 (18.9) | 7 (21.6) | 8 (21.6) |
| | | | | | |
| **Average/question** | 1.6 | 1.6 | 1.7 | 1.7 | 1.5 |
| **Total resources** | 82 | 36 | 37 | 34 | 35 |

The mean number of resources used was very similar across groups, in the range of 1.5 to 1.7 different resources per search. To summarize, the number and percentage of resources used does not vary according to risk status. However

[38] **Cochrane Database of Systematic Reviews**. This is the database produced by the **Cochrane Collaboration**. All articles are systematic reviews of treatment or intervention studies. More than 2000 reviews are included on all areas of healthcare. Accessed July 17, 2005.

[39] **OVID Evidence Based Medicine Reviews ©.** This service from OVID Technologies is a database that encompasses all **Cochrane systematic reviews**, **ACP Journal Club** abstracts, (http://www.ovid.com/site/index.jsp?top=1). Accessed July 17, 2005.

[40] **OVID MEDLINE.** OVID provides direct online access to the MEDLINE database through their own front end. (http://www.ovid.com/site/index.jsp?top=1). Accessed July 17, 2005.

[41] **Lancet** © Elsevier 2005. (http://www.thelancet.com/). Accessed July 17, 2005.

[42] **MD Consult. Elsevier 2005**A service that combines a selection of textbooks, guidelines, and a MEDLINE service. (http://www.mdconsult.com/offers/standard.html). Accessed July 17, 2005.

trend towards more use of distilled resources in the risk-avoiding group and more use of **MEDLINE** in the low-stress group are seen. I next looked at the search methods used by physicians and if this aspect varied by risk status.

#### 4.8.5.2 Searching methods used

As discussed in the previous section, it is important to understand what features of searching were related to obtaining and maintaining initially correct answers to clinical questions and if differences are evident across risk/uncertainty groups (Table 4-24). A considerable variety of searching methods were used. Overall, risk-seeking physicians and risk-avoiding physicians showed a trend towards different search methods (P = 0.2).

**Table 4-25. Number and Percentage of Search Methods Used by Risk Status.** The number of searching methods used across risk status groups is shown. Very little difference is seen in the mean number of methods per question but some differences are seen in the groups for different resources.

| Search Method Mentioned | All Participants | Risk Seeking Group* | Risk Avoiding Group* | Low Stress Group | High Stress Group |
|---|---|---|---|---|---|
| **Cache and highlight**[43] | 4 (1.5) | 4 (3.1) | 0 (0) | 0 (0) | 4 (3.1) |
| **Do search again** | 9 (5.8) | 4 (3.1) | 5 (3.6) | 1 (0.9) | 5 (3.9) |
| **Control F to find** | 10 (3.7) | 9 (7.0)** | 1 (0.7)** | 3 (2.6) | 7 (5.3) |
| **Keyword** | 119 (44.2) | 46 (35.9) | 52 (37.7) | 43 (37.7) | 53 (40.5) |
| **Combine** | 27 (10.0) | 9 (7.0) | 17 (12.3) | 8 (7.0) | 11 (8.5) |
| **Explode** | 3 (1.1) | 2 (1.6) | 1 (0.7) | 2 (1.8) | 1 (0.8) |
| **Focus** | 3 (1.1) | 2 (1.6) | 1 (0.7) | 2 (1.8) | 1 (0.8) |
| **Limit** | 38 (14.1) | 21 (16.4) | 16 (11.6) | 20 (17.5) | 15 (11.5) |
| **Subheadings** | 14 (5.2) | 6 (4.7) | 8 (5.8) | 4 (3.5) | 10 (7.6) |
| **MeSH**[44]**®** | 24 (8.9) | 13 (10.1) | 11 (8.0) | 11 (9.6) | 12(9.2) |
| **Use whole question** | 5 (1.9) | 3 (2.3) | 2 (1.4) | 4 (3.5) | 1 (0.8) |
| **Spelling issues** | 12 (4.5) | 7 (5.5) | 2 (1.4) | 7 (6.1) | 3 (2.3) |
| **Table of contents** | 11 (4.1) | 2 (1.6) | 7 (5.1) | 4 (3.7) | 7 (5.3) |
| | | | | | |
| **Average/question** | 5.6 | 5.8 | 6.3 | 6.3 | 5.7 |
| **Total** | 269 | 128 | 138 | 114 | 130 |

* P = 0.2 for the difference between risk seeking and risk avoiding for all searching methods.
** P = 0.01 for the difference between risk-seeking and risk-avoiding physicians.

[43] Cache and Highlight is a technique that allows for the search terms used in a retrieval exercise to be hightlighed in color. Often different terms are given different colors so that a searcher can quickly see instances of ideas or concepts in retrieved documents.
[44] **MeSH**. Medical subject headings used by indexers to index documents in production of **MEDLINE**. US National Library of Medicine. Accessed July 18, 2005.

Few individual search methods however showed differences across the groups. Risk-seeking physicians used more Control Find's[45]. The mean number of search methods across the 2 searches showed only a small amount of spread (5.5 to 6.1 search methods/search). Very few, if any real differences were seen in the number or proportion of search methods used across the risk/uncertainty groups.

#### 4.8.5.3 Other Aspects of Searching

I did not analyze the other aspects of searching (working with retrievals, assessment or critical appraisal of the documents, or application of the found information). However, looking at the data in Table 4-23, the proportion of the search process that physicians spent on the different aspects showed much similarity across groups with only those physicians who reported high levels of stress from uncertainty using less of their effort on discussing general features and processes related to searching in general rather than on the specific search task at hand. The majority of the searching effort was placed on working with the identified documents (35%) and the searching itself (27%) with application issues and working with resources and search engines in preparation of actual searching consuming similar amounts of effort (12% and 11% respectively). Dealing with retrievals and the general process each contributed 7% of the effort.

Looking at these categories or steps in the process is analogous to the 5-step EBM cycle (15) with:

- Question formulation mapping to Addressing Question (2% of the process codes)
- Searching for and finding information equivalent to Searching and Resource use (43%)
- Reading the information to assess quality and applicability mapping to Working with Documents (35%)
- Application of the found information (making the decision) mapping to Application (12%)
- Evaluation of the process mapping to General Discussion (7%)

[45] Control Find is a computer technique that when invoked using a key combination of control and "f" moves the viewer to the portion of a document or Internet page that has the exact match of that was entered in the control find window.

The question formulation aspect of EBM is lacking in this breakdown but is it interesting to note the relative breakdowns of the codes into these categories. Also of note are the similarities in number and proportion of codes across the risk status groups.

### 4.8.6 Correct Answers after Searching

As noted previously, physicians with different risk attitudes and stress from uncertainty did not differ for:

- Number of correct answers to the multiple-choice questions
- Total time spent searching and time spent on each task
- Number of codes and segments from the think-aloud protocols
- Resources used
- Search methods applied
- Proportion of effort placed on the information using categories (EBM steps)

The second answers to the questions (answers after searching) show similar patterns of no difference across the risk groups. The number of correct answers is still low, less than 50% despite physicians using their best information resources in an untimed situation. The rate of correct answers is close to that which would be found by chance alone.

**Table 4-26. Average Number of Correct Answers to the 2 Questions After Searching per Physician.** Physicians answered 2 questions using information resources of their choice to which they had access. The numbers of correct answers is low, sill below 50% correct (and not much higher than found by chance).

| Group | Average Number Correct | Standard Deviation | Range |
|---|---|---|---|
| **All Participants** | 0.83 | 0.87 | 0 to 2 |
| **Pearson Scores** | | | |
| **Risk Seeking** | 0.72 | 0.78 | 0 to 2 |
| **Risk Avoiding** | 0.80 | 0.92 | 0 to 2 |
| **Gerrity Scores** | | | |
| **Low Stress** | 0.73 | 0.79 | 0 to 2 |
| **High Stress** | 0.80 | 0.92 | 0 to 2 |

Further analyses of these data are fascinating—and troubling. McNemar change test analysis showed that use of information resources was not associated with a change (or improvement) in correctness of scores. It appears initially from Table 4-26 that the information resources were not all that useful at improving accuracy of answers. Without regard to risk status, 18 of the 46 questions were correct before searching and that number increased to 19 after searching—a rather disturbing fact. However, once we look more carefully at the data we see that with searching considerable numbers of answers were changed after searaching. For all physicians, 11 decisions for 46 questions (23.9%) were changed, almost equally distributed with 6 being appropriate changes (going from wrong to right) and 5 being inappropriate (going from right to wrong).

This phenomenon of changed decisions after searching is equally distributed across the physician groups of being risk seeking and risk avoiding. Looking at the Gerrity data, a slightly different picture appears. Although not statistically significant (P-values range from 0.2 to 0.1) physicians who feel high stress from uncertainty appear to answer more questions correctly before and after searching while at the same time making more changes (6 changes—2 inappropriate) than those physicians who do not feel stress from uncertainty (3 changes—2 inappropriate).

Of particular note is another comparison with the article by Hersh and colleagues (128). They found that 12% of the questions answered by the medical students and 14% by the nurse practitioner students had initially correct answers that changed from correct to incorrect. This range is very close to the 10% to 15% of the searches in this study where the answers also went from correct to incorrect. These rates of correct to incorrect were also similar to another study of searching done by Australian physicians and clinical nurse consultants answering simulated clinical question by using a suite of resources that included **PubMED**, a pharmaceutical database, several textbooks, and a national consumer information database. The initial rate of correct answers in the Australian study was low and it improved from 38% to about 50% for the physicians with 10.8% of the questions that were first answered correctly and moved to incorrect after use of the electronic information resources (129).

**Table 4-27. Number and Percentage Correct for the Same Questions Before and After Searching.** The physicians chose 2 questions to look up after they had provided an answer. They searched for information using their own preferred resources and answered the question again after searching. The absolute number of correct answers remained approximately the same and substantial numbers of questions changed from wrong to right and right to wrong.

| Group | Correct before searching | Correct after searching | Right stays right | Wrong stays wrong | Wrong goes to right | Right goes to wrong |
|---|---|---|---|---|---|---|
| **All (n = 46)** | 18 (39.1%) | 19 (41.3%) | 13 (28.2%) | 22 (47.8%) | 6 (13.0%) | 5 (10.9%) |
| **Pearson** | | | | | | |
| **Risk Seeking** | 7 (35.9%) | 8 (45.0%) | 5 (20.0%) | 10 (50.0%) | 3 (15.0%) | 2 (10.0%) |
| **Risk Avoiding** | 7 (35.0%) | 7 (35.0%) | 4 (20.0%) | 10 (50.0%) | 3 (15.0%) | 3 (15.0%) |
| **Gerrity** | | | | | | |
| **Low Stress** | 8 (40.0%) | 7 (35.0%) | 7 (35.0%) | 11 (55.0%) | 1 (5.0%) | 2 (10.0%) |
| **High Stress** | 8 (44.4%) | 10 (55.5%) | 6 (33.3%) | 6 (33.3%) | 4 (22.2%) | 2 (11.1%) |

This finding that information resources are associated with such a substantial number of changed decisions, of which almost half are incorrect decisions, has implications for resource designers and implementers. Traditionally information resources were considered to improve care or at worst, be neutral or a nuisance. Librarians and clinicians have felt that print resources that are out of date, have poor content, or are difficult to use may actually be "dangerous" in that they can provide incorrect answers. Electronic resources are able to be readily updated and offer the promise of ease of use. The finding that a substantial number of clinical questions are incorrectly answered with the use of electronic information resources is important and deserves further study.

The potential that electronic resources designed to aid clinical care to be detrimental (worse than neutral) is consistent with a study by Tsai, Fridsma, and Gatti (130). They studied internal medicine residents who used an automated electrocardiogram system that provided an automated diagnosis for the clinician to consider along with the electrocardiogram itself. After comparing correct assessments by clinicians with and without the electronic diagnosis, it appeared that the electronic assistance moderately improved accuracy. However on closer inspection, many, rather than a few of the diagnoses were changed when the electronic advice was provided. Looking at the data more closely, when the electronic advice was correct, the residents improved their scores. Alternately when the electronic advice was incorrect a substantial drop off was seen in the rate of correct diagnoses. The rate of correct diagnosis was 53.1% with no advice, 68.1% if the electronic advice was accurate, and 48.3% when the electronic advice was not correct. The fact that information resources may be associated with incorrect decisions adds more

weight to the need for researchers and developers to pay very serious attention to the design of information resources and their accuracy. I do preliminary analyses of the factors associated with correct answers in the next chapter (Section 5.5).

### 4.8.7 Combined analyses of differences in process for risk groups

I found very few differences in the process and outcomes of searching related to differences in Pearson or Gerrity scores—For primary care physicians being either risk seeking or risk avoiding or reporting low or high levels of comfort with uncertainty do not appear to predict searching behaviors across many outcomes. The next step in the analysis might be to combine the outcomes in a logistic-regression type analysis. I did not do this as standard procedure is to enter outcomes into the regression that are significant and observe interactions and effects. I do not have these statistically significant outcomes and therefore I did not conduct these analyses.

In addition, I did not combine the Pearson risk attitude and Gerrity stress from uncertainty scores into a single analysis using various 2-way analyses. I could not combine the scores because they were moderately and very highly significantly correlated. To combine the data the 2 sets of scores would have had to be independent. Therefore I end my analyses of quantitative outcomes of searching and turn to a final qualitative finding across the risk groups—searching heuristics.

### 4.8.8 Searching heuristics were more common in physicians who report low stress from uncertainty

The word heuristic has roots in Greek with *heuriskein* meaning to discover. In informatics contexts a heuristic is a way of knowing without proof and is often considered to be intelligent guesswork or problem solving, often for computer-related tasks. In this dissertation I have taken a heuristic to be a common-sense rule that guides investigation. I identified 166 heuristics from working with the transcripts. They are listed in Appendix G in groupings based on searching actions (e.g., deciding on terms and choosing articles for further evaluation). Almost all follow the "if…then…" format. As mentioned in Section 4.8.7, physicians who were risk seeking had more heuristics coded and physicians who reported low stress employed fewer heuristics while spending more of their searching endeavors on active searching.

Heuristics are interesting and important in that they often reflect underlying processes or satisficing principles that each searcher applies to his or her approach to finding and using information. They are factors for developers of information resources to consider rather than firm design parameters. Often several people used very similar heuristics during searching and decision-making. For example, I identified 25 instances of the use of the heuristic: *Heuristic-searching-retrieval: if the retrieval is less than about 25 or so I will assess them rather then keep limiting/searching.*

The 116 heuristics were identified 307 times during searching. I have collapsed and summarized categories and list them for comparison with other lists of desired resource features (32). Some heuristics occur in several sections.

1. Getting started once the searcher has defined a question.
    a. I always/often start with
        i. **Google**—if I am uncertain or for a "what question"
        **ii. MDConsult**
    b. Clinical questions are often best answered by
        i. Textbooks
        ii. Overviews or reviews
    c. General/broad questions are often best answered by
        i. **MEDLINE**
        ii. An evidence-based resource
    d. Specific questions are often best answered by
        i. A review article
        ii. A journal article
    e. Searching is easier based on
        i. My memory and experience
        ii. Previously successful searching for similar problems
    f. Searching is affected by
        i. Doing teaching rounds
        ii. Grand rounds
        iii. Research
        iv. Clinical work
        v. My own needs
        vi. My discipline and if question is in or out of it
        vii. My lack of general knowledge on a question
        viii. The question itself
            1. Age of "content"
            2. Amount of information on topic
            3. Broad/specific nature of question
            4. How important the question is
        ix. Serendipity
2. Picking search terms
    a. If I get nothing, I cut back on the number of terms
    b. All terms go into
        **i. Google**
        **ii. PubMED**
    c. Resource dictates the number of terms (e.g., **Google**, **PubMED**)
    d. Start term selection with
        i. The one l know least about

ii. The one that I think has the least amount of information
iii. The one that is most unique

3. Searching and changing directions during searching
    a. If not on topic or getting the right answer
        i. Quit and try another approach completely
        ii. Check strategy and try again with slight modification
        iii. Change formats (e.g., from **MEDLINE** to **Google** or journal)
    b. Continuing/stopping
        i. Keep going until I run out of time or patience
        ii. If less than about 25 citations stop and take a look at them
        iii. Unless I find the information in more than one spot keep going
        iv. Conflicting information keeps me going on
4. Retrievals
    a. Once I get to a certain size (about 25 citations) I stop searching
    b. I can easily assess the quality of an Internet site and it depends on
        i. Sponsor—I need to trust them before I will use their information
        ii. Nationality of the sponsor
    c. Quality features of a resource are
        i. Good organization including summary
        ii. Fast, easy, transparent access
            1. PDF©[46]s, **Powerpoint**®[47] presentations are not good
            2. I do not want passwords
        iii. Trusted source or producer
        iv. Reflects the nationality of the physician's practice setting
        v. It has provided good information in the past
        vi. Recent content—will use old if I can not find new material
        vii. Contains head-to-head comparisons not just single element evaluation
        viii. Meta-analyses, clinical practice guidelines are good (summaries)
        ix. Full text articles, web pages are good although an abstract is also good
5. Patients
    a. Patients need/use different information than I do
    b. Patients need/use the same information I do
    c. Patients need me to give them information
    d. I rely on some patients to give me information to work with
6. Impediments to searching and use of information
    a. It is hard to stay on track—too much other interesting stuff
    b. Time (mentioned by 6 people)
    c. Access to the resources
        i. Speed of resource
        ii. Availability
        iii. Cost (although I will pay if it is REALLY good)
        iv. Disappearance of the best print resources
        v. Ease of use and my experience with it
        vi. Multiple sign-ins, excessive typing/navigation are a pain
        vii. Unexpected actions of resource
    d. Question itself—some are difficult and some have no answer
    e. All resources are not created equal
7. Skills and attitudes
    a. I need my own equipment to feel at home
    b. I don't feel confident

[46] PDF, the Portable Document Format is a publishing specification for documents copyrighted by Adobe Systems Incorporated. (http://www.adobe.com/products/acrobat/adobepdf.html). Accessed July 21, 2005.
[47] **Powerpoint** ®. Presentation software from Microsoft. Copyright 2005 Microsoft Corporation. (http://office.microsoft.com/en-us/FX010857971033.aspx). Accessed July 21, 2005.

c. If I was younger this would be easier—residents know more than I do on searching but they still can learn about the quality of sites from me
d. If I can't find the answer it is frustrating
e. Searching can be
    i. Difficult
    ii. Fun
    iii. Frustrating—if too frustrating, I will not do it
    iv. Confusing
    v. Complex

I did not formally analyze for differences in the use of heuristics but from my work with the information, very little difference exists among the risk seeking/avoiding and low- and high-stress groups aside from being fewer of them in the risk-avoiding and high-stress groups (Table 4-28). I move on to the final evaluation of Question 2b—the formal models. I have summarized all of the findings in Section 4.11.

## 4.9 QUESTION 2—MODELS OF INFORMATION SEEKING AND USE

Models are important for many reasons as discussed in Section 2.5, especially in a relatively young discipline as medical informatics. Both the modified Wilson Problem Solving model (Section 2.5.1) and the Card/Pirolli Information Foraging/Information Scent model (Section 2.5.2) have aspects that make them strong candidates for modeling the electronic information seeking and use aspects seen in the primary care physicians who were studied in this dissertation. Both models embrace aspects of risk and uncertainty and are flexible and complex enough to be realistic representations of electronic searching behaviors and information application in medical domains.

### 4.9.1 Process of model comparison

The coding done for the 2 searching questions is an accurate representation of the searching and information application process performed by the physicians. The coding scheme was developed based on the data and not on the models. After the coding was completed (Section 4.8.1), the codes were summarized and used in subsequent

analyses. I also used the coding and other knowledge from the interviews to determine the fit between the searching sessions and the 2 models as presented in the next sections.

### 4.9.2 Modified Wilson Problem Solving Model concentrates on reducing uncertainty

The Wilson Problem Solving Model was developed in the late 1980s (54, 93) with updates and modifications in 1999 and 2003 (94). This model of information searching and use is based on the assumption that the person searching for information is in some state of uncertainty that is potentially resolvable with external information. Resolving uncertainty drives the information seeking behavior through stages: problem identification, definition, resolution (searching and assessment of results), and solution statement. When uncertainty is not reduced one stays in that stage or revisits previous stages until the searcher/seeker has enough information to solve the problem and cycles out of the model. Figure 2-2 represents the Wilson Problem Solving Model (54, 93).

The final 3 stages of the model fit the data well. The dissertation code, assessing the question, is equivalent to problem definition. Working with resources, Searching, and Dealing with Retrievals and Documents maps to problem resolution, and Application corresponds to the problem statement. The dissertation cycles are equivalent to moving back and forth between stages because of uncertainty resolution or increase. Many factors present in the dissertation searching (e.g., question type, difficulty, discipline of the searcher) are equivalent to the intervening variables of question, domain knowledge, personal, role-related, and environmental—all affect the searching process. The problem and domain knowledge are present in both models as are personal variables such as the study risk attitude and levels of stress from uncertainty. In addition both models incorporate role-related issues such as a discussion of limited searching for a problem related to prostate cancer recurrence because the content of question would be handled more readily and often by an oncologist rather then the primary care physician. The model also accounts for issues of environment (no time in the clinic to search or setting) from the dissertation searching. The model also captures the differences in process found for physicians with different levels of stress from uncertainty—differences based on active searching, use of heuristics, and trends toward less **MEDLINE** use and preference for **PIER** for physicians who have high levels of stress

The strength of the modified Wilson model is its ability to reflect the realities of uncertainty in health care decisions and the cyclic nature of searching based on resolving that uncertainty. One of the weaker aspects of the

model was searching that was stopped because the physician felt that he or she had given enough time to the problem and no longer wanted to proceed. In the model, this stopping could be accounted for by the intervening environmental variable, time taking on enough importance to become more valuable than the amount of uncertainty resolution that would have occurred with increased searching time. The modified Wilson Problem Solving model represents all of the aspects of information searching and use identified by the think-aloud codes well. Will the Card/Pirolli mode be as satisfactory in fitting the data?

### 4.9.3 Card/Pirolli Information Foraging/Information Scent Model concentrates on patches and scent of patches

Card and Pirolli (96-98) modeled information seeking and sense-making ideas by adapting societal and food-foraging strategies from anthropology and biology (behavioral ecology) (99, 100). To get external information to resolve uncertainty or address daily tasks individuals go through an integrative process of information seeking and sense making just as an animal seeks food and shelter to improve well-being and ensure survival. The value of information is measured in terms of improved outcomes or resolution of the task at hand and is very similar to the value given to finding food by a foraging animal. Individual foraging tasks change depending on circumstances and the animal searcher but the general processes are always the same—we need food and information regularly and to be successful, both animals and humans adapt their foraging methods to changing needs and circumstances. Animals scent food or remember locations from previous trips and proceed from patch to patch to satisfy their needs. It remains as long as the patch is providing sustenance at a rate that exceeds the amount of energy required to gather it. Searchers look for information patches based on scent (e.g., citations, icons, links, and memory) and proceed across patches until they are satisfied, consume available resources, or run out of time or energy and stop foraging. The model also describes the differences found for those physicians who have different levels of stress from uncertainty.

The features of the Card/Pirolli model can encompass the dissertation coding of the information seeking and use by primary care physicians. The individuals in the study had a wide range of ages, genders, year of graduation, etc. and approached searching in unique methods. This is analogous to a wide range of animals searching for food and shelter using unique methods and techniques. Many information patches were “scented” using a variety of search engines, indexing services, links, and previous successful experiences. Seekers in the study

spent varying amounts of time in each patch and went to one or many patches looking for enough information to satisfy the need imposed by the question (reducing uncertainty associated with the question). The searcher stopped searching when he or she was satisfied or had run out of resources (time or energy) needed to continue the quest.

The strength of the model is the scent aspect of the process that takes/leads searchers to useful information. I observed many proximal scents that led to distal information resources. One weak aspect of the Card/Pirolli model is a strength of the modified Wilson model—the delineation of the effects that intervening variables related to the question, domain, person, role, and environment have on the process and outcomes. The effects of these intervening variables are implicitly assumed in the characteristics of the animal/searcher and the information task/feeding foray.

Both models are excellent at representing a wide variety of the information searching and use behaviors. They each have strengths that far out weigh several weaknesses. Either or both could be used in further studies of information searching, use, and application in medical informatics or medical librarianship. The modified Wilson model is better for describing the external factors that shape the searching process. The Card/Pirolli model is better for describing the patches or electronic resources and how one finds and uses them.

This completes analysis of searching processes and models as well as outcomes. The third question examines preferences for resources.

## 4.10 QUESTION 3—PREFERENCES FOR INFORMATION RESOURCES

Question 3 (Section [3.6.4]),

*What are physician preferences for specific electronic information resources when answering simulated clinical questions (**Clinical Evidence** and **PIER**) and how do these preferences, and preferences for features, vary according to physician risk attitudes and levels of stress from uncertainty?*

deals with **Clinical Evidence** and **PIER** to determine if physicians have preferences for either to answer simulated clinical questions. In my proposal I predicted that each resource would be sufficient to answer the simulated questions with few statistical differences. For analyses of physicians' preferences regardless of their risk attitude or stress from uncertainty, I felt that I would find preferences and preference differences. I also predicted that physicians who were risk avoiding or report stress from uncertainty would prefer **PIER** while physicians who were risk seeking or comfortable with uncertainty would have no preferences or prefer **Clinical Evidence**. I also sought to determine the features physicians noted and other reasons why they preferred one resource over another. I compared this list with the list of features of an ideal resource from Ely and Osheroff and colleagues (35). I also predicted that the set of features identified by physicians in each of the risk status group would be different. Many predictions were realized although as in previous sections, the differences I sought between risk seeking and risk avoiding physicians as well as those who reported low and high levels of stress from uncertainty were not evident.

### 4.10.1 Description of coding for searching using PIER and Clinical Evidence

Each participant answered 2 final questions using provided pages from electronic information resources. One question dealt with a topic with which primary care physicians frequently deal—irritable bowel syndrome (Antidepressants for pain and nausea in irritable bowel syndrome). The second was a question that primary care physicians could deal with but often do not—prevention and treatment of acute mountain sickness with acetazolamide. I chose these questions because of the different rates of occurrence in primary care and also because the information on each topic was current, consistent, and correct in **Clinical Evidence** and **PIER**. The physicians provided answers using pages from the resources and then commented on what they liked and disliked about each using think-aloud protocol methods that they had used in the previous task.

Coding for these irritable bowel and acute mountain sickness questions was developed and pretested in the same manner as for the coding of the first 2 searching questions. However, because I asked the participants to comment on the why of their choices and the reasons for their preferences, this second set of question-answering tasks does not adhere to strict think-aloud data collection procedures. The coding I developed is in Appendix F.

### 4.10.2 Time spent on each question did not differ for risk groups

I also looked at time taken for the 2 questions. No differences across the risk and uncertainty groups were found in time spent on question 3 or 4 as previously noted in Section 4.7.1 with data in Table 4-12 and Table 4-13.

### 4.10.3 Number of codes for questions did not differ for risk groups

Because the questions were different, I provide the number of codes separately for each question for each study group in Table 4-29 and Table 4-30. Neither the irritable bowel syndrome nor the acute mountain illness questions showed differences in the number of codes for any of the groups based on risk categories. The differences across the 2 questions were not significant despite the fact that irritable bowel is a common problem and acute mountain sickness is not often seen. The SDs (variation in the data) for the number of codes were large, especially for low-stress physicians. This added to the power problem. Taking the data from Table 4-29 for the low- vs high-stress groups, I would have had to have had 130 physicians in each group to have a power or 80% to detect the difference I found with statistical significance. With 25 physicians I have a less than 10% power to detect a true difference.

**Table 4-29. Mean Number of Think-Aloud Codes for the Irritable Bowel Syndrome Question.** The codes are in Appendix F. No differences were seen comparing the risk groups. The variation in the Gerrity data was large.

| Group | Mean Number of Codes | Standard Deviation | Range or P-value |
|---|---|---|---|
| **All** | 39.7 | 32.7 | 9 to 175 |
| **Pearson Groups** | | | |
| Risk Seeking | 34.2 | 12.9 | n.s. |
| Risk Avoiding | 31.8 | 17.2 | |
| **Gerrity Groups** | | | |
| Low Stress | 49.1 | 45.4 | n.s. |
| High Stress | 31.4 | 13.3 | |

**Table 4-30. Mean Number of Think-Aloud Codes for the Acute Mountain Illness Question.** The codes are in Appendix F. No differences were seen comparing the risk status groups. The variation in the Gerrity data was large.

| Group | Mean Number of Codes | Standard Deviation | Range |
|---|---|---|---|
| **All** | 41.4 | 20.7 | 15 to 92 |
| **Pearson Group** | | | |
| **Risk Seeking** | 40.6 | 11.9 | n.s. |
| **Risk Avoiding** | 30.6 | 12.6 | |
| **Gerrity Group** | | | |
| **Low Stress** | 48.4 | 24.4 | n.s. |
| **High Stress** | 35.8 | 19.2 | |

### 4.10.4 Number of correct answers with PIER and Clinical Evidence did not differ for risk status

Questions 3 and 4 proved to be easier to answer for the participants with an almost doubling in the rate of being correct at baseline compared with the first 20 questions. Both **PIER** and **Clinical Evidence** contained the correct answer so it is not surprising that no physician went from a correct to an incorrect answer and that the rate of correct answers increased from 64% to 94% after using the resources. This replicates the findings of Tsai, Fridsma, and Gatti (130) showing that computer systems which provide correct answers to supplement physician expertise substantially increase the rate of making the right decision.

Note that 5 physicians in each of the Pearson risk neutral and Gerrity moderate stress groups started with an incorrect answer that was changed to a correct answer after consulting the pages from **PIER** and **Clinical Evidence**. This makes the number of questions correct at baseline for all physicians appear to be considerably less than the baseline for physicians in the risk status groups. The McNemar change test that shows that **PIER** and **Clinical Evidence** are associated with improved correctness for all participants ($P = 0.005$) as well as low-stress physicians ($p = 0.04$). A trend towards increased correctness with **PIER** and **Clinical Evidence** is seen for both risk-seeking and risk-avoiding physicians ($P = 0.07$) and for high-stress physicians ($P = 0.1$).

**Table 4-31. Number and Percent Correct Answers Before and After Using PIER and Clinical Evidence.** The information resources improved the rate of correct answering of the questions. No statistically significant differences were found for any comparisons across risk status groups. The McNemar change test that evaluated differences.

| Group | Correct before searching | Correct after searching | Right stays right | Wrong stays wrong | Wrong goes to right | Right goes to wrong |
|---|---|---|---|---|---|---|
| **All (25 people 50 questions)** | 32 (64.0) | 47 (94.0) | 32 (64.0) | 3 (6.0) | 14 (30.0) | 0 (0.0) (P = 0.005) |
| **Pearson** | | | | | | |
| **Risk Seeking** | 16 (72.7) | 21 (95.5) | 16 (72.7) | 1 (4.5) | 5 (18.2) | 0 (0.0) P = 0.07) |
| **Risk Avoiding** | 15 (68.2) | 20 (90.9) | 15 (68.2) | 2 (9.1) | 5 (15.0) | 0 (0.0) (P = 0.07) |
| **Gerrity** | | | | | | |
| **Low Stress** | 13 (65.0) | 19 (86.4) | 13 (65.0) | 1 (4.5) | 6 (27.3) | 0 (0.0) (P = 0.04) |
| **High Stress** | 17 (85.0) | 21 (95.5) | 17 (85.0) | 1 (4.5) | 4 (18.2) | 0 (0.0) (P = 0.10) |

### 4.10.5 Effect of PIER and Clinical Evidence on answers

Because each physician used both **PIER** and **Clinical Evidence** no conclusions can be drawn about which electronic resource is superior for moving physicians from incorrect to correct answers. The combination of both resources did improve correctness. Using Fisher exact methods, preference for a given resource was not associated with correct answers for either the common problem (irritable bowel syndrome) or the uncommon problem (acute mountain sickness) for all searchers or those in specific risk or uncertainty groups.

### 4.10.6 Preference for PIER and Clinical Evidence did not differ for risk groups

At the proposal stage I predicted that preference for **PIER** or **Clinical Evidence** would vary across physician groups. In addition I felt that physicians who were risk avoiding and reported high levels of stress from uncertainty would prefer **PIER** because it directs care by providing answers and specific actions. This direction might be taken as external validation of their decisions, something that supports their tendency towards avoidance of risk and expression of discomfort. The risk seeking physicians and those who were comfortable with uncertainty would prefer **Clinical Evidence** because it provides harms and benefits of treatment and leaves the decision-making and

application to the user. In addition, I wanted to ascertain if preferences varied on the prevalence of the condition with more preference for **PIER** (directed answers) for the less commonly seen condition (acute mountain sickness).

**Table 4-32. Preference for PIER, Clinical Evidence, and Both for Common and Uncommon Problems.** Physicians indicated a preference for either Clinical Evidence or PIER after each question. No differences were noted except for 2 slight trends for preference of PIER by high-stress physicians.

| Question and Group | Prefer PIER | Prefer Neither | Prefer Clinical Evidence |
|---|---|---|---|
| **Common problem (irritable bowel)** | | | |
| **All Participants** | 14 | 4 | 7 |
| **Pearson** | | | |
| **Risk Seeking** | 5 | 3 | 3 |
| **Risk Avoiding** | 8 | 0 | 3 |
| **Gerrity** | | | |
| **Low Stress** | 3 | 2 | 5 |
| **High Stress** | 7 (P = 0.15) | 2 | 2 |
| | | | |
| **Uncommon problem (acute mountain illness)** | | | |
| **All Participants** | 17 | 2 | 6 |
| **Pearson** | | | |
| **Risk Seeking** | 7 | 0 | 4 |
| **Risk Avoiding** | 8 | 1 | 2 |
| **Gerrity** | | | |
| **Low Stress** | 6 | 1 | 3 |
| **High Stress** | 9 | 0 | 2 |
| | | | |
| **Both problems—chose same resource twice** | | | |
| **All Participants** | 12 | 9 | 4 |
| **Pearson** | | | |
| **Risk Seeking** | 4 | 5 | 2 |
| **Risk Avoiding** | 7 | 2 | 2 |
| **Gerrity** | | | |
| **Low Stress** | 3 | 4 | 3 |
| **High Stress** | 7 (P = 0.2) | 3 | 1 |

I found that the physicians did indeed have strong preferences for one resource over another. Anecdotally, once they had indicated their preference, many participants also went on to question why anyone would prefer the one they had not chosen. In addition, often a physician criticized the same feature that was valued by another. This love-hate relationship with features often occurred for presentation of event rates, confidence intervals, and number needed to treat. Although resource preference varied across physicians, it was not predicted by risk status. None of the

differences are statistically significant (Fishers exact test) but the higher numbers of **PIER** preferences in those physicians who were risk avoiding or reported high levels of stress were suggestive that with a larger sample size differences could be detected in at least physicians with low and high levels of stress from uncertainty. The power that I have in this analysis is approximately 21% with alpha set at 0.05. I would need to have approximately 33 to 39 physicians in each group to bring this power up to 80% with an alpha level of 0.05—considerably more than the 10 and 11 that I now have in each group.

### 4.10.7 PIER and Clinical Evidence—Preference features

**PIER** was numerically, but not statistically, preferred more often than **Clinical Evidence** for the uncommon problem (acute mountain sickness preference of 68% vs 24%) as well as the common problem (irritable bowel syndrome of 56% vs 28%), and both problems (48% vs 16%) as seen in Table 4-32. Table 4-33 lists the features that were listed as valuable and mentioned/discussed. Table 4-34 includes data on features that physicians said they based a preference for **PIER** or **Clinical Evidence**. It also lists criticized features. To summarize, Table 4-35 compares the top 3 features from each of a) mentioned or discussed by searchers, b) listed as being valuable or desirable, c) used to form a preference decision, and d) criticized. Eight features contribute data to this table.

**Table 4-33. PIER and Clinical Evidence Features Mentioned and Mentioned as Valuable.** Coding captured features that were mentioned and mentioned as valuable during question answers sessions using **PIER** and **Clinical Evidence**. Only the features that were mentioned more than once are included.

| Feature | PIER—Times Mentioned | | Clinical Evidence—Times Mentioned | |
|---|---|---|---|---|
| | Discussed | Discussed/valuable | Discussed | Discussed/valuable |
| **Abstract/summary** | 4 (0.9) | 3 (6.3) | 1 (0.2) | 9 (20.9) |
| **Amount of information** | 3 (0.7) | 0 (0.0) | 5 (1.2) | 3 (7.0) |
| **Answer** | 14 (3.1) | 0 (0.0) | 15 (3.7) | 0 (0.0) |
| **Benefits** | 25 (5.5) | 0 (0.0) | 27 (6.7) | 0 (0.0) |
| **Clinical application/focus** | 23 (3.1) | 4 (8.3) | 17 (4.2) | 0 (0.0) |
| **Clinical content** | 108 (23.9) | 1 (2.1) | 105 (25.9) | 3 (7.0) |
| **Deals with uncertainty** | 2 (0.4) | 0 (0.0) | 1 (0.2) | 1 (2.3) |
| **Doses** | 11 (2.4) | 0 (0.0) | 14 (3.5) | 1 (2.3) |
| **Ease of use** | 2 (0.4) | 3 (6.3) | 0 (0.0) | 0 (0.0) |
| **Evaluation** | 3 (0.7) | 0 (0.0) | 4 (1.0) | 0 (0.0) |
| **Evidence/Levels of evidence** | 79 (17.5) | 6 (12.5) | 110 (26.1) | 11 (25.6) |
| **Format** | 12 (2.7) | 1 (2.1) | 12 (3.0) | 2 (4.7) |
| **Harms** | 6 (1.3) | 0 (0.0) | 32 (7.9) | 1 (2.3) |
| **Methods** | 8 (1.8) | 0 (0.0) | 10 (2.5) | 1 (2.3) |
| **Notes** | 6 (1.3) | 1 (2.1) | 6 (1.5) | 2 (4.7) |
| **Numbers** | 3 (0.7) | 0 (0.0) | 24 (5.9) | 6 (14.0) |
| **Practical** | 1 (0.2) | 1 (2.1) | 1 (0.2) | 0 (0.0) |
| **Rationale** | 19 (4.2) | 4 (8.3) | 1 (0.2) | 0 (0.0) |
| **Recommendations** | 69 (15.3) | 11 (22.9) | 5 (1.2) | 0 (0.0) |
| **References** | 25 (5.5) | 3 (6.3) | 10 (2.5) | 1 (2.3) |
| **Relation to question** | 2 (0.4) | 0 (0.0) | 1 (0.2) | 0 (0.0) |
| **Source** | 5 (1.1) | 1 (2.1) | 3 (0.7) | 1 (2.3) |
| **Tables** | 5 (1.1) | 3 (6.3) | 0 (0.0) | 0 (0.0) |
| **Usefulness** | 2 (0.4) | 6 (12.5) | 1 (0.2) | 0 (0.0) |
| **Miscellaneous (mentioned once)** | 6 (1.3) | 0 (0.0) | 1 (0.2) | 2 (4.7) |
| | | | | |
| **Total** | 452 | 48 | 405 | 43 |

Evidence and clinical content were often mentioned and discussed as valuable features of the 2 information resources but in the final choice (reasons that influenced preferences), issues of format and ease of use ranked the highest. Evidence and levels of evidence accounted for almost a quarter of the criticisms for **PIER** while it was both a preference feature and also criticized in **Clinical Evidence**. It is also interesting to note that although **PIER** was the preferred resource, it had more than double the number of criticisms than did **Clinical Evidence**. This suggests that the area of presentation of evidence and its related numbers to clinicians in a decision-making context is a

potentially rich research area. It is also interesting to note that for both **PIER** and **Clinical Evidence** the same feature was often both the reason for preference as well as a source of criticism.

**Table 4-34. PIER and Clinical Evidence Features Preferred and Criticized.** As in the previous table these data were collected from the coding for searches using PIER and Clinical Evidence. These data indicated reasons why a clinician preferred one resource over another and also lists criticisms of features.

| Feature | PIER | | Clinical Evidence | |
|---|---|---|---|---|
| | Times Preferred | Times Criticized | Times Preferred | Times Criticized |
| **Abstract/summary** | 1 (7.1) | 3 (3.9) | 0 (0.0) | 1 (3.2) |
| **Acronyms** | 0 (0.0) | 3 (3.9) | 0 (0.0) | 0 (0.0) |
| **Amount of information** | 1 (7.1) | 2 (2.6) | 2 (8.3) | 2 (6.5) |
| **Answer** | 0 (0.0) | 6 (7.9) | 2 (8.3) | 3 (9.7) |
| **Clinical application** | 0 (0.0) | 0 (0.0) | 1 (4.2) | 3 (9.7) |
| **Clinical content** | 2 (14.3) | 11 (14.5) | 3 (12.5) | 3 (9.7) |
| **Ease of use** | 1 (7.1) | 1 (1.3) | 0 (0.0) | 1 (3.2) |
| **Deals with uncertainty** | 0 (0.0) | 2 (2.6) | 0 (0.0) | 1 (3.2) |
| **Evidence/levels of evidence** | 1 (7.1) | 18 (23.7) | 7 (29.2) | 4 (12.9) |
| **Format** | 2 (14.3) | 3 (3.9) | 6 (25.0) | 1 (3.2) |
| **Harms** | 1 (7.1) | 0 (0.0) | 0 (0.0) | 2 (6.5) |
| **Methods** | 0 (0.0) | 5 (6.6) | 0 (0.0) | 2 (6.5) |
| **Numbers** | 0 (0.0) | 2 (2.6) | 0 (0.0) | 1 (3.2) |
| **Recommendations** | 3 (21.4) | 4 (5.3) | 0 (0.0) | 1 (3.2) |
| **References** | 0 (0.0) | 6 (7.9) | 0 (0.0) | 1 (3.2) |
| **Table** | 2 (14.3) | 1 (1.3) | 0 (0.0) | 0 (0.0) |
| **Time** | 0 (0.0) | 1 (1.3) | 0 (0.0) | 2 (6.5) |
| **Usefulness** | 0 (0.0) | 2 (2.6) | 1 (4.2) | 2 (6.5) |
| **Miscellaneous (mentioned once)** | 2 (14.3) | 4 (5.3) | 2 (8.3) | 1 (3.2) |
| | | | | |
| **Total** | 14 | 76 | 24 | 31 |

**Table 4-35. Summary Table of the Top 3 Features Discussed, Valued, and Used to Describe Preference or Criticism of the Resource across both Questions.** This table summarizes data from previous tables by taking the top 3 features from each for features mentioned, mentioned as valuable, used in preference decisions, and criticized.

| Feature | PIER—Percent of Column | | | | Clinical Evidence—Percent of Column | | | |
|---|---|---|---|---|---|---|---|---|
| | Discussed | Valuable | Prefer | Criticism | Discussed | Valuable | Prefer | Criticism |
| **Clinical content** | 23.9 | 2.1 | 14.3 | 14.5 | 25.9 | 7.0 | 12.5 | 9.7 |
| **Evidence** | 17.5 | 12.5 | 7.1 | 23.7 | 26.1 | 25.6 | 29.2 | 12.9 |
| **Recommendations** | 15.3 | 22.9 | 21.4 | 5.3 | 1.2 | 0 | 0 | 3.2 |
| **Usefulness** | 0.4 | 12.5 | 0 | 2.6 | 0.2 | 0 | 4.2 | 6.5 |
| **Summary** | 0.9 | 6.3 | 7.1 | 3.9 | 0.2 | 20.9 | 0 | 3.2 |
| **Numbers** | 0.7 | 0 | 0 | 2.6 | 5.9 | 14.0 | 0 | 3.2 |
| **Format** | 2.7 | 2.1 | 14.3 | 2.9 | 3.0 | 4.7 | 25.0 | 3.2 |
| **Table** | 1.1 | 6.3 | 14.3 | 1.3 | 0 | 0 | 0 | 0 |
| | | | | | | | | |
| **Total accounted for by top 8 features** | 62.5 | 64.7 | 78.5 | 56.8 | 62.5 | 72.2 | 70.9 | 41.9 |

### 4.10.8 Preference for features and how they compare with previous list

Ely and colleagues (32) studied 48 general internists, general pediatricians, and family physicians in Iowa in their practices (see Section 2.8 for a fuller description of this study). At the end of the observation session the physician was asked open ended questions, one of which was to describe the features of what would be an ideal clinical information system to support their practice. Qualitative (subjectivist) analysis identified 22 recommendations that had been mentioned by multiple physicians. I have left out the features related to access and other aspects not measured in this present study. Their top 10 features in order of how often it was mentioned by the participants follow. The second set of parentheses includes how often the feature was mentioned as a preference reason for **PIER** and **Clinical Evidence**. The numbers are out of a possible 48 for **PIER** and 43 for **Clinical Evidence** and a reason may appear in more than a single category.

- Rapid information access in documents/pages (e.g., bullets, tables) (77%) (13/2)
- Comprehensive clinical content (75%) (1/4)
- Concise, succinct, and to the point (54%) (0/3)
- Provides evidence and rationale (52%) (10/11)

- Provides directed action (42%) (11/0)
- Includes treatment details (42%) (0/1)
- Practical (40%) (1/0)
- Provides summary (31%) (4/11)
- Direct answers (29%) (11/0)
- Tempers evidence with experience (29%) (6/0)
- Provides algorithms for outcomes (29%) (3/0)

These features from Ely and colleagues align nicely with the favored and preference features provided by the clinicians studied in this dissertation project, especially around issues of clinical content, directed answers, and clinically relevant summaries of knowledge. Designers of information resources would be well advised to consider these preferred features (and ones criticized)—not all of which are readily available in existing resources. The data also supply evidence on the need for personalization.

I am now finished with the analysis of my data. I summarize the important findings from previous sections in the following section and then move to discussions and conclusions in Chapter 5. The final chapter also includes implications for various domains.

## 4.11 SUMMARY OF RESULTS

My dissertation questions centered on the searching behaviors and use of information resources of primary care physicians to determine if the information processes were different depending on the physician's risk attitude and level of stress from uncertainty. To answer these questions I recruited family physicians and general internists and spent time with them observing their use of electronic information resources to answer simulated clinical questions. Recruitment was relatively easy although finding the final risk-seeking physician proved somewhat difficult. Through various methods more than 260 physicians were invited to take part and 60 were assessed for inclusion. Twenty-five physicians filled the 40 analysis spots (10 each in the categories of risk seeking, risk avoiding, and low

and high levels of stress from uncertainty) and were subsequently interviewed. The Pearson and Gerrity scores correlated as expected (0.37, P = 0.007) with the Gerrity data being normally distributed as predicted. The Pearson data showed trends towards its predicted normalcy. The range of scores and their means were also consistent with data from previous studies (e.g., lower stress from uncertainty and more risk seeking in family physicians compared with general internists and men with women).

The group of physicians who were interviewed included a range of disciplines, genders, ages, country of practice, and clinical and academic settings. The physicians in the 4 risk groups (risk seeking and low stress, risk seeking and high stress, risk avoiding and low stress, and risk avoiding and high stress) were evenly distributed leading to stratified data groups that take into account potential confounding effects of the scales on each other. Computer skills were self reported and were uniformly high for familiarity/sophistication and use of most resources and computers in general. Computer skills and use were not different across the risk attitude and uncertainty groups.

The participants in the risk-seeking and risk-avoiding groups and in the low- and high-comfort with uncertainty groups did not differ for any baseline characteristics although the group included had overall lower risk attitude and stress from uncertainty scores than those who were screened and not included. The studied groups also had a lower proportion of general internists. As postulated, I found no differences between the risk and uncertainty groups for the number of correct answers for the multiple-choice questions. However, the number of correct answers was low and not much higher than expected by chance. Certainty of the answer was somewhat related to correctness with higher certainty for those questions that were correct. Willingness to look up an answer was also somewhat related to the the correctness of an answer but not to the certainty of the answer. These data reinforce that it is difficult to know when you are wrong and when one would benefit from seeking external information.

The major idea present in the planning of this dissertation was that the physicians in the 4 risk groups would show a substantial number of differences for the searching process using electronic information resources despite correctly answering the same number of multiple-choice questions. I did not find these differences. The groups did not differ for:

- Time—total time or time for specific tasks or subtasks
- The number of segments (idea containing portion of transcript) in the think-aloud protocols for the total session or subtasks *except that the number was lower for high-stress than low-stress physicians*

- The number of codes attached to the segments for the total session or subtasks
- Numbers of cycles per search (a unique process of searching within a resource and examination of the output that finishes a searching session or moves on to a new cycle of searching in a new electronic resource or a new approach within the same resource)
- Proportion of the searching session that was spent in active searching, appraisal of found documents, application of the information (decision making) related to the question *except physicians in the high-stress group who had a higher proportion of active codes*.
- Proportion of the electronic searching session spent on all subaspects of searching (e.g., question, searching, dealing with retrievals, document appraisal, and application) *except that risk-seeking physicians reported more searching heuristics than risk-avoiding physicians and high-stress physicians spent a smaller proportion of their searching sessions discussing general issues.*
- Few statistical differences were seen among the risk groups in resource use *although risk-avoiding physicians show a trend towards more distilled resources and high-stress physicians show a trend towards less* ***MEDLINE*** *use*.
- Physicians in all groups used a variety of search and retrieval methods while using electronic information resources *with those who were risk avoiding and reported high levels of stress appeared to rely on (trend toward) simpler methods. Fisher exact testing shows a trend towards difference in the use of resources in general but not of the specific resources themselves.*
- Searching for information did not improve the rate of correct answers for use of the physicians own electronic information resources. Both **Clinical Evidence** and **PIER** improved the rate of correct answers. *All participants and low-stress physicians improved their answer to a statistically significant degree with* ***PIER*** *and* ***Clinical Evidence***.
- Analyses of the data for use of the physicians' own electronic resources showed that a substantial number of answers changed both from correct to incorrect and from incorrect to correct. This deserves further study.
- Participants did not prefer **PIER** or **Clinical Evidence** according to risk status as postulated at the proposal stage. *However almost twice as many physicians preferred* ***Clinical Evidence*** *to* ***PIER*** *despite the high level of criticism of its features.*

- The features noted, mentioned as important, and indicated as reasons for preference were similar to the features listed in a report of a study of physicians who discussed their choices for an ideal information system (32).
- Consolidation of the 116 searching heuristics also showed congruence with the ideal information system features (32).
- The electronic searching processes elucidated in the dissertation were easily placed in both the modified Wilson Problem Solving Model and the Card/Pirolli Information Foraging/ Information Scent Model showing that formal models from other disciplines are applicable to medical informatics studies. The modified Wilson model is stronger for aspects of the searcher while the Card/Pirolli model is stronger for those who are interested in the searching sites or resources.

Many of these findings are discussed further in Chapter 5 along with additional analyses of findings suggestive of further study.

# 5 DISCUSSIONS, CONCLUSIONS, IMPLICATIONS, AND FURTHER DIRECTIONS

The driving idea behind this dissertation is that clinicians need information and the available electronic information resources are often not easy to use or readily or timely available. Medical informatics has the obligation and ability to produce high-quality computerized resources that are effective and efficient. Electronic information resources should be seamlessly integrated into the care process through the stages of research, development, and rigorous testing. Understanding users and their needs is foundational in this process. Risk and uncertainty play crucial and ever-present roles in health care. Physicians vary in their attitudes toward risk and their self-reported levels of stress from uncertainty. This variation in risk attitudes and stress from uncertainty is linked to differential use of healthcare resources and healthcare costs. Understanding if the risk and uncertainty status is also associated with electronic information resource use could provide informatics designers with insight into the need to design these electronic resources to support the differences in preference and use.

In this dissertation I also wanted to provide data to address the need for personalization of electronic information resources. Personalization of electronic resources and services is common in business applications but has not received substantial attention in medical informatics. I sought basic understanding of resource use by primary care physicians related to their attitudes toward risk and uncertainty status rather than production of a detailed list of design instructions. I also wanted to ascertain if models from disciplines related to informatics would be able to model the use of the electronic information resources by Canadian and US primary care physicians. I used both qualitative and quantitative methods in a cohort design.

## 5.1 QUESTION 1—RISK STATUS DID NOT PREDICT INFORMATION RESOURCE OUTCOMES

Question 1 dealt with the outcomes of searching for and applying information when the physicians used their own information resources to answer simulated clinical questions and if these outcomes differed across risk and uncertainty status categories. Physicians differ in their attitude towards risk (risk seeking, risk neutrality, and risk avoiding) and self-reported stress from uncertainty (high, moderate, and low levels of stress) in comparison with their peers. The scoring data for the 2 scales from the physicians in the study were consistent with other studies with respect to range, normalcy, and centrality of scores. However the difference in use of healthcare resources seen in physicians with varying risk attitude and stress from uncertainty scores in other studies was not apparent in outcomes of searching when physicians in this study used electronic information resources. The outcomes of time, resources used, search methods, cycles of searching, segments noted, codes assigned, and categories of searching and application used consistently did not show statistically significant differences across risk groups. The few differences that I did find could be attributed to chance alone, the small sample size, or the large variation in the data although some differences and trends showed that levels of stress from uncertainty could affect searching outcomes. The answer to question 1—outcomes of searching using electronic information resources is a guarded no and likely would benefit from a similar study with larger sample size.

## 5.2 QUESTION 2a—STRESS FROM UNCERTAINTY WAS ASSOCIATED WITH SOME ELECTRONIC INFORMATION RESOURCE PROCESSES

Question 2 dealt with the processes of primary care physicians using electronic information resources. For the analyses using risk attitude (risk seeking and risk avoiding) scales, no differences in process of information seeking and application are seen. Analyses of the processes for physicians who have high and low levels of stress from uncertainty show some differences. The primary care physicians who report high levels of stress from uncertainty (higher use of healthcare resources) showed statistically significant differences or trends toward

- more active searching and less discussion of general issues during the sessions

- less use of searching heuristics
- fewer verbal protocol segments
- better answers with **PIER** and **Clinical Evidence**
- a trend towards less use of **MEDLINE**
- a trend towards simpler search methods
- a trend towards favoring **PIER**

The primary care physicians who are risk avoiding (higher use of healthcare resources) showed statistical trends toward

- greater use of distilled resources
- simpler search methods
- better answers with PIER and Clinical Evidence.

The answer to question 2 is, least in this small group of primary care physicians, stress from uncertainty was associated with differences in process and risk attitude may show some trends towards differences in processes related to electronic information resource use to answer simulated clinical questions. As with most research, however, I am left with intriguing results that deserve further study, some around risk and uncertainty and electronic information use and more importantly the need for personalization of electronic information resources and to determine the features or resources that are associated with incorrect answers to clinical questions.

This difference in electronic searching outcomes based on risk and uncertainty status is a useful finding for designers and developers. Risk and uncertainty play a major role in clinical care and this dissertation shows that we may need to design systems based on this set of individual differences. I feel strongly that risk and uncertainty differences along with other individual differences should be addressed in the task of designing effective electronic clinical information resources. Individual differences do play a major role in optimizing computerized resources (41) and I observed a tremendous variation in electronic searching behaviors and substantial criticism of existing resources and features. I feel that we need to study other individual differences to determine if they are associated with differential use and effectiveness of electronic information resources. The issue of the need for personalization of electronic information resources in informatics applications deserves substantial attention.

## 5.3 QUESTION 2b—MODELS WERE ACCURATE REFLECTIONS

Question 2b of this dissertation dealt with the electronic information resources use processes those primary care physicians with different risk attitudes and levels of stress from uncertainty used and if the Wilson Problem Solving Model and the Card/Pirolli Information Foraging/Information Scent Model could model these processes. The processes of electronic information resource use did differ by uncertainty status and the differences could be easily modeled. The general processes as well as the differences used by all physicians in their quest for electronic information to answer simulated clinical questions fit well into both models.

The Wilson model (Section 2.5.1) with its uncertainty resolution driving the cyclic nature of moving from problem identification to definition, resolution, and action fit the coding scheme well. The intervening variables of domain knowledge, and personal, role, and environmental issues related to the individual and question. These variables affect each of the processes and show the complexity of the information seeking and application process. The model allows for a person's attitude towards risk and stress from uncertainty to affect the searching process but shows how it is not the only factor that affects process and outcomes. In addition, the cycles of information seeking evident from the coding are another aspect of the modified Wilson model that fits well as do the differences in active searching and use of heuristics. Looking at the coding system and outcomes, the Wilson model is one that fully and explicitly explains the searching process of primary care physicians using electronic resources.

The modified Wilson model should be used by anyone interested in aspects of electronic information resource use related to the influence of the question and its domain, personal characteristics of the individual searching and his or her role in relation to the electronic searching process, and the environment in which the searching is being done. These search-modifying aspects or intervening variables as described by Wilson can easily encompass the range of electronic searching behaviors and the richness and complexities that are needed to understand and model clinical information use within an electronic environment. Those who continue on with research into the need for individualization of these and other informatics applications would benefit from choosing

the Wilson model over the Card/Pirolli model. The Wilson Problem Solving model is the model of choice for consideration of the searcher in electronic information resource use.

The Card/Pirolli Information Foraging/Information Scent Model also represents the searching processes elucidated in this dissertation well, although it emphasizes other aspects of searching for information using electronic resources. The cycles of searching that most of the participants followed were an exact match for the patches of information described in the model. The scent nature of knowing where and when to move to the next resource was evident in statements of previous success with a resource, citations from **MEDLINE**, links in Google, or thumbnail pointers to other web pages. The aspect of searching until the resources or energy ran out or the searcher was satisfied with the content was also nicely modeled by the satisficing concept of an animal with a full stomach rather than consuming (or considering) all available resources. The risk and uncertainty aspects of modified Wilson model are not as evident in the Card/Pirolli model but they can certainly be modeled by the characteristics of the individual forager and unique patches available and chosen. The proportion of active searching and reliance on heuristics for the physicians with different levels of stress from uncertainty also fit well. In summary, the Card/Pirolli Information Foraging/ Information Scent Model as with the Wilson model are both capable of modeling the information searching and use behavior of primary care physicians and their use of electronic resources.

The strength of the Card/Pirolli model for medical informatics is in understanding of how a searcher knows or learns to move from one patch to another based on hints or scents. Those people who are interested in building or evaluating electronic information resources and are concentrating on issues of access format (how to find something) such as indexing, building links, and providing snapshots or thumbnails would benefit from using the Card/Pirolli model in their deliberations. Those who are interested in providing content access to an electronic resource or item in that resource (e.g., a structured abstract or declarative title in clinical resources or the 1-line summary in **Google** listings) would be better served by using the Card/Pirolli Information Foraging/Information Scent model than the Wilson Problem Solving model. The Wilson model is best for consideration of the searcher while the Card/Pirolli model is best when considering the electronic resources themselves.

The answer to Question 2b is yes, the Wilson and Card/Pirolli models can model electronic searching behavior by primary care physicians. The models cover both the similarities in searching and application processes as well as differences in process and the outcomes based on risk and uncertainty status. Both models have their strengths in modeling electronic information access by primary care physicians and those interested in models

should consider the Card/Pirolli model if they are interested in the systems or resources themselves or the modified Wilson model if they are interested in the searcher or the effects of external modifiers.

## 5.4 QUESTION 3—PHYSICIANS HAVE PREFERENCES FOR INFORMATION RESOURCES BUT THEY ARE NOT BASED ON RISK STATUS

Question 3 deals with electronic resource preference. First, resource preference exists. Second, it is not related to risk seeking/avoiding or low/high stress from uncertainty. All participants preferred **PIER** to **Clinical Evidence** by a factor of 2.5 despite a higher level of criticized features with **PIER**. With further analysis, no preferences were seen based on risk attitude or stress from uncertainty although a trend toward favoring **PIER** was seen for physicians who reported high levels of stress. With respect to favored features, format and clinical content were among the most favored feature for both resources. **PIER'**s other choice feature was its recommendations and **Clinical Evidence** was also valued for its evidence. Evidence was a preference and criticized feature the same number of times for **PIER**. Features used for preference decisions were consistent with other lists of features (32) and should be considered by those that produce information resources.

Data from answering Question 3 and some from Question 2 add weight to the need to study personalization of electronic information resources in primary care. Physicians had strong preferences either **PIER** or **Clinical Evidence** and often expressed disbelief that other clinicians would prefer the alternate resource. Physicians often criticized features seen by another physician as preferred or valuable. Physicians also used a wide variety of electronic information resources and search methods and their electronic searching heuristics showed a range of behaviors and searching triggers or methods of approach. Personalization of electronic resources is effective in commercial systems. I feel that personalization is a rich area of research in medical informatics and one that has already shown positive results (1).

In addition, the data on preferences show that electronic information resources are not seen as being completely satisfactory. Although **PIER** was preferred more than twice as often as **Clinical Evidence**, the 25 physicians had 76 criticisms of 20 separate features. **Clinical Evidence** had 31 criticisms of 17 features. These

numbers of criticisms show that more research and development of electronic information resources needs to be done. Added to this, clinicians who did not choose a resource as preferred would often state that they could not decide between the **PIER** and **Clinical Evidence** because of a conflict between a mix of preferred and criticized features across the resources.

Also of note is the fact that physicians showed that they felt a lower level of certainty for incorrect answers and this lower level was associated with a willingness to search for information to answer the simulated clinical questions. The willingness to search was not associated with correct answers. These findings of the clinicians not being aware of the need to pursue external information in an electronic environment adds to the need to work toward prompting electronic information systems intelligently and effectively integrated into electronic clinical information systems. Push and pull electronic information systems will not address the inability to know when to go to external resources.

One of the most important aspects of the dissertation is the aspect of electronic information resources being associated with incorrect answers. Two additional studies show a similar level of about 10% to 15% of questions going from right to wrong after searching (30, 118). This finding of moving from correct to incorrect answers is discussed in the next section.

## 5.5 FACTORS ASSOCIATED WITH CORRECT ANSWERS BECOMING INCORRECT

The choice of an effective electronic information resource is vital to individual physicians and also those who work to integrate information systems into electronic medical record or clinical information systems. Physicians do not always make the right choice of information resources as shown by the unchanged rate of correct answers when the study participants used their best electronic resources (Section 4.8.6) compared with the change towards more correct answers with the use of **PIER** and **Clinical Evidence** (Section 4.10.4). I propose the need for more research into discovering the features of an electronic information resource, or resources themselves, that are associated with correct answers to clinical questions. We get some hints of what some of the resources are that need to be pursued from Table 5-1 **OVID MEDLINE** and **MEDLINE** (**OVID** and **PubMED**) as well as **UpToDate** show a trend

(Fishers exact test) towards being associated with incorrect rather than correct answers. **InfoPOEMs** was associated with 4 incorrect and 1 correct answers but this difference did not reach statistical significance. **MDConsult** showed a trend towards being associated with a correct answer. These data are not associated with the questions studied in this dissertation. Because of this, these findings are to be used only as interesting findings, to be confirmed in future studies. The resources that were used in the questions that were changed from correct to incorrect were:

- **Cochrane**
- **OVID MEDLINE** (2 instances)
- **UpToDate**
- **Google**[48] (3 instances)

The resources that were associated with an answer being changed from incorrect to correct were:

- **PIER** and **Clinical Evidence** (14 instances for irritable bowel syndrome and acute mountain sickness questions)
- **MDConsult** (2 instances)
- **OVID MEDLINE** and **PubMED** (2 instances)
- **Epocrates**[49]
- **Lancet**
- **Google**

[48] Note that I did not differentiate between Google being used to provide an answer or to provide access to other resources or web pages.

[49] **Epocrates.** Hand-held system that provides clinicians and pharmacists with drug prescribing information. (http://www2.epocrates.com/index.html). Accessed July 18, 2005.

**Table 5-1. Number and Percentage Each Resource Used by Total Resources Used for Correctness of Answer.** This table is beyond the scope of the dissertation questions. It shows initial hints on what resources could be pursued in the study of effective information resources that lead to improved question answering.

| Resource Mentioned | Answer correct after searching (19 questions) | Answer wrong after searching (27 questions) | Answer changed-right to wrong (5 questions) | Answer changed-wrong to right (6 questions) |
|---|---|---|---|---|
| **Clinical Evidence** | 2 (6.1) | 0 (0) | 0 (0) | 0 (0) |
| **Cochrane** | 4 (12.1) | 4 (7.8) | 1 (11.1) | 0 (0) |
| **InfoPOEMs** | 1 (3.3) | 4 (7.8) | 0 (0) | 0 (0) |
| **Lancet** | 1 (3.3) | 1 (1.9) | 0 (0) | 1 (14.3) |
| **MD Consult** | 5 (15.2) (P=0.1) | 2 (3.9) | 0 (0) | 2 (28.5) |
| **OVID EBMR** | 2 (6.1) | 5 (9.8) | 0 (0) | 0 (0) |
| **OVID MEDLINE** | 5 (15.2) (P = 0.2) | 14 (28.6) | 2 (22.2) | 1 (14.3) |
| **PubMED** | 4 (12.1) | 7 (13.7) | 0 (0) | 1 (14.3) |
| **UpToDate** | 0 (0.0) (P = 0.1) | 5 (9.8) | 1 (11.1) | 0 (0) |
| **Google** | 11 (33.3) | 10 (19.6) | 3 (33.3) | 1 (14.3) |
| **Epocrates** | 0 (0) | 0 (0) | 0 (0) | 1 (14.3) |
| **Average number of resources /question** | 1.7 | 1.9 | 1.8 | 1.2 |
| **Total number of resources** | 33 (100%) | 51 (100%) | 9 (100) | 7 (100) |

The number of resources that were associated with changed answers as listed above is very small and I draw no real conclusions from them aside from stating that this is another rich area for research. Assessing the correct answer to a real clinical question in real clinical time is tremendously difficult and a resource-intensive process. Production of meaningful and substantial questions and having them completed in a realistic setting is probably the most crucial factor in further research in this area. I am looking forward to taking on this task.

## 5.6 LIMITATIONS RELATE TO SAMPLE SIZE AND COMPLEXITY OF THE PROJECT

This study has several limitations. The most important to the project is the artificial situation in which the searching was done and the simulated questions. Handing the physicians pages from electronic resources (**PIER** and **Clinical Evidence**) was also an artificial situation with cuing that the answer was probably within the pages I provided. I needed to control the setting and questions as much as possible to be able to compare searching episodes and

outcomes and therefore chose to use simulated questions. The data I have can be used for analysis and study but one of its strongest uses is to develop further research related to electronic information resource use. Almost 20% of my participants mentioned that the searching they were doing did not follow their usual patterns of searching for information needed in clinical care. The study results still have value however, in emphasizing the need for clinicians to make careful choices, designers and developers to use care in development, and to plan new studies. It also provides strong evidence that personalization of electronic resources should be investigated further. The next section expands on contributions of this dissertation to medical informatics and other domains.

Almost as important to the dissertation project as the artificial nature of the project is the small sample size. Each of the risk groups had only 10 to 11 physicians in each of the 4 risk groups. This likely contributed to the inability to find differences in the process of information seeking and use across the groups. This small sample size is in a small way mitigated in that many of the statistical tests used were exact tests (Fisher and McNemar change test), which may not be as affected by small sample sizes as some other statistical tests. Power calculations on several of the outcomes for the risk groups showed I have from approximately 10% to just over 20% power to detect some of the differences I was seeking. My data showed that I would need a sample size of approximately 40 physicians in each group to detect changes in **PIER** and **Clinical Evidence** preferences to more than 250 physicians per group to detect differences in rates of correct answers to have an alpha of 0.05 and a power or 80%.

Another limitation of the study related to the data is the wide variation. In some instances, the standard deviations were almost as large or larger than the point estimates. For example in Table 4-29, the mean number of codes for the irritable bowel question was 39.7, SD 32.7 with a range from 9 to 175 codes. This variation in the data also contributed to the inability of the study to find statistically significant differences across the risk groups.

## 5.7 EXPECTED CONTRIBUTIONS TO MEDICAL INFORMATICS AND RELATED DOMAINS

The results of my dissertation will likely contribute to research and applications in several domains or areas of interest to health care: medical informatics, library and information science, shared patient-physician decision-making, and health services research.

### 5.7.1 Results enhance medical informatics research and resource design

This dissertation contributes to medical informatics on several fronts. The biggest contribution is likely for those who design our electronic information systems and resources and integrate them into the clinical care process or electronic medical record systems. Design is vital in computer systems because of the huge differences in productivity across users that can be substantially reduced by attention to the uses, good design, and training. We now know that designing or personalizing resources based on risk attitude or comfort from uncertainty may be justified. In addition, we do know that clinicians have strong preferences for electronic information resources. Within a certain resource, features are differentially preferred and criticized across users of the systems. All of this adds to the need to personalize electronic information resources. Cimino and colleagues (1) have already started to study and implement personalization of systems by being able to direct information requests to healthcare provider-specific (nurses and doctors are sent to different resources) electronic resources or hospital-specific electronic resources.

More importantly, we know that electronic information resources can not only improve clinician question-answering ability, at least for simulated questions; they also can be associated with substantial numbers of incorrect answers—both those that started incorrect and stayed incorrect and those that started out correct and move to incorrect. These latter correct/incorrect answers are not only found in this dissertation but in 2 other studies (30, 118) and are in the range or 10% to 15% of all study questions going from correct to incorrect after use of electronic information resources. This negative effect of computerized information resource use is analogous to the effect of electronic prompts that accompany some advanced electrocardiogram systems (130)—electronic systems that provide prompts are heeded by clinicians. When the prompting is correct, the physician substantially improves his or her accuracy. When the prompting is incorrect, the physician's accuracy decreases to below that what he or she would have had without the added prompts. My findings on which electronic information resources and features of these resources are preferred and why align with the Ely and Osheroff self-report data (33) on ideal information resource features. These features can be used to enhance existing resources and plan for new ones. Those who design must realize that these features are not universally desired and personalization of the resources may be necessary.

In addition, my findings also validate the fact that physicians, like all individuals, do not always know when they need to look up information. This highlights the need for information resources that are built to be prompting systems even though these systems are very difficult to implement well (100) and require substantial resources for implementation and maintenance.

Because medical informatics is a new discipline and somewhat lacking in a substantial theoretical basis, the good fit between the searching and information use by clinicians and both the modified Wilson Problem Solving model and the Card/Pirolli Information Foraging/Information Scent model is important. Both models have characteristics that provide a deeper understanding of the electronic information seeking and use processes in clinical care, at least for primary care physicians. The modified Wilson model is best for studying how external factors associated with the question, domain, and searcher with his or her role and environment affect electronic information seeking processes and outcomes. The Card/Pirolli model is best for those who are interested in the information resource themselves, especially aspects of getting to the resource and its content. This dissertation also provides an example of how methods from information and cognitive science can enhance understanding in medicine and medical informatics. It shows the role that electronic information resources play in improving a clinician's ability to answer clinical questions correctly and that design of the resources and integration into electronic medical record systems need very careful attention.

### 5.7.2 Library and information science

Library and information science researchers and practitioners benefit from a validation of theoretical models in health care and awareness that purchase of information resources requires careful decision-making. Showing the link between resource use and both improved and potentially worsened ability to answer questions correctly is important to both researchers and practitioners in this domain and is one that has not often been shown before. Librarians need to know that information resources can be detrimental to efficient question answering and be willing to adapt their services and collection as resources change and improve—the facts that **MEDLINE** might be associated with incorrect answers and that distilled resources may be preferred are important for librarian trainers and clinical medical librarian/informaticians to consider. Another area of interest that this dissertation has is a broadening of the knowledge base for information seeking behavior studies in health professionals.

### 5.7.3 Patient education and risk groups

Risk and uncertainty are part of health care and will remain so. Attitudes towards risk and stress from uncertainty are also important aspects of care even though they may not be associated with information resource use. I feel that looking at the same risk attitude and stress from uncertainty characteristics in patients could be fruitful in several areas and deserve further research. First, attitude towards risk (75) affects how physicians choose continuing education course content and format. Patients also have risk attitudes and stress from uncertainty similar to physicians and therefore patient education might be improved by tailoring patient educational materials and training based on risk/uncertainty factors.

Studies have shown that patients choose treatments, either alone or in conjunction with a healthcare professional, based on their risk or uncertainty status for lupus nephritis (131), multiple sclerosis (132), complementary and alternative medicine (133), and benign prostatic hypertrophy (134). Knowing the risk or uncertainty status of a patient may enable better discussions of decision options and related harms and benefits. Patients also want to know uncertainties associated with their condition and in a 2000 study by Gordon and colleagues (135), patient satisfaction was linked to expressions of uncertainty about their conditions. This wanting to know uncertainties had changed from 12 years before when a 1988 study by Johnson and colleagues (136) showed that patients did not want to be informed of clinical uncertainties as any uncertainty in care decisions was deemed to reflect poorly on the physician and his or her ability to care for the patient.

### 5.7.4 Health services research—Does risk/uncertainty make a difference?

The emphasis behind this dissertation is to possible improved care through better utilization of healthcare resources. I did find some differences around information seeking and use of electronic information resources based on stress from uncertainty of individual physicians and some hints that differences might also be related to risk attitude. I also found that the choice of information resource to use in making clinical decisions ultimately has a large effect on a clinician's ability to get accurate answers to his or her information needs. We must design or redesign information resources that lead quickly and efficiently to the correct answer without little, if any, effort by the physician. This

design and direction will likely lead to an electronic prompting information resource system strongly and intelligently linked to a computerized medical record or clinical information system. We then may be able to make more efficient use of existing healthcare resources. My work fulfils the first part of this sequence—finding differences and model building. The results of my dissertation point to possible design features but also indicated that we need to know more about what makes an accurate and useful information resource for all that need information and for individual clinicians.

In summary, several domains can benefit from the findings of my dissertation—some more so than others. The benefits center on strengthening the theoretical basis of a domain (e.g., medical informatics and library and information science) and also on very practical applications—do we design or redesign or implement electronic information resources that lead to correct and timely answers to both identified and unidentified individual information needs and should we seriously pursue personalization of the resources?

## 5.8 FURTHER RESEARCH

Several areas of research come out of this dissertation. First, I want to develop an additional set of clinical questions that I will use to ascertain which electronic information resources and which features of the information resources are associated with correct answers (ones that move an incorrect answer to a correct one while maintaining initial correct answers). I would also like to ascertain which electronic information resources or features of a resource are associated with correct answers being changed to incorrect ones for comparison. I will also likely measure both risk attitude and stress from uncertainty in these studies to determine if differences exist in choice of information resources as hinted by some differences and trends in this dissertation. Research into personalization of information resources is another potentially fruitful area to pursue. I also feel that patient risk attitude and stress from uncertainty are important and need to be addressed. If I do not pursue this aspect or risk I will encourage others interested in consumer informatics to do so.

This dissertation project has been fascinating and will remain an important part of my research career. I am delighted I had a chance to complete it. Thank you to all who have helped me make this journey.

## 5.9 RESIDENT WOES—THE END OF THE STORY

Dr. Lakeland investigated the issue of resource utilization further to determine if obtaining specific resources would make clinical care on the wards run more smoothly. He found that although risk seeking and avoiding and low and high stress from uncertainty were important for many aspects of healthcare resource use, the differences in the use of the resources was not likely going to be fixed by selectively supplying information resources. He told Bailey of his findings and his intent to make sure that all of the physicians under his supervision used high-quality electronic information resources that supported them in obtaining or maintaining correct answers. He also vowed to work more closely with the clinical information system implementation team. He was not sure that the resources could make the team more uniform in their use of resources but he wanted the decisions his peers and residents made based on electronic information resources would be correct as often as possible.

# APPENDIX

## A. ABBREVIATONS USED

| | |
|---|---|
| CI | Confidence interval |
| EBM | Evidence-based medicine |
| ERB | Ethics Review Board (Canadian equivalent of US IRB) |
| GIM | General internal medicine |
| HMO | Health Maintenance Organization |
| IRB | Institutional Review Board (US equivalent of Canadian ERB) |
| PIER | Physician Information and Education Resource (published by the American College of Physicians) |
| PRU | Physician Reaction to Uncertainty (Gerrity Scale) |
| SD | Standard deviation |
| SUS | Stress from Uncertainty—a subscale of the PRU scale |
| UK | United Kingdom |
| US | United States |

## APPENDIX

### B. CLINICAL QUESTIONS AND ANSWERS

1. Is their any benefit of routine pap smear in persons who have had a hysterectomy for benign disease? Answer: No
2. Is ultrasound the best diagnostic test available to exclude the presence of lower extremity deep vein thrombosis? Answer: Yes
3. Are non-acetylated salicylates really safer, e.g., have less incidence of acid-peptic problems, in patients with NSAID GI intolerance (who benefit from anti-inflammatory effect)? Answer: Yes
4. Is the elevation of alkaline phosphatase a better indicator of recurring prostate cancer than a rising PSA? Answer: Indeterminate
5. Is the cyto brush superior to a spatula in obtaining cells for PAP smears in terms of technical quality (e.g., percent of interpretable smears)? Answer: Yes
6. For institutionalize adults, to prevent influenza and reduce mortality from it, is it more effective to vaccinate health care workers for influenza than patient/residents? Answer: Yes
7. Is there any benefit for ultrasound as physical therapy for sprained ankle? Answer: No
8. Is Penicillin superior to Ciprofloxacin for the outpatient treatment of pelvic inflammatory disease? Answer: Indeterminate
9. Is anti-inflammatory therapy (NSAIDs) better than Tylenol for elderly patients with degenerative joint disease? Answer: No
10. Is there evidence of an association between petroleum product exposure and bladder cancer? Answer: No
11. Is a high dose (1200 to 1500 mg daily) regimen of zidovudine therapeutically superior to a low dose (500 to 600 mg daily) one in patients with positive HIV antibody for reducing the progression to AIDS? Answer: No
12. Will prostate specific antigen screening lower the mortality rate of prostate cancer in low risk men after they reach the age of 50? Answer: Indeterminate

13. Is there good evidence that an antibiotic can prevent endocarditis in an 18-year-old woman with rheumatic heart disease (mild mitral regurgitation) who is to have a dental root canal? Answer: Indeterminate
14. A 52-year-old woman recently had a modified radical mastectomy for infiltrating ductal carcinoma of the breast. Her axillary lymph nodes are negative for tumor. Would estrogen receptor negativity be more like to indicate a relatively poor prognosis for this patient, rather than thyroid hormone receptor positivity? Answer: Indeterminate
15. A 40-year-old premenopausal woman consults you about her risk of breast cancer. Does prior use of birth control pills increase her risk? Answer: No
16. Does anti-reflux surgery in patients with Barrett's esophagus reduce the risk of developing adenocarcinoma? Answer: Indeterminate
17. Is long-distance running associated with intervertebral disc narrowing in men? Answer: Indeterminate
18. Would plasma norepinepherine levels indicate poor prognosis in congestive heart failure better than hyponatremia? Answer: Indeterminate
19. Is Trental (Pentoxifylline) the best drug available to improve symptoms of peripheral vascular disease? Answer: No
20. Do the majority (>50%) of terminal AIDS patients have clinical symptoms of cardiac involvement? Answer: No

**-----The following 3 questions are not part of the original set and were added to allow for use with PIER and Clinical Evidence (Question 3 of dissertation)**

21. Are antidepressants effective for reducing pain and nausea in patients with irritable bowel syndrome: Answer: Yes
22. Is advocacy (empowering) a useful approach for helping a woman leave an abusive situation? Answer: Yes
23. Is acetazolamide effective for both preventing and treating high altitude illness? Answer: Yes

## APPENDIX

### C. SAMPLE VERBAL PROTOCOL DIVIDED INTO SEGMENTS

1. Interviewer: Okay so switch over to Cindy's computer. Here is the question so it can be in front of you. I think if you wiggle the mouse you'll get the screen up.
2. Okay.
3. Interviewer: The only thing I am going to say is please keep talking. If you're quiet for too long I'll give you a bump to get you going again.
4. So this is a question about testing, uh, or screening and the value of a certain type of test as compared to another in getting a valid answer.
5. Uh, What I want to know is whether or not there has been a trial which has compared one to another directly
6. and uh so one of my favorite places of all
7. even though it doesn't make a lot of sense, the place I always start is with **Google**
8. …(typing)
9. look for the very broad sweep of what might show up on the first page using words that are likely to be fairly unique
10. …(typing) uh in literature uh
11. …I see (cytobrush) that there seems to be an article
12. in American Family Physician
13. that compares or that talks about anyway the two methods that are talked about in this question.
14. Uhm so I may come to that …this looks more like a commercial advertisement…It is sort of related
15. ….What I like about this is that it's the National Institutes of Health
16. (this is a **MEDLINE** citation from **Google** and it is NOT an NIH document)
17. —I trust that even though it might not be dealing exactly with the question that I am asking–although it looks like it is very close
18. and may be a bit quicker to read than this article up here.
19. So that is good. … (reading)
20. … and it looks like information for the patient so that is not going to be very helpful for this.
21. So uhm I am going to go to the one to see if it gives me any leads to help me with this article.
22. And this is from the Journal…looks like it's the same thing as this journal article up here…(reading)
23. … Now I'm gonna quite quickly stop looking at this…uhm because it is going to take too long
24. —This one uhm,… (reading) …so the question was technical quality that you asked uhm however,
25. uh, and they sorta talking about one aspect of technical quality—uhm which is the yield of endocervical cells
26. so it may not encompass all the things we think about when we talk of technical quality
27. but they did, uhm uh it looks like it is an assessment of two different methods head to head—a pretty good method for comparing our two uh methods in question.
28. Uhm and …I'd read further on into the article to see how more detail about the methods were done
29. but for the sake of uhm using this in the clinic I would start to believe that we have some pretty good indication although a small number of samples so far in only one study.
30. So I'm getting the idea that there may be some evidence that uh that the cytobrush is better than the spatula for getting endocervical cells.
31. Now uhm I'm not happy with that…It's not going to answer my question because it is only one study so uh my next step is to go to,

32. very quickly to shift over to the **TRIP Database©**[50] and uhm … (typing)
33. and what I'm looking for is preferably a clinical practice guideline that has summarized a number of studies or a meta-analysis
34. and uhm again I will use the term cytobrush because it is not likely to be overlapping with much else…and uhm it seems to
35. …I trust TRIP because I know how they uh how the search technique is used
36. but I'm surprised that there isn't anything under guidelines or even evidence based queries which I would have expected some on
37. ... (reading). So what we have, what it looks like original articles.
38. All right try this again, go more general with Pap…(typing)
39. … and…uh So here I've got some guidelines and I'd see what I've got… (reading) …"
40. Obtaining an optimal Pap smear". So this may well …
41. uhm I'm looking for what kind of study, or sorry what kind of review this was… (reading) …And it actually looks like it was
42. … a bit about how to do it …It has a little bit on the brush but not much data.
43. …So we've got good articles here (bibliography).
44. These are all pretty old articles that were based on, not all of them… uh …looks like we could do better
45. so I'm going to go to the bibliographic services because they have dealt with this
46. …Interesting here is the answer to one of the other questions … "Is there benefit to Pap testing in women who have had a hysterectomy?" --I'm dying to know the answer so let me just take a peek.
47. … Okay… So now I'm not getting much there either…evidence based…(reading) … (reading)
48. … Well we have this meta-analysis of Pap test accuracy. I would love to see a meta-analysis
49. but it is older and I'm
50. …it probably wouldn't have a comparison although the cytobrush did come up right around that time so.
51. … (reading). … "The accuracy of Pap test by comparing the test results and histology".
52. That's not the answer to the question either
53. …Okay. I'm starting to get the impression that the level of evidence available for this project is less that I had thought.
54. So I'm going to go back now. That's too may to review (**MEDLINE** citations in **TRIP**)
55. so I'm not even going to look at those but I'm going to do that cytobrush again and take a look at… What's going on?
56. which would be a good source for this … I know that this also searches Cochrane
57. uhm but so far nothing is coming up there. So let's see uhm see diagnosis articles
58. … I'm looking for … titles that would have, that would lead me to believe that there may be a comparison with cytobrush and spatula
59. and "cytobrush and endcervical curvette" … A relatively recent article in a gynecology journal
60. but I'm going to take a quick look in there.
61. …not sure what the term endocervical curette means … I think it gotta be spatula –
62. Yeah …uh I look at the first line to see whether the objective matches what I'm looking for and then I go to the conclusion.
63. "achieved sufficient specificity to the … curette and much greater rate of adequate specimens than using the endocervical curette" ..is a reasonable substitute.
64. Okay so it looks like it agrees with the pervious article I looked at in the sense that it speaks to better adequacy of specimens but for those specimens a similar rate of pick up
65. … so. …again they must going after the, they must be analyzing the ones that are adequate.
66. Interviewer: Okay, so what is your answer to the question?
67. Okay the answer to the question at this point with what uh I've got is that the cytobrush is superior to spatula for obtaining cells and that the answer is yes
68. and uh that there is evidence to support this and my confidence has gone up.
69. Interviewer: What is that number.
70. Uh, let's say 90% -- the part that remains for me is so now that I've really basically seen two studies
71. two individual studies that support this but there are more still in there that look at this on the page
72. and uhm I'd like to look a little bit more carefully at things like **Cochrane**

[50] **TRIP Database©**. Ad UK based company that provides a database of integrated evidence-based resources. (http://www.tripdatabase.com/). Accessed July 21, 2005.

73. and Clinical Practice Guidelines Databases.
74. I believe I would not find anything there
75. because **TRIP** already, already searches these
76. but if I really needed a more or a better answer or I needed a policy I would look harder. I am surprised that there isn't more than I've seen.
77. Should I keep going?
78. Interviewer: If you are satisfied with your answer from a clinical point of view, no. If you're not going to do rounds on this just something that came up in the clinic, stop.
79. So I feel that this would help and I would feel fine with this.
80. Interviewer: Moving right along on this next question.
81. So this is kinda of a harm question, it is a risk for disease outcome…and um this will have,
82. it probably isn't useful to go into **Google**
83. that's just too bit a new.
84. Umn, pretty specific question.
85. And I'm guessing that it is going to have a very small numbers, a small amount of data to address it. …So where will I start?
86. I think I would, will start with **TRIP**. I don't think there is going to be, this isn't something you'd get a guideline on – uh it's not about an intervention –
87. and so we're going to get articles, original articles primarily uhm… very unlikely we will find a meta-analysis.
88. So I will put in here … (typing) .. running – actually just run I don't want to lose things because we've got different endings.
89. Uh, well we do have an evidence based … which doesn't have anything to do with it a query answering which is more about Raynaud's Syndrome so that is no good.
90. … So you can see we have lots of articles that have "run" in them.
91. I think my best source for this is going to be **MEDLINE** which I'm gonna, will just do
92. and in **MEDLINE** … (searching the Internet for **PubMED**)
93. …. It's been a while since I've used the queries … but I think I will… I don't see it…try that… (looking)
94. …I guess it's been so long that I can't even see it.
95. I'm gonna go… There we go… And so… give it a try with etiology… and … uh …
96. will go with a broad search because I don't think there are going to be a large number.
97. Put in (typing) … "run" and "intervertebral" and won't use any other terms
98. ….and we'll see if any show up … (reading) … (reading) … Looks at age on intevertebral compression in runners. That would certainly be a good start.
99. … "Spinal shrinkage in fast bowling". Interesting.
100. People certainly have really looked at this.
101. …. (reading) … "Common injury pathologies" … "disk degeneration and associated abnormalities of the spine in gymnasts"
102. …. It looks like we are close on this first article
103. ..So this indicates that previous studies have shown intervertebral disc compression under axial loading
104. which is news to me
105. …. uh. Okay. Maybe, while the reference section of this article might have good things…. Well okay
106. …. uh the purpose of this study was to determine if the amount of vertebral column height loss induced by running was significantly different between two age groups.
107. So right way I am getting the idea that there is in fact a fair bit of data to support the notion that disk space narrowing occurs,
108. it is not specifically in men, but although this study is not really asking that question, it is saying in fact it is assuming that there is narrowing and it wants to see whether it differs by age, and so what they find is that uh.
109. …. (reading) … They have this was of measuring it, and I don't know enough about this subject area to know whether the measurement they are using is valid or reliable or accepted in the literature but I'll assume it is for now –
110. …. (reading) … so they have concluded that there is no significant differences between age groups
111. …. uh but in spite of that it demonstrated that there was significant decreases in vertebral column height after a six mile … run.
112. …. Now vertebral column height isn't necessarily the same as intervertebral disc narrowing
113. although I can't imagine any other way a vertebral column would lose height so I'll assume that that is okay too

114.… so “although no significant differences….these findings for physical therapy among older male patients may have back symptoms\….patients may be advised …adjusted … (mumble)… (reading) …
115.This abstract gives me the impression that in an area where I know very little, a fair bit in fact, more has been done than I had assumed
116.and that the weight of evidence is in favor of the statement being true.
117.Uhm in the clinical setting I would be happy to say, uhm, we have an answer
118.and I'm feeling 90% confident that the statement is true.
119.Interviewer: You’re good….You’ve have the tough stuff done. Okay you can shut that down and come on back over to the desk. The next part is a little bit easier.
120.Good.
121.Interviewer: Okay, Here is the question …”Are antidepressants effective for pain and nausea in patients with irritable bowel syndrome? Now here are your two information resources, they uhm. I’ve taken away all the identifying information and they are sort of polar extremeness in how they present data to you. I want to see if either helps you answer the question and if you have a preference.
122.Well …Keep talking through it again?
123.Interviewer: Yes, please.
124.Okay. Well it is different from the very beginning.
125.Uh, …Right away I'm gong town the left one because it has something about drug therapy (Jones) right at the top and.
126.…..So I know that a lot could be included in a general discussion of this
127.but on the other hand,
128.this one has antidepressants medications right at the top as well
129.so I’ll continue down …
130.(reading) … Okay…
131.So this looks a little bit more like a practice guideline.
132.It has recommendations
133.and it seems to have some levels of evidence attached to them
134.which means I would need to trust the people who have created the levels of evidence
135.and their evaluation of the literature.
136.It does say something about tricyclics in diarrhea
137.and in pain and diarrhea
138.–here we are talking about pain and nausea
139.but uh there seems to be a fairly strong level of evidence to recommend antidepressants
140.… uhm yeah, on several levels.
141.So SSRIs and tricyclics.
142.… at least for pain.
143.…I still haven’t seen anything about nausea.
144.Uhm, and then we have some rationale for why these work
145.and which studies give us evidence for the different effects that they have on the outcomes …
146.so … “Initially benefits … patients most who are not depressed”
147.…without getting into that this feels like it has an answer to the question
148.and has given me information that I could look up if I felt skeptical
149.or wanted to convince myself that the uhm methodologies were okay
150.… Uh. It’s got … people who have reviewed it
151.although I'm not sure from this who they are
152.–anyway that’s how I would think through that one.
153.Uhm. The article on the right also reviews it
154.…It looks to me like we have a sort of a similar.
155.… (reading). So in this case they have actually been more specific
156.and said, they have named where they have randomized controlled trials
157.–So, uh, on the left (Jones) we just have there are studies
158.and there are articles and,
159.oh but they say there are controlled trials as well
160.… I think the one on the right (Kennedy) it’s just a different way of packaging the clinical relevance I suppose
161.…so Uh immediately you go to sections on benefits,
162.harms, uhm, harms.

163.…nice and short
164.…has a final comment.
165.Sort of a bottom line
166.—an overall statement on the quality of studies.
167.…This article seems to come out a fair bit more cautiously on recommending antidepressants
168.… uhm, this article makes much more conclusive statements about how to use them
169.and for what, uhm.
170.I would probably come away from the two articles feeling differently about how my practice should, should go.
171.guess it just feels like the people reviewing this were more skeptical about the quality of the evidence that was being used.
172.I should…they probably used may of the same articles
173.…only one article
174.….only reviewing one systematic review okay,
175.but the systematic review itself came out with,
176.with more conservative statements
177.…Interesting.
178.Interviewer: Preferences?
179.I prefer, in terms of format or in terms of what they are saying in the end?
180.…This is …uhm… talking about a meta analysis.
181.I would, I would be more inclined to work with this, hum.
182.There people (Jones) are doing a review
183.that is uhm not a meta-analysis
184.–it has summarized the data from a variety of studies uh,
185.which I would trust less.
186.so I would go for the right one (Kennedy).
187.Interviewer: Okay. So get to do it again. Acetazolamide for people going up the mountain. Kennedy there and Jones there.
188.(reading)
189.… (reading)
190.… (reading)
191.… So uhm so I'm specifically looking for systematic reviews (Kennedy)
192.and randomized controlled trials that follow the reviews. …
193.uhm …again benefits versus harms
194.…give us a fairly detailed analysis of the rigor of …the article.
195.… (reading) …
196.Uh we find that uhm
197.… it is of questionable value in the meta-analysis
198.but the subsequent randomized controlled trial
199.… uhm … in which acetazolamide was more effective
200.… the same one?
201.… (reading)
202.… This reads like a textbook
203.… (reading)
204.… (reading)
205.…Okay. This is a "how to do" something,
206.textbook kind of report
207.–the same as the other one I guess or a guideline
208.… (reading)
209.(shuffling pages)
210.… Well, hum again a
211.…I think I prefer this. (Kennedy)
212.…I'd probably prefer another one in different situation.
213.Interviewer: what is your answer to the question?
214.You want that too? (chuckles)
215.Interviewer: Yup.
216.Right. (reading)

217.… (reading)
218.….. (reading)
219.… (reading)
220.… (reading)
221.… (shuffles pages).
222.My answer to that is acetazolamide is effective at
223.… probably at specific doses,
224.higher doses,
225.and that the evidence is moderate for that conclusion.
226.Interviewer:  Certainty?
227.Certainty that
228.…so the answer is yes,
229.there's evidence and the certainty about the evidence,
230.about what I would prescribe is probably about 60%.
231.Interviewer:  You're done. Fascinating. Thanks.

## APPENDIX

### D. CODING SCHEME FOR FIRST TWO QUESTIONS

1. Attempt
    - 1.1. first
        - 1.1.1. first and last
    - 1.2. second
        - 1.2.1. second and last
    - 1.3. third
        - 1.3.1. third and last
    - 1.4. fourth
        - 1.4.1. fourth and last
    - 1.5. fifth
        - 1.5.1. fifth and last
    - 1.6. sixth
        - 1.6.1. sixth and last
    - 1.7. seventh
        - 1.7.1. seventh and last
2. General discussions around the issue but not related to the searching for speficic questions
    - 2.1. discuss searching including discuss process
    - 2.2. discuss own knowledge
    - 2.3. discuss training
    - 2.4. explain behavior
    - 2.5. express anxiety
    - 2.6. express frustration
    - 2.7. express satisfaction
    - 2.8. having trouble finding
3. Resources and search engines
    - 3.1. resources that are used for searching
        - 3.1.1. discuss
    - 3.2. general
    - 3.3. discuss
    - 3.4. mention
    - 3.5. go to
    - 3.6. search engines that are used for searching
    - 3.7. mention
    - 3.8. discuss
    - 3.9. go to
4. Searching itself
    - 4.1. question
    - 4.2. discuss question
    - 4.3. discuss question-analyze it
    - 4.4. discuss question-answer
    - 4.5. clinical application
    - 4.6. clinical content

4.7. compare with document
4.8. difficulty
4.9. how to approach
4.10. patient
4.11. why important and real
4.12. read question
4.13. search approaches
4.14. academic center
4.15. access
4.16. across databases
4.17. any question
4.18. bookmarking
4.19. broad
4.20. clinical application
4.21. do it again
4.22. equipment
4.23. evaluation
4.24. general
4.25. keyword
4.26. limit
4.27. memory
4.28. not easy
4.29. own equipment
4.30. patient
4.31. person
4.32. research
4.33. resource
4.34. review
4.35. source
4.36. specific
4.37. time
4.38. discuss search methods
4.39. cache
4.40. change db and re-run
4.41. combine
4.42. ctl f
4.43. do again
4.44. explode
4.45. focus
4.46. keyword
4.47. limit
4.48. mesh
4.49. phrase
4.50. put in whole question
4.51. spelling
4.52. subheadings
4.53. table of contents
4.54. what's new
4.55. search methods
4.56. cache
4.57. change db and re-run
4.58. combine
4.59. ctl f
4.60. do again
4.61. explode
4.62. focus

4.63. keyword
4.64. limit
4.65. mesh
4.66. phrase
4.67. put in whole question
4.68. spelling
4.69. subheadings
4.70. table of contents
4.71. what's new
4.72. field
4.73. related topics
4.74. stop searching
4.75. I've done enough
4.76. I can't find answer
4.77. I'm satisfied
4.78. I'm too frustrated to go on
4.79. troubles
4.80. heuristics
4.81. mistake
4.82. modify/verify search strategy

5. Retrieval
6. Documents and web sites and pages
   6.1. discuss document
   6.2. abstract
   6.3. age
   6.4. answer
   6.5. choosing
   6.6. clinical application
   6.7. clinical content
   6.8. evaluation
   6.9. evidence
   6.10. format
   6.11. full text
   6.12. getting
   6.13. journal title
   6.14. language
   6.15. methods
   6.16. question
   6.17. recommendations
   6.18. source
   6.19. summary
   6.20.
   6.21. discuss web site
   6.22. go to web site
   6.23. mention web site
   6.24. discuss web page
   6.25. go to web page
   6.26. mention web page
   6.27. read document (plain)
   6.28. looking for clinical content
   6.29. looking for evidence
   6.30. looking for explanation of document
   6.31. looking for prognostic/risk factors
   6.32. references
7. Application
   7.1. discuss clinical application including conflicting results

7.2. summarize
7.2.1. summarize what I have done
7.2.2. summarize what I have found
7.3. make decision
7.4. make decision—plain
7.5. make decision ponder
7.6. make decision initial
7.7. make decision confirm
7.8. make decision final
7.9. certainty
7.10. what l like
7.11. what I dislike

8. Heuristic
8.1. before searching
8.2. choosing document
8.3. decision making
8.4. general
8.5. if my usual
8.6. searching choosing sites
8.7. searching choosing
8.8. retrieval

## APPENDIX

### E. CODING SCHEME FOR SECOND TWO QUESTIONS

1. Discuss
   - 1.1. Discuss question
   - 1.2. Discuss clinical content
   - 1.3. Discuss own knowledge
   - 1.4. Discuss/mention resource besides J and K
   - 1.5. Discuss process and related terms
2. Read
   - 2.1. Read J looking for …
   - 2.2. Read K looking for…
3. Discuss feature-J (see list below for subcategories)
4. Discuss feature-K (see list below for subcategories)
5. Prefer feature-J (see list below for subcategories)
6. Prefer feature-J (see list below for subcategories)
7. Criticism feature-J (see list below for subcategories)
8. Criticism feature-J (see list below for subcategories)
9. Nice feature-J (see list below for subcategories)
10. Nice feature-K (see list below for subcategories)
11. Mistake
12. Preference-J (see list below for subcategories)
    - 12.1. Initial
    - 12.2. Final
13. Preference-K
    - 13.1. Initial
    - 13.2. Final
14. Preference-neither
    - 14.1. Initial
    - 14.2. Final
15. Reason prefer-J
16. Reason prefer-K
    - 16.1. Amount of information
    - 16.2. Answer
    - 16.3. Benefits
    - 16.4. Brevity
    - 16.5. Clinical application
    - 16.6. Clinical content
    - 16.7. Clinical focus
    - 16.8. Concise
    - 16.9. Deals with uncertainty
    - 16.10. Evidence
    - 16.11. Format

16.12. Harms
16.13. Levels of evidence
16.14. Methods
16.15. No predetermined actions
16.16. Not textbook
16.17. Practical
16.18. Recommendations
16.19. References
16.20. Summaries
16.21. Time
16.22. Trust
16.23. Usefulness

17. Clinical Application
18. Decision making
19. Certainty
20. Heuristics
21. Satisfaction
    21.1. Express Satisfaction
    21.2. Express Dissatisfaction

Subcodes for categories of "Features" (Discuss, Criticism, Prefer, and Nice)

1. Abstract
2. Accuracy
3. Acronyms
4. Age
5. All the same
6. Amount of information
7. Answer
8. Benefits
9. Clear/clarity
10. Clinical application
11. Clinical content
12. Clinical focus
13. Comprehensive
14. Deals with uncertainty
15. Definitive
16. Differentiates
17. Doses
18. Easy to use
19. Evaluation
20. Evidence
21. Format
22. Good for teaching
23. Guidelines
24. Harms
25. Honest
26. How prepared
27. Levels of evidence
28. Methods
29. Notes
30. Numbers
31. Practical
32. Rationale
33. Recommendations
34. References

35. Relevant to question
36. Review
37. Search
38. Source
39. Summary
40. Table
41. Textbook
42. Time needed
43. Usefulness
44. Vague
45. Question

## APPENDIX

### F. SAMPLE PROTOCOL ANALYSIS WORKSHEET FOR QUESTIONS 1 TO 4

| | | |
|---|---|---|
| Well I haven't used Cochrane, yet | Mention resource-**Cochrane** | Attempt-1 |
| and I'd even know if I have access to it but I'll just check and see if I can get into the **Cochrane Group**. | Go to resource-**Cochrane** | |
| Here we ago—**Cochrane Collaboration** (from **Google**). Ah, it is just a **PDF**. | Discuss resource-**Cochrane** | Heuristic-general-if I do not know how to use a resource it is frustrating |
| So I'm searching on **Google** for the **Cochrane Collaboration** | Go to search engine-**Google** | Mention search engine-**Google** |
| and all I'm getting is a **PDF** page. | Discuss retrieval | |
| Uh and I'll see if there's any kind of index. | Mistake-never got to **Cochrane** | |
| That's of no use at all. | Discuss resource-evaluation-Cochrane | |
| So I don't think **Cochrane** is going to be useful to me at all until I have a direct route to it. | Express dissatisfaction-resource-**Cochrane** | |
| Now another thing I can do which I usually do is to go to **PubMED**. | Mention resource-**PubMED** | |
| Uh so I'll just quickly bring it up. | Go to resource-**PubMED** | Attempt-2 |
| It is not in my list of favorites. I usually have it on my work stations | Discuss process-organization | Heuristic-general—if I am not at my best computer for searching I get very frustrated with the process |
| | *** | |
| but I'll look it up here. … And (typing) search for pap smear | Search methods-keyword-**PubMED** | |
| and post hysterectomy | Search methods-keyword-**PubMED** | |
| …Uh and the search is not…Only 23 citations | Discuss retrieval | |
| —I'll quickly scan through them (reading) … (reading) … (reading) … | Discuss document-choosing-journal article | |
| Interviewer: Please keep talking. | ** | |
| Okay there's a citation here: "Pap smear examination in women post treated with general organ diseases by radiation. | Read document-looking for clinical content | |
| It might be of use. And uh here is a second one that might be useful. | Discuss document-evaluation-journal article | |
| Let's see if they have abstracts. | Discuss document-abstract-journal article | |
| The first citation looks at 846 pap smears in women uh post general organ disease…uh … 67% had had uh…surgery, 30% hysterectomies | Discuss document-clinical content-journal article | |
| …this is not pertinent. | Discuss document-evaluation-journal article | |
| Second citation might be more appropriate. | Discuss document-choosing-journal article | |
| 340 women with hysterectomy Now these were not benign diseases mind you. They had squamous changes or early stage, prostate, uh, early stage cervical cancer uh | Discuss document-clinical content-journal article | |
| and the conclusion in this situation …was…that screening with vaginal paps was appropriate but in this situation it pertains to women who had cervical cancer or early stage cervical cancer | Discuss document-clinical content-journal article | |
| so again it is not exactly what the question asks | Discuss question-clinical application | |
| …. Uh, some of these pertain to women who have their cervix left behind after hysterectomy—which is not a common | Discuss document-clinical content | |

| | | |
|---|---|---|
| procedure | | |
| …and I must admit my search has not been probably the most efficient. | Discuss search approach-evaluation | |
| There are three more citations that I can go to and have a quick look | Discuss document-choosing-journal article | |
| and none of my citations here pertain directly to what I was looking for. | Discuss document-evaluation-journal article | |
| Uh…post hysterectomy. | Discuss question-clinical content | |
| Add one more thing (types in recommendation) but it probably won't pick it up… Yup. So if I specify recommendation | Search methods-keyword-**PubMED** | |
| but I can't find anything there. | Discuss retrieval | |
| But again recommendation doesn't mean that there is evidence for it either. It could be consensus based. | Discuss process-handling evidence | Attempt-3-last |
| I could just go to the Canadian guidelines (**Google** search). | Mention web site-association | Go to web site-association |
| I'll have to search for that because I don't have it check-marked here… | Discuss process-organization | |
| ...Okay. Screen for cervical cancer | Search methods -keyword-**Google** | |
| ….again….(reading) …pertain …pap… cervical…. (reading) | Read document-looking for clinical content | |
| That wasn't useful. (Canadian Task Force site in **Google**). | Discuss document-evaluation-guideline | |
| (shows frustration) | Express frustration-can't find answer | |
| I need a better search engine than the one that I've got. | Discuss search engine | |
| And I don't know if there is anything that exists at this point | Discuss own knowledge | |
| and I don't have access to the **Cochrane** at this point | Mention resource-**Cochrane** | |
| which might be useful and there's is another thing that I don't have access to. | Discuss search approaches-access | |
| It's OVID, so I'm going to stop. | Mention resource-**OVID** | |
| Interviewer: Okay. Good. Uhm, so what's your answer to that one? | ** | |
| (laughs) "Is there any benefit for routine pap smears in women who have had a hysterectomy for benign disease?" | Read-question | |
| I would say that….I don't think there is good evidence | Make decision-final | |
| but I do it about every 5 years. | Discuss clinical application | |
| Interviewer: Certainty? | ** | |
| Uh. I forgot what I put down there. I think it was 70% or 90%. | Certainty | |
| Interviewer: Is there another question you want look up? We can probably do an easier one. You probably picked one of the most difficult ones last time. | ** | |
| Yeah. Well we will do an easier one this time. | * | |
| We'll try acetazolamide for high altitude illness. | * | |
| Interviewer: Actually you are going to look that up next so I can't let you do that one. So you'll have to pick another one. | ** | |
| That's a more concrete one. | * | |
| What were the other ones? | * | |
| Can you mention a couple of the other ones? | * | |
| Interviewer: Okay. Well there is ultrasound for DVT. Do you want to try that one? | ** | |
| Oh, yeah. We'll try that one. | * | |
| Interviewer: Okay. Here is the question on that one. | ** | |
| PubMED®) | Mention resource-**PubMED** | |
| (typing in"diagnosis DVT ultrasound" | Search methods-keyword-**PubMED** | Go to resource-**PubMED** |
| Too many citations. | Discuss retrieval | Heuristic-searching-retrieval—if the retrieval is < about 25 or so I will read not keep limiting/searching |
| Okay (adds in venography, | Search methods-keyword-**PubMED** | |
| Clinical trials). | Search methods-limit using methods-**PubMED** | Attempt-1-last |
| That narrows it down to 60 (citations). | Discuss retrieval | |
| Uhm (reads…..) … (reading) … (reading) … | Read-document-choosing-journal article | |
| Interviewer: Please keep talking. | ** | |
| There are a number of citations that are probably pertinent here. | Discuss document-choosing-journal article | |
| Uh, one I'm looking at right now refers to the incidence of | Discuss document-clinical content- | |

| | | |
|---|---|---|
| DVT looking at ultrasound for DVT uh…, and they're comparing ultrasound with phlebography or venogram for systematic screening. | journal article | |
| The results of the study… uh...the phlebography…the ultrasound was 95% uh sensitive and 94% specific uh | Discuss document-clinical content-journal article | |
| and wait….(mumbles while reading) nicely... …so it was very, it was a good screening test…(reading) …(reading) | Discuss document-clinical content-journal article | |
| …Unfortunately it is not clear here if they were considering phlebography to be the gold standard although it ought to be the gold standard. | Discuss document-methods-journal article | |
| I'll look back to see if there is another study that might be more useful….(mumble) (in **PubMED**). | Discuss document-choosing-journal article | |
| Ah, here we are "comparison of venography and ultrasound for diagnosis of asymptomatic deep venous thrombosis | Discuss document-methods-journal article | |
| ….(laughs)… | Express frustration-can't find answer | |
| it is for upper body. That is a very specific study….it might not be the best… (reading) … compression ultrasound (reading). | Discuss document-clinical content-journal article | |
| … This one might be useful….(reading) | Discuss document-evaluation-journal article | |
| In this study they were seeing if ultrasound was sensitive and specific but they were using plebotomography or venography as the gold standard. | Discuss document-clinical content-journal article | |
| Based on this gold standard, ultrasound was specific and sensitive for detection of asymptomatic DVT. | Discuss document-methods-journal article | |
| However….the trial assesses that venography is more accurate than ultrasound….(reading) | Discuss document-clinical content-journal article | |
| ….looking at ah…more of a review comparing… (reading) … (reading) looking at venograms. | Discuss document-choosing-journal article | |
| Yeah, and this isn't evidence based. Well, the article is based on evidence. The article is written by someone who has reviewed clinical trials | Discuss document-methods-journal article | |
| but their recommendation is that ultrasound and plethysmography can be used a screening test | Discuss document-recommendation-journal article | |
| but that venograms are still the gold standard so what I'm seeing here—going through what I can there and scanning | Discuss document-methods-journal article | |
| is that venograms are still is the gold standard for picking up DVTs. | Discuss document-methods-journal article | |
| Ultrasounds are good as screening tests. | Discuss document-clinical content-journal article | Stop searching-I've done enough |
| Certainly less invasive but not as accurate. So that is my answer. | Make decision-final | |
| Interviewer: Certainty on that one? | ** | |
| About 90%. | Certainty | |
| Interviewer: Okay. Great. So you are done looking up information. You've got the hard parts out of the way. You don't need the computer any more. | ** | ** |
| Okay. | * | |
| Interviewer: I want you to take a look at these and see which one you like better and why and if they help you answer the question. Okay? Here you go. Keep talking out loud and I'm not going to say anything. | ** | |
| One is listed under Jones. | Read-document-J | |
| The other Kennedy. High altitude illness. | Read-document-K | |
| I'm looking at Jones is recommendations | Read-document-J | |
| —the evidence—"small prospective studies". | Discuss feature-J-evidence | |
| It is actually a combination of one study of acetazolamide and dexamethasone in the treatment, | Discuss feature-J-clinical content | |
| not prevention | Discuss feature-J-clinical content | |
| …and then a larger study, prospective at high altitudes. | Discuss feature-J-evidence | |
| Not enough detail | Criticism-feature-J-amount of information | |
| —but refers to the study showing benefits | Discuss feature-J-clinical content | |
| and decreased incidence of high altitude illness (reading) | Discuss feature-J-clinical content | |
| … (reading) | Read-document-J | |
| … Those are just recommendations. …(reading) | Discuss feature-J-recommendations | |
| … I'm going to look at the second paper (Kennedy) | Read document-K | |
| because the first was a bit nebulous. | Criticism-feature-J-focus | |

| | | |
|---|---|---|
| …Uhm This one looks a little better | Prefer resource-K | |
| because it is a systemic (sic) review | Prefer feature-K-format | |
| and they finally refer to a randomized clinical controlled trial | Prefer feature-K-evidence | |
| Which none of the others trials refer to | Prefer feature-K-evidence | |
| ---which should potentially be a better study. | Prefer feature-K-evidence | |
| … (reading) uh… | Read-document-K | |
| and a systemic review too that looks at 9 randomized controlled trials, 254 people. | Discuss feature-K-clinical content | |
| Should be a better study. | Prefer feature-K-evidence | |
| Gives a lot more detail about the design of the study and uhm | Prefer feature-K-amount of evidence | |
| … it compares it to placebo, | Discuss feature-K-evidence | |
| Which is certainly the best way to start out…. | Discuss feature-K-evidence | |
| uh…(reads) and this is used as a prevention also for altitude sickness. | Discuss feature-K-clinical content | |
| So it is more specific of the question asked | Discuss question | |
| and the evidence was that it was beneficial. | Discuss feature-K-evidence | |
| So I would definitely say the second paper, uh the Kennedy paper, | Prefer resource-K | |
| was far more useful to me than the first (Jones). | Reason prefer-K-useful | |
| It presented better information in a more concise format. | Reason prefer-K-format | |
| Interviewer: Okay. What is your answer to the question? | ** | |
| It is effective at preventing and I don't recall whether it was referred to treatment…. Uh | Make decision | |
| … The second paper doesn't actually answer if, it is effective at treating it | Criticism-feature-K-answer | |
| but it does answer that it is effective at preventing it | Discuss feature-K-answer | |
| so I can answer that it certainly is effective at prevention it | Make decision | |
| and it may or may not be effective at treating it. | Make decision | |
| Interviewer: Certainty? | ** | |
| Uh. 90%. | Certainty | |
| Interviewer: Okay. One more to do. We are almost done. Here is the question on antidepressants for irritable bowel syndrome. | ** | |
| Yeah. That's a good question actually. | Discuss question | |
| Interviewer: Again, here are Kennedy and Jones. | ** | |
| Okay. Jones. We'll start with first. Therapy. | Read document-J | |
| Jones always presents recommendations first | Discuss feature-J-recommendation | |
| and the evidence is more the type of brief citations. | Discuss feature-J-evidence | |
| It talks about the clinical trials | Discuss feature-J-evidence | |
| and I don't have the time to go looking up the citations to see if they're valid studies. | Criticism-feature-J-references | |
| At best I can get abstracts while I'm searching (**PubMED**) | Discuss feature-J-references | |
| —they don't usually give me enough detail anyway. | Criticism-feature-J-abstracts | |
| Kennedy right off the bat … refers with more detail to the way they reviewed the evidence | Read-document-K | |
| systemic review | Discuss feature-K-evidence | |
| —8 randomized controlled trials | Discuss feature-K-evidence | |
| …uh and it compared it to placebo too | Discuss feature-K-evidence | |
| —so they've already sourced out the best information. | Discuss feature-K-evidence | |
| Obviously they know how to search better than I do… | Discuss process-searching | |
| . (reading) … | Read-document-K | |
| (reading) … | Read-document-K | |
| and they did show benefit uh in terms of the answer to the question if antidepressants are effective at reducing pain. | Discuss feature-K-clinical content | |
| Definitely for reducing pain there was a benefit seen | Discuss feature-K-clinical content | |
| –uh…the second review (reading) | Read-document-J | |
| … (reading) …. | Read-document-J | |
| Then there is a nice comment at the bottom to qualify the results of the studies. | Discuss feature-J-comment | |
| And they mention that the studies were low to moderate quality, | Discuss feature-J-evidence | |
| so there isn't a huge amount of certainty in the conclusion drawn by the studies… | Make decision | |
| . But at least it is a more honest presentation | Discuss feature-J-honest | |
| —it certainly shows that some of the studies suggest that there is a reduction in pain. | Discuss feature-J-clinical content | |

| | | |
|---|---|---|
| I don't believe there is a reference to the nausea | Discuss feature-J-clinical content | |
| so I don't know if it makes a difference there in terms of irritable bowel syndrome but it is defiantly a better format. | Made decision | |
| Answer: Yes. | Make decision | |
| Interviewer: Certainty? | ** | |
| I would definitely say 80% confident for reducing pain. | Certainty | |

## APPENDIX

## G. SEARCHING HEURISTICS IDENTIFIED BY PROCOTOL CODING

### Before Searching and General

Heuristic-general-doctors are better at knowing about questions than patients (!!!)
Heuristic-general-patient information is not for physicians
Heuristic-before searching—if I do not have enough background knowledge I will check this first*
Heuristic-before searching—if I know a lot about the question I will go to a journal article first
Heuristic-before searching—if I don't know a lot about the question I will go to a textbook first
Heuristic-before searching—if I don't know a lot about the question I find it hard to search
Heuristic-before searching—I look at the question and decide what I want to find
Heuristic-before searching—some questions are easier to find the answers for than others
Heuristic-before searching—I look at the question and decide how "old" the issue is-it affects searching
Heuristic-before searching—I look at the question and decide how much is on it-it affects searching
Heuristic-before searching—before I start I decide if the question is broad or specific and choose where to go based on this decision
Heuristic-before searching—questions fall into categories and I go to where I have been able to answer similar questions in the past
Heuristic-before searching-specific questions are often best answered by a review article
Heuristic-general-if I am searching for my own knowledge I will be satisfied with a couple of relevant documents
Heuristic-general-if I am searching for a patient I want to have something to print out to give them
Heuristic-general-patients need information that I can provide
Heuristic-general-if I am searching for a research project I will check the references (do more searching and reading)
Heuristic-general-if I a working on a report or research my searching is different than if I had a patient question
Heuristic-general-if I in a teaching clinic I search differently than my own clinic
Heuristic-general-if a resource is good enough I will pay for it even though others are free
Heuristic-general-if I have to pay for a resource I will more often choose the free ones
Heuristic-general-the good print resources disappear and that is frustrating
Heuristic-general-my memory and experience are very good searching agents and guide my processes
Heuristic-general- if my usual search approaches for specific searches aren't helpful I will switch to more general approaches
Heuristic-general-searching for general things if often difficult, more difficult than for specific topics
Heuristic-general-if my usual search approaches for broad searches aren't helpful I will switch to more specific approaches
Heuristic-general-if it is a broad question then I can probably use more of an evidence-based resource
Heuristic-general- **MEDLINE** is a good place to start if it is a general question
Heuristic-general-all questions go into **Google**
Heuristic-general-"what" questions are really good in **Google**
Heuristic-general-if I am uncertain where to start I go to **Google**
Heuristic-general-I always start with **MDConsul**t
Heuristic-general-I prefer a text book to journals for clinical questions

Heuristic-general-I search not only for a specific answer but I also search for general overviews if a patient is coming in and I need to brush up on my own knowledge
Heuristic-general—if I am not at my best computer for searching I get very frustrated with the process*
Heuristic-general-if it is slow coming up, I get frustrated and am tempted to move on
Heuristic-general-if it takes too much time I will stop searching and make a decision with what I have already found/know
Heuristic-general-if I do not know how to use a resource it is frustrating
Heuristic-general-time is a very important factor in how long I will search
Heuristic-general-time-some of my important searching is done outside of clinic time
Heuristic-general-speed of an entity is a very important factor in whether I will use it
Heuristic-general-it my system does something that I do know what it to do, I get frustrated
Heuristic-general-if I was younger (or trained differently) I would find this easier (the residents are faster (and better than I am)
Heuristic-general-if it is good enough for me, it is good for the residents too and I'm going to tell them
Heuristic-general-if I have to do a lot of typing I get frustrated very quickly
Heuristic-general-if I have to keep signing in I get frustrated very quickly
Heuristic-general-if searching is too frustrating I won't do it
Heuristic-general-even if I can't find it I do not really want to admit it and give up
Heuristic-general-I want to understand what is going on besides getting the answer
Heuristic-general-searching is almost always frustrating for me
Heuristic-general-searching can be a lot of fun
Heuristic-general-searching-academics have access to a lot of resources
Heuristic-general-searching part of the appeal of searching is the serendipity aspect
Heuristic-general-I often have a hard time staying on track during searching—too much is interesting
Heuristic-general-I don't really feel competent with my searching skills
Heuristic-general-if this is not really in my field I will not do too much searching for question
Heuristic-general-if I can't find anything I will keep trying until I run out of time or patience
Heuristic-general-if I can't find the answer it bothers me quite a bit
Heuristic-general-guidelines are good for specific searches

## During Searching

Heuristic-searching-choosing-search engines—all search engines are not created equal
Heuristic-searching-choosing-sites—if it is an intervention choose Canadian sites to avoid a lot of advertising
Heuristic-searching-choosing sites—if I am not looking up a drug I am less worried about commercial sites (advertising)
Heuristic-searching-choosing-sites—if a resource does not have it I will go to a specific journal
Heuristic-searching-choosing-sites—If it looks like a commercial site, I'm not all that interested
Heuristic-searching-choosing-sites—what I want in a resource is that it is fast
Heuristic-searching-choosing-sites—what I want in a resource is that it is easy to use
Heuristic-searching-choosing-sites—what I want in a resource is that it is well organized
Heuristic-searching-choosing-sites—what I want in a resource is that it comes from a trusted source
Heuristic-searching-choosing-sites—what I want in a resource is that it summarizes information
Heuristic-searching-choosing-sites—what I want in a resource is that it reflects national differences
Heuristic-searching-choosing-sites—I need to be able to use many sites (and I do)
Heuristic-searching-choosing-terms—if I have a question then the whole thing goes in **Google***
Heuristic-searching-choosing-terms—if I have a question then the whole thing goes in **PubMED**
Heuristic-searching-choosing-terms—I can use fewer search words in a resource (**PubMED**) than I can in a search engine (**Google**)
Heuristic-searching-choosing terms—if I have several components to my search I usually start by looking for the one that I know least about
Heuristic-searching-choosing terms—if I have several components to my search I usually start by looking for the one that is least common
Heuristic-searching-choosing-terms—if I have several components to my search I usually start by looking for the one that is the most unique (weird)

Heuristic-searching-choosing terms-if a lot of terms give me nothing, I cut back on the number of terms
Heuristic-searching-retrieval—if the retrieval is less than about 25 or so I will read rather then keep limiting/searching
Heuristic-searching-retrieval—if the retrieval is too small check the strategy and try again (**PubMED**)
Heuristic-searching-retrieval—if the retrieval is not on topic check the strategy and try again (**PubMED**)
Heuristic-searching-retrieval—if the retrieval is too broad I will narrow it down and try again
Heuristic-searching-retrieval—if the retrieval is reasonable size-look at them before searching again
Heuristic-searching-retrieval—if the retrieval is too old check the strategy and try again (**PubMED**)
Heuristic-searching-retrieval—if there is nothing in one discipline, I will try another one
Heuristic-searching-retrieval—if there is nothing in my new attempt I can go back and review previous material

## Working with documents after searching including locating them

Heuristic-choosing-document-web page---if I have been there before and it is good I trust it and will go back. (The **RxFiles©**[51] from Saskatoon)
Heuristic-choosing-document-web page---if it is a drug company and I have other options I am not going to go there
Heuristic-choosing-document-web page—if it asks me for a password I probably won't look at it
Heuristic-choosing-document-web page---if it is a **Powerpoint** presentation I probably won't open it
Heuristic-choosing-document-web page---if it is a **PDF** I probably won't open it
Heuristic-choosing-document-review/article—before a document is chosen to look at many features are observed (date, title, journal title, format and some match on content)
Heuristic-choosing-document-review/article-entities with many features of interest will be further looked at
Heuristic-choosing-document-review/article-entities with many features of interest will be further looked at
Heuristic-choosing-document-if the clinical content is about animals I will not read it
Heuristic-choosing-document-review/article—if two look about the same content and quality go with the more recent one
Heuristic-choosing-document-web page-I want to know who produced this before I will go to it
Heuristic-choosing-document-web page-I want to know who produced it and I can tell this from the URL
Heuristic-choosing-document-web page-an article that has a head-to-head comparison is good
Heuristic-choosing-document-web page-a review article is good
Heuristic-choosing-document-web page-a summary is good
Heuristic-choosing-document-web page-full text is good
Heuristic-choosing-document-web page-a meta-analysis is good
Heuristic-choosing-document-web page-a clinical practice guideline is good
Heuristic-choosing-document-web page-a book is sometimes good
Heuristic-choosing-document-web page-a person is sometimes good
Heuristic-choosing-search engine-if I know how it works, I trust it more

## During Decision Making

Heuristic-decision making-if trusted source makes a statement I believe it is true (entity)
Heuristic-decision making-if the document is not current I will check to see if there is more recent information-(entity)
Heuristic-decision making-if new evidence is not available then old data can answer question
Heuristic-decision making-my need for certainty of a decision varies by how important the decision is
Heuristic-decision making-if I am not 100% with one site I will check to find a confirming site
Heuristic-decision making-if I need to make a decision I want to find information in a couple of places to confirm the decision
Heuristic-decision making-if 2 documents have conflicting information I will go to a third for resolution
Heuristic-decision making-if 2 documents have conflicting information I get very frustrated

[51] RXFiles is a database of comparisons of drugs developed in a program called the Community Drug Utilization Program for Canadian family physicians in isolated areas. (http://www.rxfiles.ca/intro.htm). Copyright 2005 Saskatoon Region. Accessed July 21, 2005.

Heuristic-decision making-abstracts are good if you know something about a topic but if you don’t then full text is better

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