Medical Information Searching: A User Study Investigation

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Abstract

Medical Information Searching: A User Study Investigation

The availability of medical domains publicly has made medical information searching a popular type of search conducted on the World Wide Web. However, typical medical searchers face many issues and challenges when performing a medical search. This is because medical information searching is dissimilar to non-medical based information searching. The structure, composition and properties of medical information searching make this type of search unique and complex at the same time. This research study seeks to understand how typical medical searchers (non-medical professionals, medical professionals and medical students) perform medical information searching. Specifically, this research study focuses on how varying levels of i) task difficulty and ii) topic familiarity influence medical search behaviour. In addition, demographic variables that influence search behaviour when searching across varying levels of task difficulty and topic familiarity are also analysed. Detailed aspects of a search session are analysed to examine this effect. Search sessions are broadly classified into: i) querying details, ii) search results interaction details and iii) querying versus clicking behaviour and task completion time.

An interactive information retrieval experiment type methodology (IIR) is used to study interactive searching behaviour of typical medical searchers. A total of a hundred and eighty participants were part of this research study. Individual simulated situations are provided for each category of participant to invoke the information search process. Personal tasks are also employed. This research study provides several contributions. Firstly, search behaviour demonstrated by typical medical searchers when searching across varying levels of task difficulty (except for medical students) and topic familiarity are dissimilar in relation to results of previous non-medical based research studies. This indicates that there is a need to develop search behaviour profiles based on descriptions of search behaviour when searching across varying levels of medical task difficulty and topic familiarity. Without this search behaviour profiles inappropriate information retrieval strategies will be provided to the user. Secondly, typical

medical searchers demonstrate some similarities in search behaviour when searching on a similar level of task difficulty. This indicates that there is a need to first identify the searcher before providing the searcher with relevant information retrieval strategies. Thirdly, basic type demographic variables influence the search behaviour of medical professionals and medical students when searching across varying levels of topic familiarity. Basic and specific type demographic variables influence the search behaviour of non-medical professionals when searching across varying levels of task difficulty. More medical type demographic variables than basic type demographic variables influence the search behaviour of medical professionals when searching across varying levels of task difficulty. This indicates demographic influence on search behaviour is more significant when searching across varying levels of task difficulty than topic familiarity. Overall, this research study provides an understanding of medical information searching behaviour.

Medical Information Searching: A User Study Investigation

Declaration

I declare that this thesis is my own work and has not been submitted in any form for another degree or diploma at any other university or institute of tertiary education. Information derived from the published and unpublished work of others has been acknowledged in the text and with a list of references.

Anushia Inthiran
November, 2012

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Dedication

To my family, thank you for your love and support.

Thank you amma for everything you have done for me.

List of Publications

Inthiran A, Alhashmi, S.M. and Ahmed, P. (2012). The Affects of Task Difficulty on Medical Searches, *The 21st International World Wide Web Conference (Companion Volume), WWW 2012*, Lyon, France 16th - 20th April 2012

Inthiran A, Alhashmi, S.M. and Ahmed, P. (2012). Medical Information Retrieval Strategies: An Exploratory Study on the Information Retrieval Behavior of Non-Medical Professionals *International Journal of Healthcare Information Systems and Informatics* Jan-March 2012, Vol 7, No.1, pp. 31-45

Inthiran A, Alhashmi, S.M. and Ahmed, P. (2012). Personalization Strategies for Web Search, *Human IT: Journal For Information Technology Studies As A Human Science*, Issue 11:3, pp. 57-82

Inthiran A., Alhashmi, S.M. and Ahmed, P. (2012). Medical Students Search Behavior: An Exploratory Survey, *Behavioral Computing: Modeling Analysis, Mining and Decision*, Lecture Notes in Computer Science, Part IV Behavior Applications, Chapter 22, pp.337.

Inthiran A., Alhashmi, S.M. and Ahmed, P. (2011). Profiling a Non-Medical Professional Searcher on a Medical Domain: What Do Search Patterns and Demographic Details Reveal?, *7th Asia Information Retrieval Symposium (AIRS),* Dubai United Arab Emirates, 18th – 20th December 2011

Inthiran A., Alhashmi, S.M. and Ahmed, P. (2011). Investigating Interactive Search Behaviour of Medical Students: An Exploratory Survey, *Australian Conference in Computer Human Interaction (OZCHI)*, Canberra, Australia, 28 Nov – 2nd Dec 2011

Inthiran A. (2010), A Plan For Collaborative Personalization on Medical Search Engines, Doctoral Consortium, *3rd Information Interaction in Context, IIiX* August 18th – 22nd 2010, New Brunswick, New Jersey, USA.

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Chapter 1 Introduction

This research study provides detailed information on how typical medical searchers perform a medical based search. It is motivated by: i) the rise in medical searching performed by people from all walks of life and ii) search challenges experienced by typical medical searchers when performing a medical type search. There are several reasons as to why medical information searching is on the rise. Health consumers and prosumers engage in a process called interactive health communication *(*Robinson et al. 1998*)*. This is a process where medical professionals and non-medical professionals are actively engaged in health–based interaction using technology to provide a holistic approach to give, receive, guide and support health related issues. The emergence of health communities and support communities online also contributes to the rise in medical information searching. "An estimated one in four health-information seekers joins a support group" (Cline, 2002). These health and support communities provide a way for medical searchers to interact, share experiences and enable social support.

In addition, web-based resources provide medical professionals with the ability to supply regular and updated information on evidence-based patient care information (Vincent et al. 2006). One particular advantage of using the Internet for seeking healthcare information is the ease of acquiring information for a broad range of clinical subjects (Doyle, 2002). The ability to perform broad ranging searches is of particular importance to medical students. Broad ranging searches help medical students discover inter-related medical topics. In fact, searching for medical information is now a required component of clinical training for medical students (Dikshit et al. 2005). The growing popularity of medical information searching along with technological advances and the changes in clinical training syllabus has made the domain of medical information searching amongst non-medical professionals, medical professionals and medical students a pertinent area of study.

Typical medical searchers (non-medical professionals, medical professionals and medical students) frequently express search issues when performing a medical based search. Non-medical professionals (Spink et al. 2004 and Yang et al. 2011), medical professionals (Walker, 1991 and Ely et al. 2002) and medical students (Shelstad et al., 1994 and Auclair, 2007) experience issues in relation to query expression. In addition to issues in relation to query expression, non-medical

professionals (Can and Baykal, 2007 and Eysenbach and Kohler, 2002) and medical students (Mitchell et al. 1992 and Hersh et al. 2002) also experience issues in relation to information overload and the inability to comprehend results. Difficulties experienced during a medical search session will result in high task completion time, high search effort, cognitive overload and may cause medical searchers to experience search related stress issues. These difficulties may cause typical medical searchers to experience an unsuccessful search session (abandoned search) and they may become emotionally tired and distraught. It is important to minimize these search difficulties so that typical medical searchers experience a productive search session.

This chapter begins with an introduction to medical information searching. This is followed by a description of the problem domain and motivation. Then, research objectives and research questions for this research study are presented. Next, the research approach utilized for this research study is provided. Finally, summary of chapters included in this research study and a discussion of research contributions are presented.

1.1 Medical Information Searching

Before the existence of the Internet, medical information searching was confined to books and journal articles found in bookstores and libraries. The advent of the World Wide Web has enabled medical information to be made available online. In addition, people have also become technology savvy and use the World Wide Web to perform searches as part of their daily routine. Initially, publicly available medical information was obtainable only on general search engines but now specialised medical domains (vertical domains) or medical search engines are also available. People prefer to perform medical searches on medical domains as they trust information on medical domains (Spink et al. 2004 and Bradley, 2007). They are also able to focus on the search without being distracted with non-medical related search results. The ability to search for medical information online has several advantages. Amongst these advantages are: to allow medical professionals to obtain updated medical information quickly (Younger, 2010), to allow non-medical professionals to be better informed of general healthcare (Coiera, 2004) and to allow medical students to be able to supplement their knowledge obtained from lectures and to make better decisions during the course of clinical training (Mitchell et al. 1992).

The availability of medical information online promotes more interactivity during the search process with the availability of images and videos rather than just text documents. At some point

of their life, most people have searched for medical information. If the search was not conducted for them, it was conducted for friends, family members or just out of curiosity. A survey conducted by Pew Internet and American Life Project in February 2012 reports, "searching using a search engine is one of the most popular activities performed on the Internet" (Purcell, Brenner and Rainee, 2012) and "80% of Internet users have searched for health or medical based information online ranging from information on memory lost and dementia to information on end of life decisions" (Fox, 2012). "In the year 2011 people have searched for new medical topics such as information on food and drug safety, childbirth and pregnancy" (Fox, 2012). These new topics were not searched for in previous years. Results of both these surveys (Fox, 2012 and Purcell and Brenner and Rainee, 2012) indicate not only is medical information searching a popular type of search but the scope and range of searches performed is also growing.

1.2 Problem Domain and Motivation

Medical information searching is quickly becoming a popular type of search performed on the World Wide Web. However, increased access and availability to medical information does not mean problem-free access to information. Medical searching is not a trivial task. To a certain extent it requires expert knowledge, the need to issue technical or medical terminology and the ability to provide context to the search (Nadkarni, 2000 and Can and Baykal, 2007). One possible method to reduce search challenges and increase search satisfaction amongst typical medical searchers is to explain how varying levels of task difficulty and topic familiarity influence search behaviour. This understanding can then be used to inform the development of better information retrieval strategies in an effort to reduce search challenges and increase search satisfaction. Previous research studies on medical information searching focus on general search traits only (Can and Baykal, 2007, White and Horvitz 2009, Hersh 1998, Sutcliffe, Ennis and Watkinson, 2000, Wildemuth et al. 1995 and Hersh et al. 2002). Not many research studies focus on providing context (explaining search behaviour when searching across varying levels of task difficulty and topic familiarity) to search behaviour demonstrated by typical medical searchers. Providing context to search behaviour allows for a better understanding of search behaviour. An online medical search behaviour survey conducted by Kantar Media (2010) reports non-medical professionals between the ages of 18-34 go online to find healthcare professionals whilst people above the age of 50 seek for medical information online after consulting their physician. Women

tend to search for medical information for someone related to them while men search for medical information for friends (Kantar Media, 2010). These are some reasons as to why non-medical professionals perform medical searching online. These findings clearly indicate medical information searching is popular amongst people from all walks of life. Non-medical professionals search for medical information online because they want to be "better information before, during and after consultation with their physician" (Wainstien, Sterling-Levis and Baker, 2006). This indicates that non-medical professionals want to be equipped with background knowledge before seeing a physician, compare information provided by the physician with information they have and continue to further update their knowledge after consultation. The rise in healthcare cost has also resulted in many non-medical professionals performing medical searches online (Wells, 2007) as opposed to making hospital visits.

However, little is known about other equally important aspects of a search session. These unknown aspects include search behaviour of non-medical professionals when searching across varying levels of i) task difficulty, ii) topic familiarity and iii) demographic influence on search behaviour when searching across varying levels of task difficulty and topic familiarity. This knowledge is important because it will allow for better understanding and explanation of search behaviour. Better understanding of search behaviour will allow non-medical professionals to experience enhanced search satisfaction with the provision of relevant information retrieval strategies. Medical professionals are the earliest users to be exposed to searching for medical information online. This makes medical professionals amongst the most experienced online medical searchers.

While medical professionals may be the most experienced at performing a medical search, results of previous research studies indicate medical professionals experience the following barriers to searching: lack of time, distinct preference to asking a colleague, the need for database training, not comfortable with their searching skills (Dawes and Sampson, 2003 and Bryant, 2004) and lack of confidence in obtaining answers (Gonzalez-Gonzalez et al. 2010 and Younger, 2010). In some cases, when information could not be located, medical professionals assumed information did not exist and found the domain unreliable (Davies, 2007). In retrospect, it was an ineffective search strategy that led to this dichotomy. These findings indicate medical professionals experience search issues when performing a medical search. Advancements in

information retrieval strategies have yet to increase the search efficacy of medical professionals. Medical professionals require information "immediately at point-of-care" (Manfred, Marlene and Boyer, Date Unavailable). Thus, there is a need to understand why medical professionals experience these issues when performing a medical search. This understanding will allow the development of better information retrieval strategies for medical professionals to be able to obtain information to treat patients quickly and more effectively.

Medical students medical search behaviour was actively studied in the mid 90's and early 2000's, but thereafter no new research studies have emerged in recent years. Medical students are possibly the most disadvantaged type of medical searcher. Not only are they new to the medical fraternity, they may also struggle to perform a medical based search because they have not acquired specific search skills (Auclair, 2007). Results of previous research studies indicate medical students face a myriad of search challenges when performing a medical search (Wildemuth et al. 1995 and Shelstad et al. 1994). Information retrieval strategies are not able to support a medical students' search session. Thus, it is important to study the search behaviour of medical students so that search behaviour demonstrated can be better understood. Otherwise, it is likely that medical students may feel discouraged and de-motivated to perform medical searches. This will lead to missed out benefits obtained from performing a medical search. Amongst benefits that can be obtained by medical students as a result of performing a medical search online are: to obtain updated information, enable quicker access to information and access to a large repository of information. This will help medical students achieve improved learning outcomes towards becoming better doctors. Search issues experienced by non-medical professionals, medical professionals and medical students are factors that motivate the need to perform this research study.

1.3 Research Objectives and Research Questions

This research study aims to better explain medical information searching behaviour by providing context to medical searches performed by typical medical searchers (non-medical professionals, medical professionals and medical students). This is done by examining medical search behaviour when searching across varying levels of task difficulty and topic familiarity. It also examines the demographic influence on search behaviour when searching across varying levels of task difficulty and topic familiarity. The objectives of this research study are to:

i)   explain the affects of varying levels of task difficulty and topic familiarity on medical information searching based on a quantitative study.

ii)   identify demographic variables that influence medical information searching behaviour when searching across varying levels of task difficulty and topic familiarity.

To fulfil the objectives of this research study the following research questions are tackled:

Research Question 1: Does varying levels of task difficulty affect medical searching behaviour of typical medical searchers?

Research Question 2: Does varying levels of topic familiarity affect medical searching behaviour of typical medical searchers?

Research Question 3: Do demographic variables influence the search behaviour of typical medical searchers when searching across varying level of task difficulty and topic familiarity?

Instead of performing a general type study (without taking into account task difficulty and topic familiarity), this research study examines how varying levels of task difficulty and topic familiarity affect the search behaviour of a typical medical searcher. In addition, this research study also examines the demographic variables that influence search behaviour when searching across varying levels of task difficulty and topic familiarity. These aspects (task difficulty, topic familiarity and demographic influence on search behaviour) are studied as they are considered key influences on medical search behaviour.

1.4 Research Approach

This research study uses a user-centred interactive information retrieval (IIR) type experiment method to obtain answers to the research questions. This method of experimentation requires human interaction and accommodates for dynamic information needs of a searcher (Borlund, 2000). An interactive study method enables a more comprehensive understanding of medical information searching behaviour of typical medical searchers (non-medical professionals, medical professionals and medical students) based on the affects of task difficulty, topic familiarity and demographic influence when searching across varying levels of task difficulty and topic familiarity. An interactive study will allow for users to provide an explanation of their

search behaviour. This in turn allows for better understanding of search behaviour. A quantitative analysis is performed to investigate the affects of varying levels of task difficulty and topic familiarity on medical search behaviour as well as the demographic influence on search behaviour when searching across varying levels of task difficulty and topic familiarity.

These three categories of users (non-medical professional, medical professional and medical students) are chosen to provide a representation of typical medical searchers. A detailed search behaviour research study based on querying activities, search results interaction activities, total querying versus clicking behaviour and task completion time is performed to obtain a wide and comprehensive understanding of medical information searching.

A medical domain is chosen to perform this research study as it provides an opportunity to understand how varying influences (task difficulty, topic familiarity, demographic variables) affect search behaviour when searching on one of the most complex and information intensive expert-type domain (medical). The aspect of task difficulty, topic familiarity and demographic influence on search behaviour were selected for investigation as these factors play a major part in influencing medical search behaviour.

1.5 Summary of Chapters
A summary of chapters for this research study are presented:

Chapter 2 provides a review of literature in relation to several topic areas. These topic areas include: the information search process (ISP process) and medical search issues experienced by non-medical professionals, medical professionals and medical students. This chapter also examines the affects of task difficulty, topic familiarity and domain knowledge on search behaviour. It also provides information on demographic variables that influence search behaviour.

Chapter 3 explains the research methodology used to perform this research study. Experiment phases, data gathering and data analysis techniques are described in detail.

Chapter 4 presents results of the experiment. Results obtained from the experiment are discussed in relation to results of previous research studies. Results of the experiment also provide answers to the research questions outlined in Section 1.3

Chapter 5 presents a discussion of results and research contributions of this research study.

Chapter 6 provides a summary of research contributions and concludes this research study. It also explains the limitations of this research study and provides possible future research direction.

1.6 Research Contributions

In this section, research contributions of this research study are summarized. The findings highlight:

- Medical Searching Behaviour Across Varying Levels of Task Difficulty is Dissimilar to Non-Medical Searching (Except For Medical Students)

  Non-medical professionals and medical professionals demonstrate dissimilar medical search behaviour in comparison to non-medical search behaviour when searching across varying levels of task difficulty. Non-medical professionals demonstrate unbalanced search behaviour when searching on an easy task. Non-medical professionals demonstrate motivated search behaviour when searching on a difficult task. Medical professionals demonstrate two categories of search behaviour when searching on an easy task. These categories are: simple and tryer search behaviour. Medical students search behaviour when searching on a difficult medical task is similar to non-medical based searching. Medical students demonstrate novice search behaviour when searching on a difficult task.

- Medical Searching Behaviour Across Varying Levels of Topic Familiarity is Dissimilar to Non-Medical Searching

  Non-medical professionals, medical professionals and medical students demonstrate dissimilar medical search behaviour in comparison to non-medical search behaviour when searching across varying levels of topic familiarity. Non-medical professionals demonstrate comfortable search behaviour when searching on an unfamiliar topic. Medical professionals demonstrate expert search behaviour when searching on an unfamiliar topic. Medical students demonstrate uncertain search behaviour when searching on a somewhat familiar topic.

- Basic, Specific and Medical Type Demographic Variables Influence Search Behaviour When Searching Across Varying Levels of Task Difficulty (Except for Medical Students)
  Age is a common basic type demographic variable that influences the search behaviour of non-medical professionals and medical professionals when searching across varying levels of task difficulty. In addition specific type demographic variables which are: occupation and general search experience also influence the search behaviour of non-medical professionals when searching across varying levels of task difficulty. For medical professionals medical type demographic variables influence search behaviour when searching across varying levels of task difficulty (medical search experience, education type and medical years of practice). Demographic variables do not influence the search behaviour of medical students when searching across varying levels of task difficulty.

- Basic Type Demographic Variables Influence Search Behaviour When Searching Across Varying Levels of Topic Familiarity (Except for Non-Medical Professionals)
  When searching across varying level of topic familiarity basic type demographic variables influence the search behaviour of medical professionals (age) and medical students (gender). Demographic variables do not influence the search behaviour of non-medical professionals when searching across varying levels of topic familiarity.

In summary, research contributions add to better understanding of search behaviour when searching across varying levels of i) task difficulty and ii) topic familiarity. It also provides information on the iii) various demographic influences on search behaviour when searching across varying levels of task difficulty and topic familiarity. These research contributions inform the development of better information retrieval strategies and improve the human computer interaction experience when searching on medical domains.

Chapter 2 Literature Review

In this chapter a brief introduction to the information search process (ISP) is presented to set the stage for this research study. Then, an overview on medical information searching and how typical medical searchers (non-medical professionals, medical professionals and medical students) perform medical searching is provided. The purpose of providing an overview of search behaviour is to report on overall medical search traits and search challenges experienced by these three categories of users. This is followed by a review of literature in relation to three main sections. These sections are: i) affect of task difficulty on information search behaviour, ii) affect of topic familiarity and domain knowledge on information search behaviour and iii) demographic influence on search behaviour. These topic areas are examined because they are pertinent to provide background information to the three main research areas (task difficulty, topic familiarity and demographic influence) covered in this research study. Previous research studies for these topic areas are examined as to understand the latest development in their field. This is followed by a reflection of reviewed literature. Finally a chapter summary is provided.

While the focus of this research study is on medical information searching, the literature reviewed does not only focus on medical searching behaviour per se. This is because specific research studies on the affects of medical task difficulty, medical topic familiarity and demographic influence on medical search behaviour is limited. Additionally, much insight on medical searching can be gleaned from non-medical searching. Thus, non-medical based literature is included to provide a view on the affects of task difficulty, topic familiarity, domain knowledge and demographic influence on information searching behaviour.

2.1 The Information Search Process

The information search process (ISP) consists of a user going through six sequential stages in order to obtain information. The six sequential stages of the ISP process are: initiation, selection, exploration, formulation, collection and presentation. The ISP model developed by Kuhlthau (1991) explains these stages in detail. In the initiation stage, the user is aware that there is a need to perform a search due to lack of knowledge. During the selection stage the user divides the search process into sub-tasks and determines how to go about conducting these sub-tasks. The

user then tries to extend existing knowledge with new knowledge in the exploration stage. Some users may find it difficult to translate their information needs into the form of a query while others may experience complexities in aligning new knowledge with existing knowledge. In the event the user is unable to resolve these issues then it is likely that the user will terminate the search. If the user is able to resolve these issues, then the user proceeds to the next stage called formulation. In the formulation stage the user starts to focus on information encountered and attempts to narrow down information obtained. In the collection stage, the user concentrates on activities to extend and support the search goal. Finally, the search process is terminated in the presentation stage. There are two possible outcomes in the presentation stage, either the user feels disappointed with the search process or the user feels relieved and satisfied with the search process.

Through-out these six stages a user performs many search actions[1] (search behaviour) and goes through a deep thought process. Search behaviour and thought processes are influenced by a user's emotional state during the search process (Kuhlthau, 1994). This means information searching is a complex process influenced by external (search behaviour) and internal factors (thought process and emotional state). These internal and external factors may have different levels of influence on different stages of the information search process. These complexities make information searching a popular and interesting area of study. In the following sections, the elements within the ISP model are analysed.

2.1.1 Search Behaviour, Emotional State and Thought Processes

Previous research studies in relation to the search behaviour aspect of the ISP model focus on many dimensions. Amongst them are: search behaviour demonstrated when searching on tasks of varying levels of difficulty (Bystrom, 2002 and White and Kelly, 2006), varying levels of topic familiarity (Karimi et al. 2011, Vakkari et al. 2003) and using search behaviour to predict task difficulty based on task type (Liu, et al. 2011). Besides focusing on the property of a task (difficulty/familiarity) previous research studies have also compared search behaviour demonstrated by different categories of searchers. These categories include search behaviour demonstrated by experts and non-experts (White, Dumais, Teevan, 2008) and the search

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[1] Search actions will be deemed as search behaviour henceforth

behaviour of individuals with high domain knowledge and low domain knowledge (Freund and Toms, 2006, Hsieh-Yee, 1999 and Bhavnani, 2002).

Research studies investigating the emotional state of a user during the information search process is slowly gaining popularity (Poddar and Ruthven, 2010, Siddiqui and Unsworth, 2010 and Lopatovska and Arapakis, 2010). Research studies in relation to the emotional state of the searcher focus only on general search behaviour without emphasis on the property of the search task (difficulty/familiarity) or property of the user (expert/non-expert, high/low domain knowledge). Research studies focusing on the thought process during an information search process also do not focus on the property of the task or the property of the user (Arapakis et al. 2009, Kim, 2008 and Gwidkza, 2009). One reason as to why research studies focusing on the emotional state and thought process aspect has only been studied from a generalist perspective (without considering the property of the task/user) is because thought processes and the emotional state of the searcher are complex internal factors to analyse in comparison to search behaviour. Internal factors are more difficult to express and measure in comparison the search behaviour. Thought processes and the emotional state of the user is also a less stable form of indicator in comparison to search behaviour. Furthermore thought processes and the emotional state of the searcher can continuously change consciously and unconsciously throughout the search process (without the searcher being aware of this). These issues make these internal factors difficult to account for. At present research studies focusing on the emotional state and thought processes of a searcher are analysed from a generalist angle (without taking into account the property of the task/user). This indicates that research studies focusing on non-generalist search behaviour are more mature and stable in comparison to the genre of study which investigates thought processes and the emotional state of the searcher.

Previous research studies focusing on the various dimensions of the information search process (ISP) are popular because these types of studies enable better comprehension and explanation of search behaviour. Explanation and comprehension of search behaviour is important because it allows for better understanding of the external and internal complexities involved in a search process. This understanding then translates into the development of better information retrieval strategies and improved human computer interaction experience during a search process. As a result, a searcher experiences increased search satisfaction.

However, the spotlight of previous research studies focusing on search behaviour based on task difficulty or topic familiarity has been on search behaviour demonstrated on general search domains (with the exception of research studies conducted by Karimi et al. 2011 and Duggan and Payne, 2008). Research studies conducted to understand non-generalist type search behaviour demonstrated on expert-type domains such as a medical domain is limited. Thus, little is known about information searching behaviour of typical medical searchers when searching across varying levels of task difficulty and topic familiarity. It is important to understand medical search behaviour in relation to task difficulty and topic familiarity because this will enable better explanation and understanding of search behaviour when searching on a medical domain. This understanding will enable the development of specific information retrieval strategies and improve the human computer interaction experience when searching on a medical domain. This will minimise search challenges experienced by searchers especially when searching on a difficult task or on an unfamiliar topic. As a result a searcher is able to complete tasks faster and enjoys a productive search session.

2.1.2 Demographic Influence and the Information Search Process Model (ISP)

The ISP model focuses on changes of internal factors (thought and emotions) and external factors (search behaviour) throughout the search process. For reasons already discussed in Section 2.1.1 internal factors can be difficult to measure, are unstable and can unconsciously change throughout the search process. As a result, some research studies have opted to study a more stable and less complex element. This element is central but not directly visible in the ISP process. This element is called the information searcher (searcher). Without the searcher there will be no information search process. The searcher is central to the ISP process but there is no direct relationship between the searcher and the ISP process. To incorporate the searcher within the ISP process, some research studies (Large, Behesti and Rahman, 2002, Jones et al. 2007, Kadagoda and Wang, 2008 and Webber and Castillo, 2010) use demographic variables of the searcher to understand the influence of demographic variables on search behaviour. Demographic variables of the searcher are a less complex and more stable element in comparison to studying the emotional state or the thought process of a searcher. Moreover, there is a more direct relationship between the searcher and demographic variables in comparison to the thought process and the emotional state of the user. As such using demographic variables of a searcher provides a more viable method to study how search behaviour is related to the searcher.

Research studies focusing on the demographic influence of a searcher focus on search behaviour demonstrated when searching on a general search domain (Large, Behesti and Rahman, 2002, Jones et al. 2007, Kadagoda and Wang, 2008 and Webber and Castillo, 2010). These research studies explain how demographic variables influence querying patterns and how to provide searchers with better results based on demographic details of the searcher. However, there is limited information about how demographic variables influence medical search behaviour. This information is important because it provides better explanation of search behaviour based on the identity of the searcher (demographic).

2.1.3 Search Behaviour in Context

Regardless of the type of search performed (medical/non-medical), a typical search session is influenced by many search factors. The ISP model describes three major factors involved in the search process: the users' emotional state, thought processes and search behaviour (user based factors). Besides these three user-based factors, there are several other factors that can also influence search behaviour. Amongst these factors are task difficulty and topic familiarity (task property). These factors are more prevalent in a medical based search because searching for a medical task is mainly affected by task difficulty or topic familiarity. For example, non-medical professionals and medical students may find searching for a medical task difficult due to limited medical knowledge and expertise. Generally, medical professionals may find searching for a medical task easier in comparison to non-medical professionals and medical students due to high medical expertise and knowledge. Non-medical professionals, medical students and medical professionals may be familiar with certain medical topics based on previous search experience or knowledge. Studying medical search behaviour from a generalist perspective (ignoring the property of the task) does not clearly enlighten search behaviour. Generalist type research studies are only able to provide a narrow view of search behaviour. Therefore in this research study, instead of analysing medical search behaviour from a generalist aspect, the focus is on how varying levels of task difficulty and topic familiarity influence the search behaviour of typical medical searchers.

Besides task difficulty and topic familiarity, domain knowledge and level of expertise are also amongst factors that influence medical search behaviour. However for medical based searching there is a clear definition available for these two factors (domain knowledge/level of expertise). For example, medical professionals have high domain knowledge and expertise in comparison to medical students and non-medical professionals because of education type and occupation. As such, in this research study the focus is on the property of the task (difficulty/familiarity) and not on level of expertise or knowledge of the searcher.

Previous research studies focus on demographic influence for search behaviour from a generalist angle (Jones et al. 2007, Auchard, 2005 and Weber and Castillo, 2010). As such, little is known about how demographic variables of a searcher influence search behaviour when searching across varying levels of task difficulty or topic familiarity. Identifying demographic influence on search behaviour when searching across varying levels of task difficulty and topic familiarity will enable an understanding of what demographic variables influence search behaviour. In addition, topic familiarity, task difficulty and demographic influence on search behaviour are also the most commonly investigated variables in information searching based studies. As discussed above, medical information searching is influenced amongst other factors by task difficulty and topic familiarity. A research study analysing demographic variables that influence search behaviour without taking into account the property of the task provides a limited understanding of search behaviour. As such in this research study, the focus is on the influence of demographic variables on search behaviour when searching across varying levels of task difficulty and topic familiarity. Figure 1 provides a visual representation for the direction of this research study. Figure 1 depicts direct and indirect elements of the ISP model. It describes the domain used and study type (generalist/non-generalist) conducted by previous research studies to understand the influence of these direct and indirect elements on the ISP process. It then identifies the gap and provides the direction of this research study. In the next section, an overview of medical information searching is provided. This is followed by an analysis of medical search issues experienced by typical medical searchers.
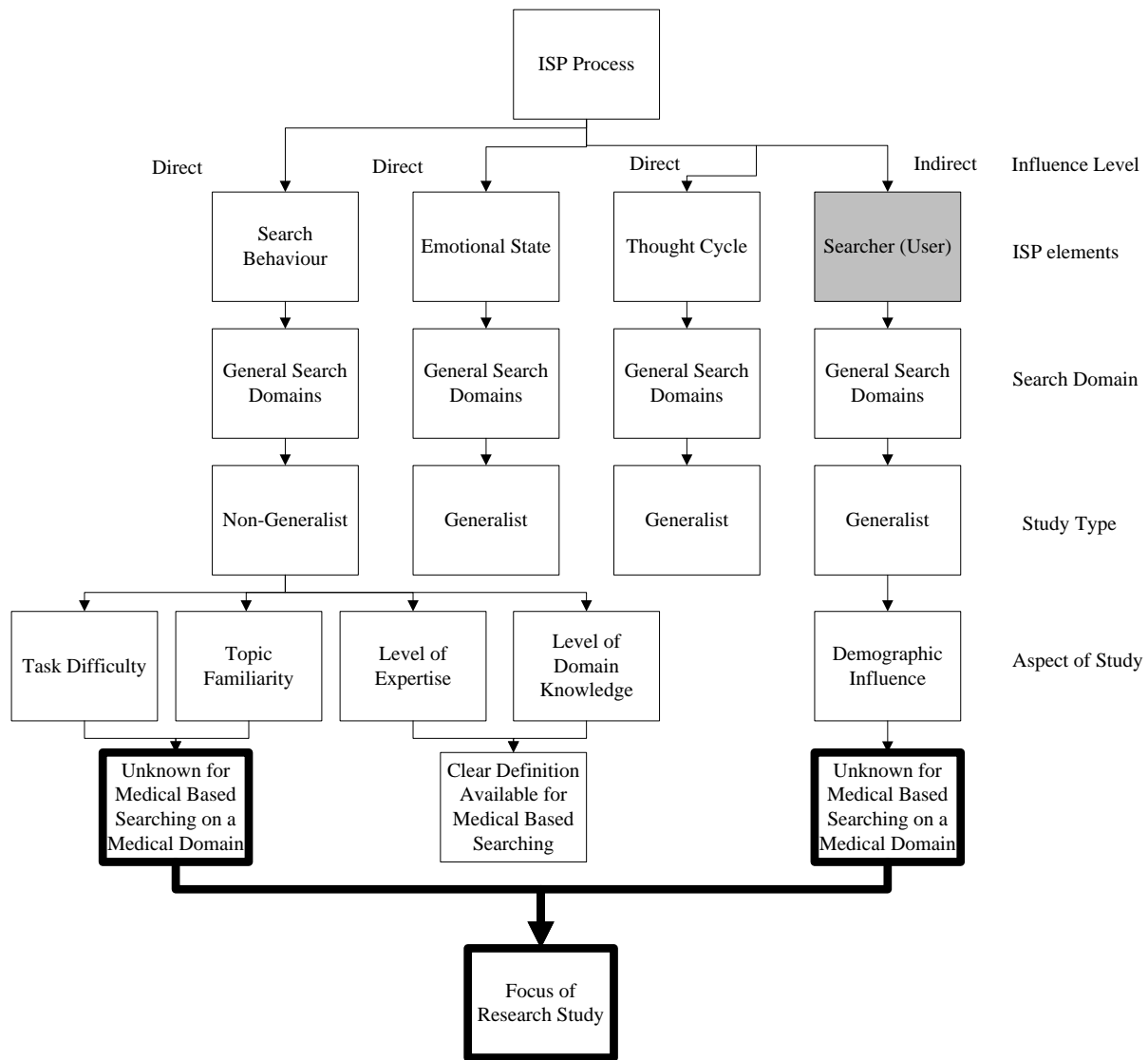
Figure 1 Research Gap and Direction of Research Study (Note: � Not officially part of the ISP model)

2.2 Medical Information Searching

Generally, a typical search session is short, contains an average of less than 2 queries, has 2.93 terms in a query (Kanvar et al. 2009) and only 10% of queries demonstrate usage of query operators (Eastman and Jansen, 2003). In non-medical type search, searchers do not issue many queries in a search session nor do they issue long queries. Searchers are unlikely to refine, re-issue, use query operators or spend much time on a search session For medical based searching,

non-medical professionals issue an average of 3.3 terms per query (White, Dumais and Teevan, 2008) and the average number of queries issued is 2.34 (Wang, 2006). In general a non-medical professionals querying behaviour is categorised as simple and short (Zeng et al. 2002). The structure and composition of medical domains are enormous and unique (Can and Baykal, 2007 and Nadkarni, 2000). This possibly explains the dissimilarities in querying patterns between medical and non-medical based searching.

Hersh (2009) states there are four properties that make medical information searching pertinent in comparison to non-medical information searching. These properties are: growth, obsolescence, fragmentation and linkage of scientific information. These properties are briefly discussed to understand why medical-based information searches are dissimilar to non-medical based information searches. Medical literature grows at an exponential rate. Each year over 300,000 citations are included in the *MEDLINE*[2] database. Due to exponential growth, medical information becomes obsolete quickly. Recent experiments are likely to provide newer findings and an up-to-date list of citations. Fragmentation refers to when a single article only provides a small part of the overall picture. Further details are fragmented across multiple articles. Hence a searcher may have to read more than one article to obtain an understanding of a new finding. The first three properties discussed above are relevant to non-medical professionals, medical professionals and medical students. The last property which is linkage of scientific information only concerns medical professionals as this refers to the study of citations of scientific literature. These characteristics indicate performing a medical based search is not a trivial task.

Previously, medical search engines were "exclusive to medical professionals, other types of users were only passively exposed to medical based information" (Coiera, 2004). Today, this is no longer true. Non-medical professionals are actively searching on medical search engines. "The Internet and social media has changed the traditional method of patient-physician relationship" (Colineau and Paris, 2010). There are several reasons for this new trend. These reasons are broadly classified into i) change in user behaviour, ii) external influences and iii) the availability of technology.

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[2] Medline is a database that contains journal citations and abstracts for biomedical literature from around the world available at http://www.nlm.nih.gov/bsd/pmresources.html

i) Change in User Behaviour

Users want to be more informed before, during and after consulting their physician (Coiera, 2004). In some cases, users solely rely on the Web for healthcare diagnosis and treatment (Khoo, Bolt and Babi, 2008, Wainstein, Sterling-Levis and Baker, 2006 and Tuffrey and Finaly, 2002). As opposed to traditional behaviour where consultation with a general practitioner is required, today non-medical professionals turn to the easiest and fastest way to search for information which is by using the Internet.

ii) External Influences

External influences have also encouraged non-medical professionals to search for medical based information online. "With doctors becoming more difficult to afford and consumers having to pay a lot for healthcare many people have become interested in searching for health information" (Wells, 2007). The United States Department of Health and Human Services reports 20% of the US population will be over 60 by 2030. An older population means more people suffering from chronic diseases and more people needing information at their fingertips. These external factors have caused people to use the Internet for immediate, unlimited and repeatable electronic consultations at almost no cost.

iii) Availability of Technology

Technology has made medical domains easily available to the masses. Medical searching can be performed on general search engines. However, over time medical and health queries have declined as a proportion of all web queries. The use of specialized medical/health websites has increased (Spink et al. 2004). One reason for this is "medical search engines perform better than general search engines. Medical search engines are able to sort results into categories, provide users with the ability to filter the search and show additional information in various tabs. Searching on a medical search engine also provides greater confidence to a searcher as information returned is guaranteed to be relevant and accurate" (Bradley, 2007). These factors have made medical domains a popular destination to perform medical searches.

Unfortunately, the increase in medical searching online has caused some side-effects. Non-medical professionals express increased anxiety when searching for medical information. Anxiety levels increase when the following criteria's are met in the search results page: the mention of serious conditions, the presence of escalatory terminology and the lack of presence of non-serious conditions. White and Hortivz (2009) coined the term 'cyberchondria' to describe this symptom. In addition Bessiere et al. (2010) state health-related Internet use is associated with small but reliable increase in depression. There are several reasons for the increase in depression rate. Amongst them are: non-medical professionals are not able to distinguish between good and poor quality medical advice, only one third of users verify Internet information with their doctor to ensure accuracy and non-medical professionals are sometimes being misinformed from factually incorrect websites. This may lead to inaccurate self-diagnosis, poor health behaviour or potentially unnecessary worry for the ill and healthy population. While it is encouraging to see the Internet being used to perform medical based searches, the after-effect of a search may create false alarms and untoward repercussions to some health consumers.

Besides non-medical professionals, medical professionals and medical students also frequently search for medical information. However, the type and quality of search performed by medical professionals is dissimilar in comparison to non-medical professionals. Medical professionals do not perform superficial medical based searches, rather "the search behaviours of medical professionals indicate their information needs occur not only from data they were reviewing for a specific task but also include background information" (Seol et al. 2004). A survey conducted in the year 2010 by the American Medical Association reports two third of physicians use the Internet to look for information related to diagnosis and treatment of patients. Nearly nine out of ten physicians said improved access to online medical information has improved quality of care and 63% of medical professionals reported having changed an initial diagnosis based on new information found online. Results of this survey (American Medical Association, 2010) indicate medical professionals benefit from performing medical based searches online.

Medical students perform medical searches throughout their duration of medical study. Early research studies indicate "medical students rely on their own, out of date or personal reference library to answer the majority of patient care question" (DeRosa et al. 1983). Newer studies indicate some medical faculties have integrated information skills training into their medical

curriculum (Mitchell et al. 1990 and Bradigan and Mularski, 1989). This shows that medical faculties recognize the importance of teaching medical students to perform proper medical based searches. In the following sections, search issues experienced by non-medical professionals, medical professionals and medical students are provided.

2.2.1 Medical Search Issues Experienced by Non-Medical Professionals

The structure and composition of medical search engines has resulted in an unsatisfactory search experience amongst non-medical professionals. Keselman, Browne and Kaufnan (2008) state regardless of web experience and general search skills, non-medical professionals may experience difficulty with health information searches. These difficulties are experienced in the query expression and the results viewing stage.

In the query expression stage non-medical professionals experience the following issues: the inability to express medical queries, submitted terms were not specific, terms were misspelled and queries were too short (Spink et al. 2004 and Zhang et al. 2012). Non-medical professionals are not equipped with medical knowledge and are unfamiliar with medical topics. This led to the inability to use medical terms in a query. The use of a medical term is essential and the inability to express medical terms in a query would degrade a non-medical professional's search experience. Berland et al. (2002) state using simple search terms while accessing health information is not effective. Bin and Li (2001) state using lay terminology is only partly successful at locating useful health information. Spink et al. (2004) summarise two pre-requisites in order for non-medical professionals to experience enhanced search satisfaction. These pre-requisites are: i) a non-medical professional must know the realm of the language and ii) the near specific location of the knowledge they seek. It is often the case when these two requirements are not met a non-medical professionals search session degrades. In a related study, Liu and Lu (2009) share similar views with Spink et al. (2004). Liu and Li (2009) state in a document of health information, medical terminology has two roles: it either becomes an obstacle for online comprehension of health information or a starting point to drill down navigation for relevant information. Thus, usage of medical terminology is an essential factor in determining the success rate of a medical search.

Even when non-medical professionals are able to express a medical query, the issue of perspective, context and sense cannot be ignored. Nadkarni (2000) states many medical terms

have multiple sense which incur challenges in medical information retrieval. Furthermore, medical terms are discussed from many different perspectives. For example, "the term hormones occur in hundreds of documents from ten diverse health topics" (Nadkarni, 2000). Hence without knowing the context of the search a non-medical professional will not be able to define his/her search goal accurately.

To understand what type of terms are used by non-medical professionals to perform a medical search, Yang et al. (2011) investigated the type of queries issued by parents on the website *AfterTheInjury.org*. *AfterTheInjury.org* provides information on psycho-education interventional content for parents with injured children. Yang et al. (2011) state the terms 'what', 'how' 'child', 'after' and 'injury' are frequently used in a query. The average query length is 6.27 terms. The research study conducted by Yang et al. (2011) reports the average query length to be longer than earlier research studies (White, Dumais and Teevan, 2008). This indicates that the medical search traits of non-medical professionals have changed over time. The research study conducted by (Yang et al. 2011) indicate non-medical professionals issue a high number of natural language type question queries and this contributed to lengthy queries. The usage of natural language queries and lengthy queries caused participants to demonstrate high querying effort. This high querying effort also increased task completion time. In most cases parents were dissatisfied with returned search results and report feeling frustrated as they were not able to assist their child in time of need. This indicates the high search effort of non-medical professionals did not translate into a productive search session.

In a similar research study conducted by Zhang et al. (2012), results indicate non-medical undergraduate students (non-medical professionals) issue query terms either based on the scenario provided or by using associated terms. They also frequently re-issued queries using synonyms. This indicates non-medical undergraduate students are unable to issue queries on their own and are dependent on the search scenario. They also rarely viewed results beyond the 1st page and frequently switched between search actions and browse actions. This indicates non-medical undergraduate students demonstrate rudimentary search behaviour when searching for medical information.

Besides experiencing issues during the query expression stage, non-medical professionals also experience issues when reviewing returned results. Amongst common issues faced are:

information overload (Can and Baykal, 2007), inability to comprehend search results (Eysenbach and Kohler, 2002), change in information acquisition search behaviour (Bath, 2008), and not able to locate information (Yang et al. 2011). It is possible to suggest that these issues are somewhat related. For example, due to a non-medical professionals inability to comprehend search results a searcher may feel that he/she is not able to locate required information. Thus, there is a possibility that search issues experienced during the results viewing stage may be interrelated. It is also possible to suggest that issues experienced during the querying stage influence issues experienced in the results viewing stage. For an instance due to a non-medical professional's inability to provide context to the search he or she may experience the information overload problem.

Bath (2008) states information needs within particular groups of people are not necessarily the same. The acquisition of information is not always beneficial and there are circumstances in which individuals may avoid information. This is particularly true in health and medicine when information needs and search behaviour can change during the patient pathway. For example, a newly-diagnosed critically ill patient who is having problems coming to terms with his/her medical condition may refuse to click on returned results based on treatment options. On the other hand, a care-giver may choose to click on results discussing treatment options. Likewise, family members and friends of this newly-diagnosed patient may also approach returned results differently. In most cases clicking on result links indicates preference for results and non-clicking translates into non-preference. As such while relevant results were returned by the search engine, the non-clicking activity of the user will provide mixed or wrong signals to the information retrieval strategy. Non-medical professionals are also likely to remain in a single search state when performing an exploratory type medical search. Non-medical professionals either remained in the evidence based information seeking or hypothesis-directed information seeking stage (Cartright, White and Horvitz, 2011). This indicates non-medical professionals are unable to multitask and only focus on a single search goal when performing a medical search. The inability to oscillate between information seeking states indicate that non-medical professionals only focus on specific aspects of returned results. This behaviour will further provide mixed or wrong signals to the information retrieval strategy.

Non-medical professionals experience information overload yet also report being frustrated when not able to locate required information. While there may be many reasons for this, one reason could be because non-medical professionals are not able to express queries effectively and this contributed to a less than satisfactory returned result set. Non-medical professionals may also be returned with non-specific results due to the poor quality of the query. As such non-medical professionals have to "filter returned search results and this requires significant mental effort on the user" (Chau et al. 2002). This results in an unsatisfactory and time consuming search experience.

Overall, it appears that non-medical professionals are bound to face challenges in the querying and results reviewing stage as both these stages are interrelated. An issue faced in one stage will affect other stages of the search process. This indicates that a contextualised research study investigating the querying and results viewing behaviour of non-medical professionals when searching across varying levels of topic familiarity and task difficulty is necessary to obtain an in-depth understanding of search behaviour.

2.2.2 Medical Search Issues Experienced by Medical Professionals[3]

Medical professionals recognize the importance of medical searching as it effected clinical decision, changed patient management, had an impact on clinical problem solving and would affect treatment of future patients (Wainstien, Sterling-Levis and Baker, 2006). Initiatives in relation to training medical professionals to perform better medical searches have been implemented (Zelnick and Nelson, 2002 and Cook et al. 2011). Results of this research study (Zelnick and Nelson, 2002) indicate as a result of training, medical professionals experienced self-reported improvements in computer and medical informatics search skills. Cook et al. (2011) state technology enhanced training is consistently associated with large effects for outcomes of knowledge and skills amongst medical professionals. The British Medical Association also recognises the importance of medical searching and provides assistance by conducting regular training for its members in relation to online searching and finding reliable sources on the Internet (British Medical Association, 2011). This indicates medical search training is a key factor in improving a medical professionals medical search skills. However what remains uncertain is if medical search training actually translates into long-term improvements to

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[3] In this section terms such as resident, physician, family doctor, clinicians, emergency medical residents and academic generalist doctor are used in the literature to describe the general term medical professional.

increase search efficacy amongst medical professionals. In a related matter it is also uncertain if the search training conducted is on a specific type of medical domain or is independent of the type of medical domain used. In the case where the medical search training is dependent on a specific type of medical domain then it is unlikely that the increase in search satisfaction will be sustained when searching on other medical domains.

Most research studies in relation to medical professionals searching behaviour focus around the use of *MEDLINE.* Haynes et al. (1990) state experienced clinicians achieved high recall[4] rates and medical librarians achieved high precision[5] rates. Novice clinicians had lower precision and recall rates, but were more satisfied with their search outcome in comparison to expert clinicians. Results of this study bring about an interesting point as to the relevance of system-related performance measures (recall, precision) in relation to medical information searching. This is because "clinicians typically do not need anywhere near 100% recall but really only need enough information to answer questions. Clinicians are more concerned with clinically significant documents being returned" (Hersh, 1994) and are not concerned with system-based performance measures. This indicates that there is a need for medical domains to review performance measures of their information retrieval strategy and have them aligned with user goals. Results of a research study conducted by Westbrook, Coiera and Gosling (2005) indicate the use of online information retrieval systems only helped clinicians arrive at correct answers 21% of the time. This indicates information retrieval strategies are not effective at enhancing a medical professional's search session. Hence there is a need to re-look at the information retrieval strategies implemented on health information systems to increase the likelihood of arriving at correct answers.

Previous research studies have also focused on specific search issues experienced by medical professionals. Walker et al. (1991) performed an observational survey to determine issues faced by clinicians when using *Grateful Med[6]* for clinical based searching. The authors summarise the following issues faced by clinicians: search formulation (48%), software issues (41%) and search failure (11%). Other minor issues involve usage of low frequency terms, usage of general terms

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[4] recall is the fraction of relevant instances that are retrieved
[5] precision is the fraction of retrieved instances that are relevant
[6] Grateful Med is a retired medical database containing information from MEDLINE and the National Library of Medicine

and excessive use of the *OR* and *AND* operand. In another survey, McKinin et al. (1991) report on search issues experienced by clinicians when performing medical literature based information retrieval. The authors found two thirds of problems are due to poor search strategy where the search concept was not explicitly used and the remaining one third of problems are due to excessive use of search operators, natural language terms, synonyms and acronyms. In a related research study, Ely et al. (2002) state academic generalist doctors and family doctors report four general obstacles when answering clinical questions. These obstacles are related to: seeking information, formulating answers, formulating questions, using the answers obtained to direct patient-care and finally recognising an information need. Results of a survey conducted by Abbas, Schwartz and Krause (2010) indicate emergency medical residents demonstrate naïve search behaviour with the use of single terms and short phrases derived from scenarios provided. They also frequently used advanced search features and used stop words such as ''an'', ''as'' and "from" to form a query. In some cases emergency medical residents were overconfident of their search capability. Medical professionals are considered domain experts and have high medical knowledge, yet they face issues in relation to query expression and in experiencing a productive medical search session.

In a systematic review conducted amongst physicians, Hersh and Hickam (1994, 1998) state clinicians do not experience better search satisfaction with the use of advanced search features. The use of advanced search features is not more effective than simple text matching during medical information retrieval. In addition, the user interface and indexing method employed by the system had no effect on a medical professionals search session. However, the authors state "regardless of how skilled the medical professional is and what type of database is used, it is unlikely that a medical professional will come close to retrieving all potentially relevant material for the search goal" (Hersh, 1998). This indicates that there is a pressing need to review the interface design and search features of medical domains.

Results of previous research studies have also found dissimilar search behaviour amongst expert and novice medical professionals. Sutcliffe, Ennis and Watkinson (2000) found medical experts perform fairly even number and more query iterations in comparison to novices. Medical experts used complex queries while novices kept their queries simple. Generally, medical experts adopted a consistent search strategy. They demonstrate broadening and narrowing of queries

while novices used the trial and error approach by substituting terms until favoured results are achieved. This indicates expert medical professionals and novice medical professionals demonstrate different search traits. Search experience and years of medical practice contributed to higher search efficacy.

Besides looking at design issues of medical domains and issues faced by medical professionals when performing a medical search, Gorman and Helfand (1995) were able to determine factors that motivate physicians to pursue or leave a clinical question unanswered. They found only two factors were significant predictors of pursuit of new information: the physician's belief that a definitive answer existed and the urgency of the patient's problem. Results of a research study conducted by Green, Ciampi and Ellis (2000) state residents approximately identify two new clinical questions in a day for every three patients which require information searching. However, residents infrequently answered them. Only 29% of these questions are pursued, lack of time and forgetting the question were the most frequent reasons for failing to pursue a question. This suggests motivating factors for performing a medical search amongst medical professionals have changed over time. While earlier research studies (Gorman and Helfand, 1995) indicate the possibility of medical professionals locating information is a motivating factor, later research studies (Green, Ciampi and Ellis, 2000) do not point to any search related issues as a motivating factor. This could mean that search related issues have become de-motivating factors for medical professionals to perform a search.

Lau and Coiera (2007) found clinicians experience cognitive biases when searching for answers to clinical questions. Results of this research study (Lau and Coiera, 2007) found that the way a document (returned results) is assessed contributes to different interaction effects between pieces of information. This subsequently influences the decision making process in determining suitability of results. This indicates besides relying on medical knowledge, medical professionals are likely to be influenced by cognitive bias when determining suitability of returned results. This may then influence a patient's treatment options and healthcare plans. This indicates information retrieval strategies have to also incorporate 'unseen' (cognitive bias) signals to better understand search behaviour as opposed to 'seen' signals (demonstration of search behaviour).

In general, results of previous research studies indicate medical professionals experience issues in relation to query expression. In particular, novice medical professionals experience more search issues in comparison to expert medical professionals. However, what is more worrying is that medical information retrieval strategies, interface design and search features are not aligned to the needs of medical professionals. Thus, it is important to study medical professionals search behaviour to understand how to better support a medical professionals search session.

2.2.3 Medical Search Issues Experienced by Medical Students

One of the earliest studies investigating medical students search behaviour was conducted to analyse the need for medical search training amongst medical students (Mitchell et al. 1990). The aspect of training medical students in relation to performing medical based searches continues to remain relevant. This is demonstrated based on the initiatives taken by medical schools. For example, the University of Texas have developed new strategies to teach first and second year medical students on how to use medical resources (Shurtz, 2009). In the University of Washington, medical educators determined that there is a need to conduct pre-matriculation competence and medical education learning expectations training for undergraduate medical students (Scott et al. 2000).

At a six month follow up study, researchers found students who were trained to use *Grateful Med* performed medical searches more frequently in comparison to before being trained. Students were able to perform searches on overlapping topics and used *Medical Subject Heading Terms* (*MeSH*)[7] terms effectively. Students were also able to recover from search errors, zero hits and demonstrate the ability to broaden or narrow down a search (Mitchell et al. 1992). Shelstad et al. (1994) conducted another follow up study on the effectiveness of training medical students on *Grateful Med*. Unlike results of the earlier study (Mitchell et al.1992), this follow up study was conducted when the same batch of medical student are in their 3rd year of study. Results of this follow-up study show medical students were not able to use proper *MeSH* terms, used inappropriate sub-headings, misspelled terms and 20% of students received zero hits. Most students thought they were retrieving exactly what they needed but in fact they missed up to 100% of available citations and some students retrieved far too many results. The usage of *Grateful Med* also decreased as up to 57% of medical students used it less than once a month.

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[7] MeSH is a controlled Medical Subject Headings Index available at http://www.nlm.nih.gov/mesh/MBrowser.html

This indicates training only had a short-term benefit to improving a medical students' search session. Previous research studies have found that there is little relationship in medical students' search behaviour between personal knowledge and search proficiency (Wildemuth et al. 1995). Personal knowledge did not help students develop better search terms or increase search efficiency. While it is common believe that personal knowledge would affect search behaviour, this is not the case with medical students. In the same study, the authors investigated the type of questions asked by medical students based on clinical scenarios. Results show most questions asked by medical students only fell into 5 categories when the clinical scenarios presented required broader areas to be covered. First year medical students commonly asked identification type questions. Other students formed a question template and utilized them across clinical scenarios. These search traits indicate medical students have limited ability to perform effective searches.

In a study comparing medical students and nurse practitioners search behaviour Hersh et al. (2002) state medical students spent more than 30 minutes on a task and were only successful at correctly answering questions less than half the time. The ability to answer clinical questions with the aid of *MEDLINE* was low. The amount of time taken to conduct a search was typically longer than time spent on a patient. This research study (Hersh et al. 2002) concludes that students undergoing clinical training are at best moderately successful at answering clinical questions correctly. In another observation study Auclair (2007) state medical students were able to correctly diagnose patients with the use of high order concepts. They were more successful at diagnosing a patient when they were able to identify the relationship between these concepts. Students who were not able to use high-order concepts or did not have the ability to relate these concepts were not able to properly diagnose a patient. Results of previous research studies indicate medical students experience a myriad of search obstacles when performing a medical search. Thus, it is important to analyse search behaviour demonstrated by medical students. This is done by incorporating context to search behaviour demonstrated. One method of providing context is to analyse search behaviour based on the affects of task difficulty and topic familiarity. In the next section, a summary of search issues experienced by non-medical professionals, medical professionals and medical students are presented.

2.3 Summary of Search Issues Experienced by Non-Medical Professionals, Medical Professionals and Medical Students

In this section, an integrated view of search issues experienced by non-medical professionals, medical professionals and medical students are summarised. A summary of these issues are provided in Table 1.

Search Issue/Searcher Category and Research Study	Non-Medical Professionals	Medical Professionals	Medical Students
Inability to Evaluate Search Results	Eysenbach and Kohler (2002), Chau et al. (2002), Can and Baykal (2007) and Yang et al. (2011)	Gonzales- Gonzales et al. (2011) and Younger (2010)	Hersh et al. (2002)
Poor Search Skills and High Search Failure	Yang et al. (2011) and Zhang et al. (2012)	Walker (1991) and Abbas, Schwartz and Krause (2010)	Shelstad et al. (1994) and Hersh et al.(2002)
High Task Completion Time	Yang et al. (2011)	Gorman and Helfand (1995)	Hersh et al. (2002)
Search Goal Not Fulfilled	Bath (2008)	Hersh and Hickam (1994, 1998)	N/A
Is Search Training Helpful?	N/A	*Helpful Zelnick and Nelson, (2002) and Cook et al. (2011)	*Short Term Benefit Shelstad et al. (1994)
Is the Information Retrieval Strategy Helpful?	N/A	*Unhelpful Hersh and Hickam (1994,1998) and Westbrook, Coiera and Gosling (2005)	N/A
Side-effects of Medical Searching	White and Horvitz (2009) and Bessiere et al. (2010)	N/A	N/A
Does Years of Medical Practice / /Personal Knowledge /Cognitive Bias Influence Search Experience?	N/A	*Yes (Medical Years of Practice) Sutcliffe et al. (2000) *Yes (Cognitive Bias) Lau and Coiera (2007)	*No (Personal Knowledge) Wildemuth et al. (1995)
Information Retrieval Strategy Not Aligned to User Search Goal	Bath (2008) and Cartright and White and Horvitz (2011)	Hersh (1994,1998)	N/A

Table 1 Search Issues Classified by Searcher Category (Note: N/A – Not Applicable)

Non-medical professionals, medical professionals and medical students have varying levels of medical expertise, medical knowledge and medical search experience. However, these categories of users face some similar search challenges. Based on Table 1, query expression issues, search results evaluation issues, poor search skills, high search failure and high task completion time are common issues experienced by non-medical professionals, medical professionals and medical students. In addition specific category-based issues like the side effects from medical searching, incompetency in performing the search, unhelpful information retrieval strategies and unaligned information retrieval strategies with search goals also exist. Previous research studies provide an understanding of medical search issues experienced by typical medical searchers (non-medical professionals, medical professionals and medical students) from a generalist perspective (ignoring task property). This is because previous research studies in relation to medical searching are conducted without including context to search behaviour. Thus, generalist type research studies only provide a general idea of what search challenges are experienced without an explanation of why these challenges are experienced. As a result, only general-type information retrieval strategies are developed. These general-type information retrieval strategies are not able to fully support a typical medical searchers search session in order to minimise search challenges and increase search satisfaction. This is demonstrated by the search issues experienced by typical medical searchers provided in Table 1.

These issues highlighted in Table 1 indicate some medical search issues experienced by typical medical searchers continue to exist over time. For example, non-medical professionals continue to experience issues in relation to evaluation of returned results (Eysenbach and Kohler, 2002, Chau et al. 2002, Can and Baykal, 2007 and Yang et al. 2011). Similarly, medical professional's still feel medical information retrieval strategies are unsuitable (Hersh and Hickam 1994, 1998 and Westbrook, Coiera and Gosling, 2005). Medical students (Shelstad et al. 1994 and Hersh et al. 2002) and medical professionals (Walker, 1991 and Abbas, Schwartz and Krause, 2010) also continue to experience issues in relation to poor search skills and high search failure. This indicates that medical search issues experienced in the late 90's and early 2000's continue to exist into the mid 2000's. This suggests that there has been little progress in relation to minimising search challenges experienced by typical medical searchers.

One method to better understand search behaviour of typical medical searchers is to incorporate context to search behaviour. One such method to incorporate context is by studying how varying levels of task difficulty and topic familiarity influence search behaviour of typical medical searchers. This allows for better explanation of search behaviour and provides an understanding as to why search challenges are experienced. As discussed in Section 2.1.1, the affects of varying levels of task difficulty and topic familiarity have been extensively studied on general domains. However these types of research studies are hardly performed on medical domains. As such, little is known about how typical medical searchers search across varying levels of task difficulty and topic familiarity.

It is important to obtain this information because topic familiarity and task difficulty are amongst major influences on search behaviour especially when performing a medical search task on a medical domain. Without this information, it is difficult to understand what type of search behaviour is demonstrated when searching across varying levels of task difficulty and topic familiarity. Understanding search behaviour when searching across varying levels task difficulty and topic familiarity is important because typical medical searchers (non-medical professionals, medical professionals and medical students) may have varying perceptions of task difficulty and topic familiarity. Furthermore they may find searching on a difficult task or on an unfamiliar topic time consuming, tiring, frustrating and may be unsuccessful in the search process. As such, better information retrieval strategies and search features need to be developed to improve the human computer interaction experience when searching across varying levels of task difficulty and topic familiarity. In return typical medical searchers will experience increased search satisfaction. In the next section, the affects of task difficulty on information search behaviour are examined.

2.4 The Affects of Task Difficulty on Information Search Behaviour

The focus of this research study is on medical information searching. However literature on how task difficulty affects medical information searching is not widely available. Thus literature based on non-medical information searching is examined to provide an understanding of how task difficulty affects information search behaviour.

Previous research studies in relation to search behaviour are multi-dimensional. Bystrom (2002) and Bystrom and Javerlin (1995), found as task difficulty increased a searcher is less likely to determine the type of information they need and more likely to be dependent on experts or search assisting features to provide relevant information. This indicates a searcher searching on a difficult task does not have any expectation of the type of results needed and relied on the search engine to provide relevant results. Because of the over reliance on the search engine strategy and inability to determine suitability of returned results it is likely that a searcher will not be able to complete searching on a difficult search task successfully. Aula, Khan and Guan (2010) state users used more query operators and natural language queries when searching on a difficult task. Users resorted to using natural language queries because they were not able to express their information need using standard methods such as using keyword type queries. They also used query operators to limit the scope of the search process and limit the number of returned search results. It is likely that non-medical professionals and medical students may also use natural language type queries in their search sessions when searching on a difficult task. This is because non-medical professionals and medical students may be unable to express specific keywords in a medical search session. On the other hand, medical professionals may use query operators in their search sessions to only focus on 'unknown' or 'specific' areas.

Users use more sources (Bystrom 2002 and Li and Belkin 2008) when searching on a difficult task. Domain information type searches are performed prior to fulfilling a search goal. For example, say a searcher is interested in obtaining information on which bank offers the best housing loan? When this search is performed by a layman, several background searches are required to obtain information on base lending rate, mortgage options and bank interest rate before actually determining which bank offers the best housing loan. Background information is required to gain better understanding of a search goal. These background information type searches require a user to issue more queries, use more sources and click on more results. It is likely that a medical type search requires many domain information and background type searches to be performed. However, this trait may not be demonstrated by all categories of medical searchers. This is because a medical professional may not need to perform background searches due to high domain knowledge and medical expertise.

Task difficulty also had an effect on the type of source used. Some research studies indicate as task difficulty increased more external sources and channels are used (Tiamiyu, 1992 and Bystrom and Javerlin, 1995). Other research studies indicate internal sources and channels are used when searching for a difficult task (Culnan, 1993 and Pinelli et al. 1993). Internal sources are defined as internal documents, internal company databases or phonebooks. External sources are defined as results from a search engine, results obtained from a journal or research article. It would seem reasonable to suggest that when searching on a difficult task a searcher would first use 'known' or internal sources first and use external sources thereafter if the internal sources fail to provide necessary information. When searching on a medical domain, it is likely that typical medical searchers may require search assisting features to reduce task difficulty. It is also possible to suggest that medical professionals may not be inclined to use search assisting features due to high domain knowledge. On the other hand, non-medical professionals and medical students may be inclined to use search assisting features. However, they may find these 'search assisting' features inadequate or unhelpful due to low domain knowledge.

Task completion time also increased in relation to task difficulty (Liu et al. 2010 and Li, 2008). As a searcher issues more queries and views more resources, it is obvious that task completion time will increase. Besides looking at the overall task completion time, Shinoda and Morida (1994) and White and Kelly (2006) state when reviewing results, a searcher spends the most amount of time viewing the first result clicked as opposed to subsequent results clicked. This suggests some amount of learning had taken place when reviewing results on the first page which resulted in less time spent reviewing other result links clicked on. When searching on a difficult task, longer dwell time was spent on results page and more content pages were visited (Liu et al. 2012). All three research studies (Shinoda and Morida, 1994, White and Kelly, 2006 and Liu et al. 2012) state when searching on a difficult task, searchers focus on the results segment of a search session. A possible explanation for this is that when searching on a difficult task searchers experience issues in relation to query expression thus focused more on the results segment of a search session. It is also likely that searchers learn more about a difficult task when reviewing returned results. Non-medical based searches do not require high knowledge thus, it is possible to learn and obtain knowledge as a result of thoroughly evaluating returned results. However this 'active learning' method may not be possible when searching on a medical domain due to high level of technical contents on a page.

In the late 90's Vakkari (1999) developed a search model demonstrating how a relationship of factors can be used to determine task difficulty. Succinctly, this model shows information activities are systematically connected to task difficulty and the structure of problem at hand. In a later research study, Gwizdka and Spencer (2006) built on this model and indicate that there are three predictors of search behaviour when searching on a task of high level of difficulty. These predictors are: high search effort, low navigational speed and low search efficiency. More unique pages are visited, higher average time was spent on a page and more deviations from the optimal search path are observed when searching on a difficult task.

Besides examining the concept of task difficulty as a finite state, Kim (2008) states perception of task difficulty can change throughout a search session. Kim (2008) states perception of pre and post task difficulty is more likely to change when conducting a factual type task in comparison to when searching for an exploratory type task. When searching for an exploratory type task, pre-search task difficulty is positively co-related to pages saved and query reformulation. When searching for a factual task, post-search task difficulty is positively co-related to time spent, pages viewed and search engine used. This indicates based on task type perception of task difficulty can change before commencing and after completing a search. Furthermore only specific aspects of search behaviour are indicative of pre and post task difficulty. Results of this research study (Kim, 2008) indicate when searching for an exploratory and factual task, perception of task difficulty rarely remains the same (pre and post perception).

Previous research studies indicate several features of search behaviour can be used to determine task difficulty. However, it is possible that a medical search session (an expert type search performed on an expert type domain) may not provide much search variability due to the high level of technicality involved when performing the search. Table 2 provides a summary of search features demonstrated when searching on a difficult task.

Search Behaviour on a Difficult Task	Research Study
Query - More Queries - More Usage of Natural Language Type Queries and Query Operators	- Bystrom (2002) - Aula, Khan and Guan (2010)
Timing - High Task Completion Time - High Dwell Time on 1st Results Page - Low Navigation Speed - More Dwell Time on Results Page	- Li (2008) and Liu et al. (2010) - Shinoda and Morida (1994) and White and Kelly (2006) - Gwidzka and Spence (2006) - Liu et al. (2012)
Search Results Interaction - More Usage of Internal Sources - More Usage of External Sources - Inability to Locate all Required Information - More Sources Viewed - More content pages visited	- Culnan (1993) and Pinelli et al. (1993) - Tiamiyu (1992) and Bystrom and Javerlin (1995) - Bystrom (2002) - Li and Belkin (2008) - Liu et al. (2012)

Table 2 Search Feature Classification for Difficult Type Task Based on Research Investigated

Results of previous research studies indicate many interesting findings in relation to how task difficulty affects search behaviour. However, these research studies are not medical based. Thus it is not possible to determine if medical task difficulty affects search behaviour in a similar manner. Medical searching requires a certain level of expertise and different categories of searchers (non-medical professionals, medical professionals and medical students) may demonstrate different search behaviour when searching on tasks of varying levels of difficulty. In

the next section, the affects of topic familiarity and domain knowledge on search behaviour are provided.

2.5 The Affects of Topic Familiarity and Domain Knowledge on Information Search Behaviour

In this section, the affects of topic familiarity and domain knowledge on search sessions are reviewed. For the purpose of literature review both these areas are reviewed as there is a very close relationship between topic familiarity and domain knowledge when searching for a medical type task on a medical domain. There is a possibility that for certain types of medical searchers (medical professionals and medical students) topic familiarity and domain knowledge are interrelated. However, the aspect of domain knowledge is not analysed in relation to experiment results for this research study for reasons mentioned in Section 2.1.3. With the exception of one bio-medical based research study (Karimi et al. 2011) non-medical based searching is reviewed to provide an understanding of how topic familiarity affects search behaviour. This section begins by reviewing literature in relation to bio-medical searching and then proceeds to discuss literature in relation to non-medical searching.

In a research study conducted to understand how topic familiarity affects the search behaviour of bio-medical domain experts, Karimi et al. (2011) analysed the search behaviour of thirty eight domain experts. In this study, domain experts are identified as academics, working professionals and students involved in the biomedical domain. Karimi et al. (2011) state domain experts who are familiar with a topic enter substantially fewer queries and less Booelan type queries during a search session. The total number of query terms a user submits in a search session also varies significantly with the level of topic familiarity. Substantially fewer query terms are entered when a user is highly familiar with a topic. On the other hand, the number of results pages viewed did not vary based on topic familiarity.

In non medical related research studies, the type of query and query properties used when searching on tasks of varying levels of domain knowledge and topic familiarity provide several findings. Allen (1991) examined the relationship between domain knowledge and search behaviour in an early online library catalogue system. Searchers with high domain knowledge had greater familiarity with vocabulary for a topic and found more items. Research studies

conducted by Hoelsher and Strube (2000), Bhavnani (2002) and Hsieh-Yee (1999) also found that users with high topic familiarity found more search results.

In relation to usage of terminology in search sessions, Vakkari et al. (2003) conducted a study to examine students at multiple points in time as they were developing their thesis proposal. Results indicate the use of more varied and specific vocabulary when students became more familiar with their research topic. In another research study conducted on a cultural heritage domain, Alia et al. (2008) found cultural heritage experts report difficulties when searching on a cultural heritage domain especially when they are not familiar with the correct usage of controlled vocabulary. In addition White, Dumais and Teevan (2009) state domain experts used technical vocabulary and were more successful in their search sessions in comparison to non-domain experts. Domain expert searchers use twice as many search terms and issue longer queries in comparison to non-domain expert searchers (Zhang et al. 2005 and Alia et al. 2008). This indicates high domain knowledge and topic familiarity encouraged searchers to be more motivated in their querying sessions. This is demonstrated with the usage of longer queries, more queries and usage of technical vocabulary. Hembrooke et al. (2005) state self rated domain experts issued longer queries and more complex queries in comparison to non-domain experts. Self-rated domain experts also used more elaborate query reformulation strategies in comparison to novice searchers who used simple stemming and backtracking strategies. This indicates regardless of how topic familiarity is assessed, (self-rated or non-self-rated) search behaviour demonstrated when searching on a topic of high familiarity is similar.

In a medical based search, high topic familiarity may cause low search interactivity amongst medical professionals. This is because medical professionals may be more familiar with medical topics and have high domain expertise in comparison to non-medical professionals and medical students. Thus, medical professionals may issue specific or targeted queries in order to obtain relevant results. Medical professionals may not spend much time issuing many queries or long queries. However, it is likely that non-medical professionals and medical students may demonstrate dissimilar search behaviour in comparison to medical professionals when searching on a familiar topic due to low or limited medical knowledge.

Besides differences in query usage and query properties there were also dissimilarities in the type of source used to perform a search and selection of search results. Wen, Ruthven and Borland

(2006) state participants used more formal resources and search engines when searching on a familiar topic as opposed to when searching on an unfamiliar topic. For example, websites like *Google Scholar*[8] and *ACM Digital Library*[9] are used when searching on a familiar topic. For unfamiliar topics, sites like *Yahoo*[10] and *Wikipedia*[11] are used. Participants used generic sites for unfamiliar task because it helped them structure their search session. Kelly and Cool (2000) state searchers of high topic familiarity spend less time reading search results in comparison to searchers with low topic familiarity. A searcher with high topic familiarity demonstrates high search efficacy in comparison to a searcher with low topic familiarity. In a related research study, Cole et al. (2011) state a user's task and domain knowledge are key factors in link recognition and selection. Participants with high domain knowledge usually selected 'best' documents returned. Participants with low domain knowledge were reasonably successful at selecting 'best' available documents while participants with intermediate knowledge often failed to select 'best' pages.

This indicates high topic familiarity allowed participants to choose specialised search domains to perform the search. Participants with high topic familiarity were also able to determine 'best' results in the shortest time. Prior knowledge allowed for the ability to experience a productive search session. Prior knowledge and high topic familiarity for a medical type search may also allow for participants to be more adventurous in their search effort in order to experience a productive search session. Medical professionals are considered domain experts due to education type but may have different perceptions of medical topic familiarity. Thus, when medical professionals perform a search on a high or low topic familiarity task there may be different variations to search behaviour. Non-medical professionals and medical students who are not considered domain experts may also demonstrate dissimilar search behaviour when searching on tasks of varying levels of familiarity.

Generally participants with high domain knowledge and topic familiarity demonstrate dissimilar search behaviour in comparison to participants with low domain knowledge and topic familiarity. However, Duggan and Payne (2008) state in certain domains, domain expertise had

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[8] http://scholar.google.com/advanced_scholar_search
[9] http://dl.acm.org/
[10] http://www.yahoo.com
[11] http://www.wikipedia.org

no effect on search behaviour. Duggan and Payne (2008) state for the music domain, there was little effect of domain expertise on search behaviour. For the football domain, expertise was positively correlated with search accuracy and negatively correlated with time spent on web pages and mean query length. Football expert searchers also processed pages related to their domain more quickly in comparison to music domain experts. This indicates when searching on certain expert domains, the level of domain knowledge and topic familiarity had little effect on search behaviour. Results of this research study will determine if different types of search behaviour is demonstrated by typical medical searchers when searching across varying levels of medical topic familiarity.

While results of previous research studies indicate topic familiarity influence many aspects of search behaviour, there are aspects of search behaviour that are not indicative of topic familiarity. Muresan et al. (2006) state there is no relationship between high topic familiarity and aspects of readability, abstractness or concreteness. In this research study, Muresan et al. (2006) defines readability as the use of specific terminology in the document. A document of high readability is defined as a document that contains specific and appropriate terminology. Abstractness and concreteness is indicated by the overall rating of the document. For example, an abstract document is one that has a high proportion of abstract terms while a concrete document is a document with a high proportion of concrete terms. Typically, searchers of high topic familiarity would favour documents with high readability and high concreteness. However, results of this research study (Muresean et al. 2006) indicate readability, abstractness and concreteness have no relationship with topic familiarity**.**

The research study conducted by Karimi et al. (2011) generally classified participants as domain experts by their field of study (biomedical). This method of classification is too general as working professionals and academics could be experts in specific fields. On the other hand, students may not qualify as domain experts. Furthermore, the focus of the research study conducted by Karimi et al. (2011) is on biomedical searching. In this research study, three categories of participants (non-medical professionals, medical professionals and medical students) are used to represent typical medical searchers. The focus of this research study is on clinical-medical based scenarios. These differences make this research study dissimilar in comparison to previous medical related research studies (Karimi et al. 2011). A summary of

search behaviour demonstrated based on high topic familiarity and domain knowledge based on non-medical searching and medical based searching is provided in Table 3 and 4 respectively. In the next section, the affects of demographic influence on search behaviour are provided.

Search Behaviour Based on High Topic Familiarity and Domain Knowledge	Research Study (Non-Medical)
Vocabulary Usage • Greater Familiarity with Vocabulary	• Allen (1991), Alia et al. (2008), Hsieh Yee (1999), Bhavnani (2002) and Hoelsher and Strube (2000)
• Usage of More Varied and Specific Vocabulary	• Vakkari (2003)
Search Results • Found More Search Results	• Allen (1991)
• Found Best Search Results	• Cole et al. (2011)
Query Property • Longer Queries • More Queries	• Alia et al. (2008) and Zhang et al. (2005)
Usage of Resources • Formal Resources	• Wen, Ruthven and Borlund (2006)
Time • Less Search Results Reading Time	• Kelly and Cool (2000)
Abstractness, Concreteness and Readability • Not Significant	• Muresan et al. (2006)

Table 3 Search Feature Classification for High Topic Familiarity and Domain Knowledge Based on Research Investigated (Non-Medical Searching)

Search Behaviour Based on High Topic Familiarity and Domain Knowledge	Research Study (Medical)
Vocabulary • Technical	• Karimi et al. (2011)
Query Property • Less Queries • Less Boolean Type Queries	• Karimi et al. (2011)
Results Clicking • Not Significant	• Karimi et al. (2011)

Table 4 Search Feature Classification for High Topic Familiarity and Domain Knowledge Based on Research Investigated (Medical Searching)

2.6 Demographic Influence on Search Behaviour

In this section demographic factors that affect search behaviour are provided. Research studies examined in this section are not specific to medical based searching (with the exception of a research study conducted by Liao and Fu, 2012) nor based on task difficulty or topic familiarity. Rather general search traits are reported to show how demographic factors are able to influence aspects of a search session. This section begins by reviewing a research study in relation to how demographic variables influence credibility judgement of online health information. This is then followed by a review of research studies in relation to demographic influence on non-medical based research studies.

Liao and Fu (2012) indicate older adults are less likely to be influenced by user reviews, message content and web site reviews (credibility cues) when making credibility judgements of online health information. Results of this research study (Liao and Fu, 2012) indicate older adults (ages 58 to 80) were less able to distinguish between high credibility content and low credibility content. Older adults are also likely to accept documents read without further deliberation or reflection. Younger adults (ages 18-30) are prone to be influenced by credibility cues. This indicates external factors (credibility cues) are instrumental in influencing younger adults' perception of suitability of returned results.

Besides perception of credibility of returned results, demographic factors are also able to influence terms used in a query. Weber and Castillo (2010) conducted an in-depth study to relate specific search behaviours with demographic details. Older and younger searchers use different

terms to arrive at the same result page. Younger adults use the term weed while older adults use the term marijuana to arrive at the same page. Searchers from higher income per-capita brackets commonly issue navigational type queries. Searchers from low income per capita brackets use fact-finding type queries to locate a web page. Queries used by younger people tend to focus on chat rooms, social networks and music. Hu, Zeng and Niu (2007) state the gender of the searcher can be identified by analysing words on a page clicked on and topic classifiers used. Similarly, Jones et al. (2007) and Auchard (2005) were able to determine the age bracket of a searcher based on terms used in a query.

Demographic influence also played a part in influencing querying patterns, results clicking and results evaluation behaviour. Higher educated searchers issue longer queries, clicked on more search results and clicked deeper into links (Weber and Castillo, 2010). Large, Beheshti and Rahman (2002) state boys used significantly fewer words per search and more one-word type searches in comparison to girls. Female searchers submitted significantly longer queries to *Google* than male searchers. Lorigo et al. (2006) state men had greater average fixation duration on selected web documents than women. Jones et al. (2007) state male and female searchers click on different search results based on a similar query entered. Females are more likely to click on pages relating to the piano or the composer for the query wagner while males are interested on pages relating to the producer of a paint brush. Besides gender, nationality also affected results clicking behaviour. In a survey examining information search behaviour of participants from 5 European countries, Zander and Hamm (2011) state Swiss and German respondents spent more time searching for information and clicked on the most number of search results in comparison to Italians, British and Austrians. Austrians spent the least amount of time reviewing search results. However there is no difference amongst nationalities in relation to search heuristics and information acquisition strategy.

Information seeking patterns and the type of search conducted are also influenced by gender. Laroche et al. (2000) state when purchasing Christmas presents, women tend to make elaborate, extensive, detailed analysis with existing information. They search in multiple information sources, both online and offline. On the contrary, men behaved less interested. The type of search conducted also differed based on gender. Results of a research study conducted by Auchard (2005) reports differences in the type of online search performed by men and women.

More women searched for health and religious information online as opposed to men. The same research study reports, a movie genre clicked on can be used to determine the gender of a searcher. Teenagers clicked on the movie genre cartoon, men on action and women on love.

Research studies have also been able to relate specific search strategies to demographic features. Kadagoda and Wong (2008) state low literacy users take up to eight times more time to complete an information search task. They also spent one third more time on a web page but did not seem to be informed by it. Low-literacy users employed a much less focused information search strategy, tracked back thirteen times more frequently, are likely to re-visit web pages and are more likely to be 'lost' throughout the search. Summers and Summers (2005) state low literacy users tend to read word by word and skipped chucks of text that were long. Kadagoda, Wong and Khan (2009) state low literacy users did not verify information found for correctness, were unable to recover from mistakes, had dissimilar trajectories in their search path and are more likely to feel dissatisfied and abandon a search. Based on results of previous research studies investigated (Weber and Castillo, 2010, Jones et al. 2007 and Hu, Zeng and Niu, 2007) more than one demographic factor is able to influence search behaviour. However, gender is a major demographic influence on search behaviour for non-medical based searches. Gender is able to influence terms clicked on a page (Hu, Zeng and Niu, 2007), query property (Zanden and Hann, 2011 and Large, Behesti and Rahman, 2002), results clicked (Jones et al. 2007), time spent on a page (Lorigo et al. 2006), type of search performed (Auchard, 2005) and execution of search strategy (Larohe et al. 2002). A summary of search features influenced by demographic factors are provided in Table 5.

Search Feature	Demographic Influence	Research Study
Query Terms Used	• Age • Income Bracket	• Weber and Castillo (2010) • Jones et al. (2007)
Terms Clicked on Pages (Topic Classifiers)	• Gender • Age	• Hu, Zeng and Niu (2007)
Query Property	• Education Level • Gender	• Weber and Castillo (2010) • Zanden and Hann (2011) and Large, Behesti and Rahman (2002)
Result Clicks	• Gender • Nationality	• Jones et al. (2007) • Zanden and Hann (2011)
Time Spent on Results Page	• Gender	• Lorigo et al. (2006)
Type of Search	• Gender	• Auchard (2005)
Type of Results Preferred	• Gender	• Auchard (2005)
Search Strategy	• Gender • Literacy Level	• Larohe et al. (2002) • Kadagoda and Wang (2008), Kadagoda, Wong and Khan (2009) and Summers and Summers (2005)
Credibility Perception (medical based searching)	• Age	• Liao and Fu (2012)

Table 5 Demographic Influence on Search Behaviour

Results of previous research studies are not related to medical information searching (with the exception of Liao and Fu, 2012) hence it is not possible to determine if similar demographic variables influence medical search behaviour. For non-medical based searching, general demographic variables like gender and age emerge as influencing factors but for a medical search performed on a medical domain, it is highly unlikely that basic type demographic variables influence medical search behaviour when searching across varying levels of task difficulty and topic familiarity. This is due to the nature of a medical search which requires some level of technicality in relation to issuing a query and comprehending returned results. Thus, it is likely that more specific type demographic variables influence medical search behaviour. This research study incorporates typical medical searchers from three specific categories (non-medical professionals, medical professionals and medical students) thus it is possible that dissimilar type demographic variables influence the search behaviour of typical medical searchers when searching across varying levels of task difficulty and topic familiarity. In the next section, a reflection of reviewed literature is provided.

2.7 A Reflection of Reviewed Literature

In relation to the ISP process search behaviour is the most actively researched element in comparison to thought processes and the emotional state of the user. Specifically, non-generalist type research studies focusing on search behaviour when searching across varying levels of task difficulty and topic familiarity. The emotional state and thought processes of the searcher are rarely studied in relation to task difficulty or topic familiarity (generalist type studies only). Search behaviour is easier to analyse and measure in comparison to the emotional state and thought processes of a user which can be unstable and difficult to account for. This indicates that this aspect of study (search behaviour based on task difficulty and topic familiarity) is deemed a more profitable area for study than studying the emotional state and thought processes from a generalist perspective. Research studies conducted on general search domains focus on search behaviour in relation to task difficulty and topic familiarity. However, this genre of study (search behaviour based on task difficulty and topic familiarity) has yet to be studied for medical information searching. As such, little is known about how varying levels of task difficulty and topic familiarity influence the medical search behaviour of typical medical searchers.

Previous medical based research studies of typical medical searchers are conducted from a generalist perspective without taking into account the property of the search task. As such only generalist type of search challenges experienced by typical medical searchers are known (Section 2.3, Table 1). In return only generalist type information retrieval strategies are implemented on medical search domains. When searching on a medical domain, generalist type research studies only provide a partial view of search behaviour. The characteristics of a medical based search are dissimilar from non-medical based search (Section 2.2). As such typical medical searchers are bound to be influenced by many factors in the search process. Amongst major factors are task difficulty and topic familiarity. A contextualised research study incorporating search behaviour when searching across varying levels of task difficulty and topic familiarity will enable better understanding of search behaviour. This in turn will result in the development better information retrieval strategies and improvements to the human computer interaction experience when searching on a medical domain.

Previous research studies focusing on direct elements of the ISP process have analysed how demographic influence affect general search behaviour when searching on a general search domain (Weber and Castillo, 2010, Hu, Zeng and Niu, 2007, Jones et al. 2007 and Auchard, 2005). However these demographic influences are studied from a generalist perspective. Medical based searching is unique and dissimilar to non-medical based searching as such search behaviour cannot be analysed from a generalist perspective. Moreover, medical based searching is bound to be influenced by task difficulty and topic familiarity. Hence, in this research study demographic influence on medical search behaviour is analysed in relation to task difficulty and topic familiarity.

Non-medical related research studies indicate when searching on a difficult task, users issue more queries, use more query operators and natural language type queries. Users took a long time to complete the task, viewed more results, used more resources, spent more time on results page but were unsuccessful most of the time (Table 2, Section 2.4). However, similar type search behaviour may not be demonstrated when searching on a medical domain. This is because non-medical professionals may perform low search interactivity when searching on a difficult task due to low medical knowledge. Medical professionals may also demonstrate low search interactivity when searching on a difficult medical task due to high medical knowledge.

When searching on a familiar topic and on a topic with high domain knowledge, users used technical vocabulary, found more search results, issued longer, more queries and used more formal resources. Users also spent less reading time on results page when searching on a familiar topic (Table 3, Section 2.5). However in comparison to search behaviour when searching on a familiar bio-medical related task, users issue less queries and Boolean type queries (Table 4, Section 2.5). Results clicking behaviour was not significant regardless of topic familiarity. This indicates that there is a difference in search behaviour on a similar level of familiarity based on the type of search performed (bio-medical /non-biomedical). As such, it is possible to suggest that medical information searching may provide dissimilar search behaviour in comparison to non-medical based searching and bio-medical searching.

General type demographic variables influence the search behaviour for non-medical based searching. In most cases gender is a major demographic influence on search behaviour. However, demographic influence when searching across varying levels of task difficulty and topic familiarity for a medical based search is unknown. In a medical based search there is a need to consider the property of a task (difficulty/familiarity), as such demographic influence on search behaviour cannot be studied from a generalist perspective. Moreover, based on the unique structure and composition of a medical based search, non-basic type demographic variables may influence search behaviour when searching across varying levels of task difficulty or topic familiarity. It is also likely that non-universal demographic variables influence the search behaviour of typical medical searchers. In the next section a chapter summary is provided.

2.8 Chapter Summary

In this chapter, the ISP process was discussed in detail. The discussion on the ISP process indicates a search process is a complex procedure which goes through six sequential stages. It also explains the external and internal factors involved in the search process. The discussion on the ISP process specifically explains why the focus of this research study is on the search behaviour aspect and not on the emotional state or thought process of the searcher. The discussion further dwells into the direct and indirect influences of the ISP process and explains why a direct influence element is selected for the purpose of this research study. Based on the discussion of the ISP process, literature gaps and the direction for this research study are provided.

Next, literature in relation to medical based searching is presented. Specifically, search challenges experienced by typical medical searchers (non-medical professionals, medical professionals and medical students) are discussed in detail. Then, literature in relation to task difficulty, topic familiarity, domain knowledge and demographic influence on search behaviour was provided. In most cases literature discussed is not related to medical based searching. Aspects of demographic influence on search behaviour are discussed from a generalist perspective (without taking into account task difficulty/topic familiarity). Findings from previous research studies are provided in order to understand the influence of task difficulty, topic familiarity and demographic influence on search behaviour. Finally, a reflection of reviewed literature is presented. In the next chapter, the research methodology used for this research study is explained.

Chapter 3 Research Methodology

This chapter presents details of the research methodology utilised for this research study. The chapter begins by providing background information on various research methodologies used to conduct information retrieval based experiments. This is followed by a discussion on key developments within information retrieval experimentation methodologies. Then, a brief discussion on major research approaches and a summary of quantitative research methods are provided. Next, the experiment design overview, the recruitment process, data gathering techniques and experiment phases utilised for this research study are presented. Then, the experiment procedure is provided. This is followed by a brief description of interactions available on *MedlinePlus*[12] is provided. Thereafter a discussion on experimentation threats and validity is provided. Finally, a chapter summary is provided.

3.1 Major Information Retrieval Experimentation Methodologies

In general information retrieval experimentation methods are broadly classified into three basic techniques. These techniques are known as the system-focus or Cranfield (Sparck-Jones, 1998) (which will be termed system-focus henceforth) experimentation methodology, archetypical interactive information retrieval experimentation studies and human focus methodology (Kelly, 2009). The system-focus methodology is concerned with how an information retrieval system works. "The main objective of the information retrieval (IR) system is the retrieval of relevant information" (Saracevic, 1996). As such system-focus methods are concern with how to make a system function so that relevant documents can be provided to users. System-focus methods are arguably, the most common and oldest information retrieval experimental methodology in the field of information retrieval. The emphasis of system-focus methods of experimentation is to obtain general conclusions of an information retrieval system. In most cases, general conclusions obtained are based on measurements of precisions and recall of the information retrieval strategy. In some cases measurements relating to the effectiveness or efficiency of the information retrieval system are also reported.

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[12] http://www.nlm.nih.gov/medlineplus

There are several sub-techniques within the system-focus methodology which include: Text Retrieval Conferences (TREC) style studies, user relevance judgement methods and selective dissemination of information techniques (SDI). These sub-techniques revolve around developing and evaluating information retrieval algorithms and indexing techniques. There are no real users involved. Instead, only assessors are used to evaluate returned documents. System-focus sub-techniques pay little attention to the interactions performed during the search process (Voorhees and Harman, 2005). TREC style studies focus on issues in relation to precision and recall of a TREC approved infrastructure or system. User relevance judgement methods employ users to make relevance judgement of documents of a newly built infrastructure. Users do not perform searching on the system but only provide their assessment of the infrastructure. User relevance judgement techniques are usually used when a TREC approved infrastructure is not available for use (Teevan et al. 2004).

The last sub-technique is known as the selective dissemination of information (SDI). In this technique the user and the system are important but the interactivity aspect of a user searching on a system is not accounted for. At best, the SDI technique attempts to understand how user profiles should be developed and how to present relevant documents to the user for the purpose of personalization (Kelly, 2009). These major sub-techniques within the system-focus methodology concentrate on system performance measures and pay little attention to the user. In this research study, a user's search behaviour and search interactivity is central in providing answers to the research propositions. Thus, system-focus methods of experimentation are not suited for the purpose of this research study. In addition, for the purpose of investigating behavioural changes and interactivity in search behaviour many user-variables are involved and must be accounted for in an information search process (Kuhlthau, 1993). System-focus methods do not incorporate these important features. System-focus methods suffer from limitations due to its restricted assumptions on cognitive and behaviour changes of a searcher. As such system-focus methods are not suitable for the purpose of this research study.

The archetypical interactive information retrieval studies method represents an evolution within information retrieval methodologies. This is because attention shifts from system-based performance measures to interactivity of search behaviour demonstrated by real users. This key evolution marks the change from information retrieval experimental methodologies (IR) to

interactive information retrieval methodologies (IIR). The archetypical interactive information retrieval study methods focus on performing interactive information retrieval evaluations with the user. Sub-techniques include log based studies, TREC interactive study, experimental information behaviour and information seeking behaviour with information retrieval system. Log based studies require many assumptions to be made about the user and the user's intention. This is because search interactivity and behaviour are obtained from log files and not from 'live' observations of search behaviour. In most cases log type studies are able to explain search behaviour based only on the identification of commonality in search behaviour (Kelly, 2009). Amongst seminal research studies performed using log based studies are to analyse querying patterns and click-through behaviour (Agichtein et al. 2006, Bilenko and White, 2008 and Jansen and Spink, 2005). The next sub-technique is known as TREC interactive study. In this sub-technique, users evaluate system features or the search interface. In most cases, measurements are calculated based on the ability to find useful documents. The goal of a TREC interactive study methodology is to improve the search process. Exemplarily research studies conducted in this field include research studies conducted by Joho and Jose (2008) and White et al. (2005).

The next type of sub-technique, known as experimental search behaviour is where certain aspects of a search process are controlled. This is unlike a standard IIR type study where no aspect of the search is controlled. For example, the researcher might control the order of presented results or what results are presented to the user (Kelly, 2009). This type of study focuses on specific aspects of search behaviour rather than investigating search behaviour in its entirety. The aim of experimental search behaviour type studies is to focus on saying something good about search behaviour rather than demonstrating the benefits of using certain systems or system features. Amongst research studies in this area are research studies conducted by Kelly et al. (2008), Arapakis and Jose (2008) and Turpin and Scholer (2006).

The last sub-technique is known as information seeking behaviour with an information retrieval system. This type of study focuses on general information search behaviour without the use of an experimental system. Search behaviour under natural conditions or naturalistic type studies are used to understand detailed aspects of a users search behaviour. Information seeking type research studies covers a wider scope in comparison to information search behaviour type research studies. Information seeking involves how users re-find information on the Internet and

use other search intermediaries within the search process. This sub-technique focuses on the search process and not on the system. Seminal research studies using the information seeking behaviour with an information retrieval system method include research studies conducted by Bystrom (2002) and Kim and Allen (2001). Archetypical interactive information retrieval studies focus on using real users and the search interactivity performed by users during the search process. While earlier sub-techniques within this methodology focus on explaining search behaviour based on logs and focus on improving system features and the search interface (log-based studies and TREC interactive study). Newer sub-techniques focus on explaining the search behaviour of users (experimental search behaviour and information seeking with an information retrieval system) without the use of an experimental information retrieval system or measuring the effectiveness of search features of the information retrieval system. As such, newer sub-techniques within the archetypical interactive information retrieval studies are best suited for the purpose of this research study. These newer sub-techniques focus on search behaviour of real users without the use of search logs. As such user-variables involved in an information search process are accommodated for (Kuhlthau, 1993).

Finally, the human-focused methodology currently only has one sub-technique which is known as information seeking behaviour in context. In this sub-technique the researcher explores real information needs of users and their subsequent information seeking activities. The aim of this sub-technique is to better understand information seeking behaviour and also inform the design of information retrieval strategies based on search behaviour. This sub-technique is also suitable for the purpose of answering the research questions outlined for this research study. This is because emphasis is on the user and search behaviour.

Figure 2 presents a visual representation of the continuum of information retrieval research methodologies. The intent and purpose of a research study is important in determining where a study belongs in the research methodology continuum. For the purpose of this research study, the research approach used falls under two continuums: the archetypical interactive information retrieval studies and the human-focused methodology. Specifically the sub-technique: information seeking behaviour with an information retrieval system and information seeking behaviour in context. However, slight modification is required to these sub-techniques for the purpose of this research study. Similar to the conditions of the information seeking behaviour

with an information retrieval system sub-technique, this research study uses a non-experimental information retrieval system – *MedlinePlus*. The aim of the sub-technique information seeking behaviour with an information retrieval system is to obtain an understanding of general information search behaviour. The purpose of this research study is to understand how medical search behaviour is influenced when searching across varying levels of task difficulty, topic familiarity and demographic influences on search behaviour. As such this sub-technique is suitable to answer the research questions outlined in this research study. However, unlike information seeking behaviour with an information retrieval system the scope of the experiment is confined to *MedlinePlus* only. As such no intermediaries are used for the purpose of this research study. The sub-technique information seeking behaviour in context allows for such contextualization of search behaviour. Furthermore, the purpose of this sub-technique is to inform the design of information retrieval systems (Kelly, 2009). However, modifications to this sub-technique are necessary. Instead of using real information needs a substitute called simulated situations is used. The use of simulated situations is further discussed in Section 3.7.2.1. Similarly instead of information seeking, the search scope for this research study is confined to *MedlinePlus* only. As such the experiment methodology utilised in this research study is a modified version the sub-techniques: information seeking behaviour with an information retrieval system and information seeking behaviour in context. The term information searching with an information retrieval system in context is used to describe this modified research approach. In the next section, key developments within information retrieval experimentation methodologies are presented.
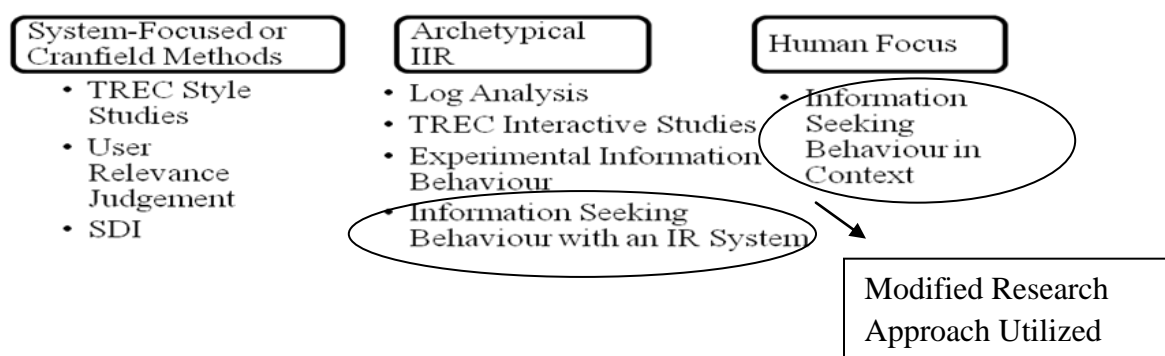
Figure 2 Information Retrieval Experimentation Methodologies (Methods For Evaluating Interactive Information Retrieval Systems With Users - Kelly, 2009).

3.2 Key Developments within Information Retrieval Experimentation Methodologies

With respect to information retrieval experimentation methodologies, there have been three revolutions within the information retrieval experiment methodologies. These revolutions are important because they further influence the selection of a suitable research methodology for the purpose of information retrieval. These revolutions are known as the cognitive, relevance and interactive revolution (Robertson and Hancock-Beaulieu, 1992). The cognitive revolution revolves around the concept that there are many user variables involved in an information search process. These variable are: the anomalous state of knowledge (ASK) of the searcher (Belkin, 1990), individual perception of information need (Belkin et al. 1993) and the changing information needs of a searcher (Kuhlthau 1993 and Bates 1989). The relevance revolution revolves around the idea that an input query into an information retrieval system is not necessarily a reflection of a searchers information need (Borlund, 2000). In addition, there are over 80 relevance criteria that influence user's relevance judgment (Schamber, 1994). Furthermore, a user's relevance criteria is dynamic (Bruce, 1994) and might change over time (Spink, Greisdorf and Bateman, 1998).

The interactive revolution is based on the notion that "most information retrieval systems are built with interactive features and cannot be evaluated without including interactivity" (Robertson and Hancock-Beaulieu, 1992). This means that using measures of precision and recall (system focus methods of measurements) and early sub-techniques within the archetypical interactive information retrieval studies do not account for these revolutions. These experimentation methods (early sub-techniques within the archetypical IIR methodology) do not provide the ability to cater for dynamic information needs and assumes that the user input query is an absolute. It also does not allow for realistic understanding of information search behaviour.

In light of this, suitable methodologies that encompass these revolutions are the following sub-techniques: information seeking behaviour with an information retrieval system and information seeking behaviour in context. These three revolutions further support the selection of the research methodology utilized for this research study – information searching with an information retrieval system in context. System-focus methods only focus on system measurements and do not utilize real users. The log based sub-technique does not incorporate

search interactivity. The TREC interactive study sub-technique allows users to evaluate system features and does not focus on the search process performed by the user. The experimental information behaviour sub-technique while interactive controls certain aspects of the experiment and focuses on specific aspects of search behaviour only.

These three revolutions further spur the concept of using simulated situations as an instrument for interactive information retrieval methodologies. Simulated situations are used as a replacement for real user tasks. Interactive information retrieval studies based on simulated situations are able to: i) use real test users, ii) take into account individual needs, iii) allows for individual interpretation and accommodates for change in search sessions and most importantly iv) allows for search interactivity (Borlund, 2000). These four elements of simulated situations support the three key revolutions within the information retrieval experimentation methodologies. Furthermore, the use of simulated situations is gaining popularity with its increase usage in many research studies mainly to perform empirical evaluations (Borlund and Schneider, 2010). The use of simulated situations is further explained in Section 3.7.2.1. In the next section, a discussion on the research approach is provided.

3.3 Research Approach

Generally there are three common approaches used to perform research studies. These approaches are: i) exploratory ii) descriptive and iii) explanatory type studies. Exploratory studies are used when little is known about an aspect of study. Exploratory studies usually use a variety of methods for the purpose of data collection. The aim of an exploratory study is to learn about a specific aspect of study. Descriptive type studies focus on describing and documenting a particular phenomenon. The aim of descriptive studies is to provide classifications based on query logs or search behaviour. Explanatory studies examine relationships between two or more aspects of study with the aim of performing some type of prediction. Explanatory studies are often conducted in the laboratory because it enables the researcher to have some control over a particular situation of study (Kelly, 2009). While little is known about how typical medical searchers search across varying levels of task difficulty, topic familiarity and demographic influence on search behaviour, it is interesting to not only classify search behaviour but also explain these search behaviour traits. As such this research study utilises an explanatory

approach to provide answers to the research questions outlined for this research study. In the next section, quantitative analysis methods are discussed.

3.4 Quantitative Analysis Methods

Quantitative analysis methods comprise of descriptive and inferential statistics. Descriptive statistics focus on describing central tendency and variation. Inferential statistics are used to compare the relationship amongst two or more variables and to test hypotheses. Inferential statistical tests are often performed in order to determine whether null hypotheses can be rejected or accepted (Abelson, 1995 and Kelly, 2009). In this research study, inferential statistics methods are used to determine significant difference for the following aspects: i) perception of task difficulty and topic familiarity, ii) search behaviour demonstrated across varying levels of task difficulty and topic familiarity and iii) demographic variables that influence search behaviour. In addition inferential statistics can be conducted based on parametric and non-parametric test. The decision to run the type of test will depend on the variables examined. If variables examined are normally distributed then a parametric test is conducted. For the purpose of this research study non-parametric tests are utilised because variables examined (query length, number of queries and task completion time) are not normally distributed.

The Chi-Square and standardised residuals test are used to determine significant difference in perception of task difficulty and topic familiarity. The Kruskal-Wallis and Dunn's post-hoc test is used to determine difference in search behaviour. The Anova test, T-test and Bonferroni test are used to determine demographic variables that influence search behaviour when searching across varying levels of task difficulty and topic familiarity. When there are more than two demographic groups obtained based on search behaviour when searching across varying levels of task difficulty and topic familiarity the Anova and Bonferroni post-hoc test is performed. When there are only two groups, an Anova and T-test is performed. Figure 3 provides a visual representation of research techniques utilised for this research study. In the next section, an overview of the experimental design is provided.
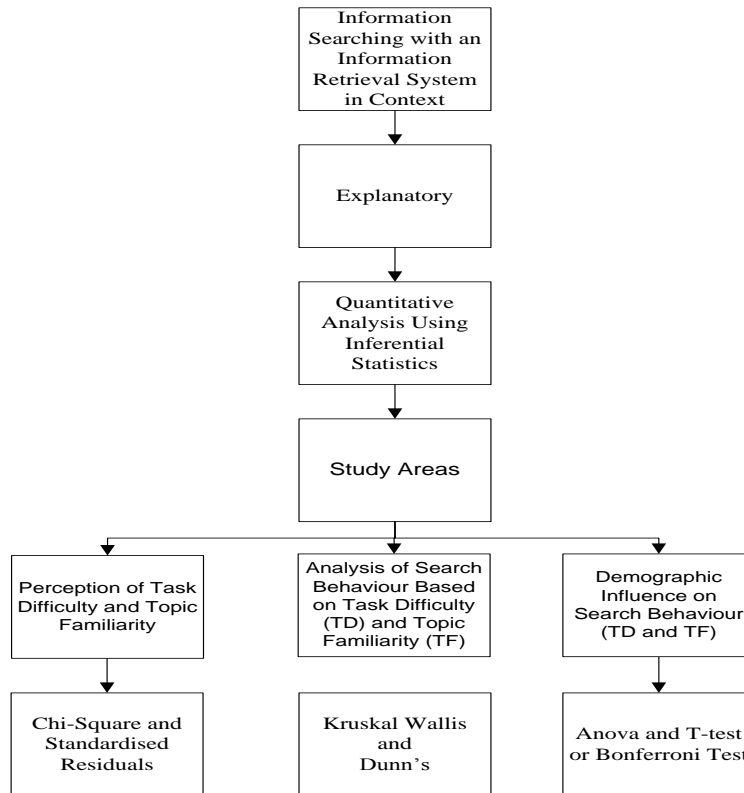
Figure 3 Research Techniques Utilised

3.5 Experimental Design Overview

A non-probability sampling method in a university setting is used to recruit participants for the purpose of this research study. Participants who responded were segregated into three main categories: non-medical professionals, medical professionals and medical students. These three categories are used to broadly represent typical medical searchers. The search domain used to perform this research study is *MedlinePlus*. *MedlinePlus* is a publicly available medical domain managed by the United States National Institutes of Health and the National Library of Medicine. *MedlinePlus* is selected as the domain to perform this research study because it does not perform any background information retrieval processing. As such 'true' interactive search behaviour is obtained. *MedlinePlus* is also a suitable domain to perform clinical based searching. Further details on the recruitment of participants and the domain used to perform this research study are explained in Section 3.6. An overview of the search interactions available on *MedlinePlus* is explained in Section 3.10.

The experimental procedure consisted of four data gathering techniques: the pre-experiment interview, search interactivity, structured observation and post-experiment interview. The search interactivity data gathering technique involves the use of simulated situations and a personal task. Participants had to complete searching on three simulated situations and on one personal task. These data gathering techniques are further explained in Section 3.7. A participant who expresses interest to participant in this research study is first separated into one of three categories (non-medical professionals [NMP], medical professionals [MP] or medical students [MS] – Figure 4). Then, the pre-experiment interview is administered. This is followed by the search interactivity and observation process. The observation process is conducted for all four search tasks (three simulated situations and one personal task). Then, the post-experiment interview is conducted. The post-experiment interview is conducted upon completion of each search task.

This research study was conducted in two phases. These phases are the pilot test and the main experiment. Further details on the experiment phases are provided in Section 3.8. Observation of search behaviour is segregated into three main sections: i) querying behaviour, ii) search results interaction activity and iii) querying versus clicking behaviour and task completion time. These main sections represent typical segregation of a search session. Detailed aspects of these three main sections are provided in Section 3.7.3. Results of the main experiment are reported to provide answers to the research questions. In-depth explanation of the experimental procedure administrated on participants is provided in Section 3.9. Figure 4 provides a visual representation of the experimental procedure. In the next section, the procedure for recruitment of participants and explanation of the search domain used for this research study is provided.
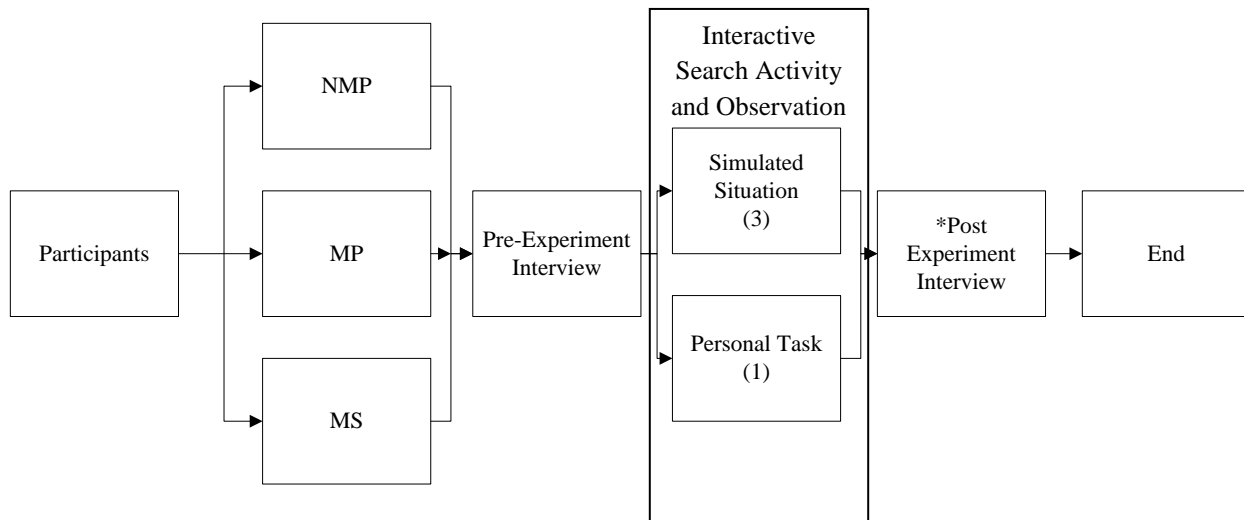
Figure 4 Visual Representation of Experimental Procedure (Note: * repeated for each task)

3.6 Recruitment of Participants and Search Domain

Participants were recruited based on non-probability sampling in a university setting. Call for participation emails were sent to research managers and head of departments for dissemination within the university. Participants who responded were segregated into three categories: non-medical professionals, medical professionals and medical students based on education type/level. Participants who qualify as non-medical professionals must not have had any formal medical education. Participants who qualify as medical professional must have completed an undergraduate medical degree at minimum (medical professionals can also be pursuing post-graduate medical degree). Participants who qualify as medical students must be pursuing an undergraduate medical degree. Participants are segregated into these three categories to provide a general representation of typical medical searchers. Individuals were selected based on a stratified sampling design. Criteria for stratification are based on education type (undergraduate medical degree/non-medical undergraduate degree), occupation (medical professionals/non-medical professionals) and education level (completed undergraduate medical degree/enrolled in an undergraduate medical degree). This led to the three groups being investigated (non-medical professionals, medical professionals and medical students). The approach adopted is a single stage sampling method (Babbie, 2007).

The search domain chosen to study medical searching behaviour is *MedlinePlus*. *MedlinePlus* is chosen as the domain of study because it is a popular clinical medical domain provided by *MEDLINE* - the premier medical database used by medical professionals. *MedlinePlus* is managed by the United States National Institutes of Health and the National Library of Medicine, this assures participants that information obtained from this site is accurate and trustable. *MedlinePlus* only utilizes basic text-based matching and spelling correction. This allows for the observation of 'true' interactive searching without participants being influenced by query suggestions or any other type of background information retrieval strategy. All search sessions are restricted to *MedlinePlus* to avoid data interference or search behaviour influence as a result of searching on non-medical domains. In the next section, data gathering techniques used for this research study are presented.

3.7 Data Gathering Techniques

In this section, various data gathering techniques utilised for this research study are provided. These data gathering techniques are: pre-experiment interview, interactive search activity, structured observation and post experiment interview.

3.7.1 Pre-Experiment Interview

The pre-experiment interview is used to obtain demographic details, information on general search experience, medical search experience and perceived medical knowledge. Participants are asked to rate their perception of medical knowledge using one of three ratings: poor, average or expert. Medical knowledge rating is performed based on participant's perception as a standard medical knowledge evaluation test is not available. Participants were also asked for reasons to have performed a medical search in the past. Medical professionals and medical students are asked additional questions. Medical professionals are asked for years of medical practice, if they are a specialist, a specialist in training or a general practitioner. Medical students are asked for the year of medical study.

Pre-search topic familiarity and clarity of the simulated situations is also obtained at this stage. Topic familiarity is obtained after providing participants with each simulated situation, before commencing the search. Participants rated their perception of topic familiarity using one of three options: familiar, somewhat familiar or not familiar. Typical medical searchers may be familiar

with medical topics for a variety of reasons. Non-medical professionals may have friends or family members who may have been diagnosed with specific symptoms or due to in-depth reading or from talking to doctors and other family members. An outbreak of a new disease may cause non-medical professionals to be unfamiliar with related topics about this new disease. Medical students may be more familiar with a topic that they have studied or based on cases encountered during clinical training. Likewise medical professionals who are specialist in training or who are a specialist in a specific area of medicine may be more familiar with certain topics in comparison to a general practitioner.

Participants' perception of clarity of simulated situations is obtained to determine that the descriptions provided in the simulated situations did not cause participants to experience any unnecessary 'search stress' due to poor construction of simulated situations. Participants rated their perception of simulated situation clarity using one of three options: clear, not clear or somewhat clear. When participants found the simulated situation to be unclear or somewhat clear, they are asked to provide some explanation as to why they found the simulated situations unclear or somewhat clear. Perception of task clarity is obtained before a search is conducted to ensure that the search experience did not influence participant's perception of task clarity. Pre-Experiment interview questions are provided in Appendix A.

3.7.2 Interactive Search Activity

To study interactive medical search behaviour amongst participants simulated situations and personal tasks are employed. In the following sections the use of simulated situations and personal tasks are explained.

3.7.2.1 Simulated Situations

The concept of simulated situations is an idea derived from a culmination of concepts mainly: i) Ingwersen's cognitive communication models (Ingwersen, 1992 and Ingwersen, 1996) and ii) the application of work task concepts (Bystrom and Jarvelin, 1995). A simulated situation provides a description of the search task for the purpose of information retrieval. A simulated situation contains two sections, a simulated work task scenario and an indicative request. The simulated work task scenario contains a short cover story that describes a situation that leads a participant to use an information retrieval system. The indicative request contains suggestions or search goals for a person to conduct a search (Borlund 2000, 2003). The indicative request helps users

to initiate a search process or to provide search hints to the user. It is not mandatory that the details in the indicative request must be used during the search process. It merely functions as a starting point for participants who are not able to initiate the search on their own. Thus, a simulated situation provides a short and focused description for participants to invoke a search.

Simulated situations are a suitable substitute for real world information needs (Borlund, 2000 and 2003) to study interactive search behaviour. It provides a platform to study and compare search behaviour amongst participants using a standardised scenario as it invokes a common information need amongst participants. For these reasons, this research study employs simulated situations to study interactive medical searching behaviour.

All categories of participants are provided with individual-category based simulated situations. The three categories of participants are not provided with the same simulated situation, as this would not be realistic. Providing all participants with the same simulated situation would be too difficult or too easy for some participants. This will not provide a reflection of 'true' interactive search behaviour. Neither does it allow participants of different categories to engage in the search task. Simulated situations also provide a standard platform for comparison of search behaviour. As such, simulated situations are a suitable instrument to study interactive search behaviour of non-medical professionals, medical professionals and medical students (as a replacement for real tasks).

Simulated situations need to reflect an environment that participants are able to relate to "in order for them to adapt to the simulated situation and treat it naturally" (Borlund, 2000). Clinical based scenarios are developed for non-medical professionals and medical professionals as this type of search is typically performed by these two categories of participants (Gonzales-Gonzales et al. 2010 and Spink et al. 2004). Simulated situations are developed based on prevalent cases surveyed at a public hospital. Clinical and theoretical scenarios are developed for medical students to suite medical students who would be at different stages of their medical study. These scenarios are then modified to fit the description of simulated situations. Each simulated situation has several search goals and covers different topics to provide search variety. Simulated situations developed were verified by two independent medical doctors to ensure that tasks are medically accurate and developed at an appropriate level to suite the three categories of users.

Borlund (2000) used three simulated situations and one personal task in her research study to test the effectiveness of simulated situations. Li et al. (2011) used three simulated situations for the purpose of measuring task difficulty. Poddar and Ruthven (2010) used three simulated situations and one personal task for the purpose of measuring emotional impact in a search process. Previous research studies have used three simulated situations for their respective aspects of study. Thus, based on practices of previous research studies three simulated situations are developed for each category of users. The order of the task is rotated for each participant "to neutralise any effect caused by previous search activity in relation to increased topic familiarity or reduced task difficulty from the experiment" (Borlund, 2000). Task A1, A2 and A3 are developed for non-medical professionals. Task B1, B2 and B3 are developed for medical professionals. Task C1, C2 and C3 are developed for medical students. Description of the simulated situations for non-medical professionals, medical professionals and medical students are provided in Appendix B, C and D respectively.

3.7.2.2 Personal Task

The purpose of the personal task is to observe and compare differences in search behaviour when searching on the simulated situation and the personal task. The personal task is prepared by the participant. Participants are told to prepare a medical based personal task beforehand. The personal task could be a topic currently being searched, have yet to be searched for or searched before on a domain other than *MedlinePlus*. The order of the personal task is rotated with the simulated scenario. Additional questions are asked to provide background information about the personal task prior to commencing the search on the personal task (except for Question 4 which is asked after the entire experiment). These questions are provided in Appendix E. Personal tasks are only used for the study of task difficulty as participants may already be familiar with their personal task based on previous experiences (pre-influencing topic familiarity based on search or non-search related factors).

3.7.3 Structured Observation

A structured observation study as opposed to a log-based study is utilised for this experiment. This is to incorporate the context of the search and to facilitate the post-experiment interview. Observational studies have proven to be helpful to "understand how search strategies are used" (Robertson, 1997). Furthermore, log based research studies "provide a limited scope as little is known about the individual users, their needs or intentions during a search session" (Kelly,

2006). A structured observation based study is utilised for this research study because it allows for participants to explain their search behaviour and why they were dissatisfied with search results (user perceived satisfaction).

To facilitate analysis of results, search sessions were segregated into three sections. These sections are: querying activities, search results interaction activities, total querying versus clicking behaviour and task completion time. In the querying activity section the following activities are observed: the number of queries issued per search session, the type of query issued (medical/non-medical), usage of query operators, length of the query (number of terms per query), query re-issues (exact), ineffective queries (query which returned no search results), natural language queries, queries without clicks (users did not click on search results) and usage of querying assistance. A query is qualified as a medical term query (medical query) when a term/s used in the query is found in the *MeSH* medical vocabulary database. The *MeSH* vocabulary database is used to qualify a query as a medical query because *MeSH* is the only formal controlled vocabulary thesaurus available managed by the National Library of Medicine. *MedlinePlus* also utilises *MeSH* to map medical terms to documents available on *MedlinePlus* (Miller, Lacroix and Backus, 2000). Thus, the existing relationship between *MedlinePlus* and *MeSH* is utilised to qualify a query as a medical term query (medical query). A query is qualified as a natural language query if the query issued is a complete English Language type sentence.

In the search results evaluation activity section the following activities are observed: number of search results viewed for each task, result revisits, the number of sub-links clicked within the result page, viewing results beyond the 1st result page, using the Find Command (Control-F), and the numbers of unsuccessful search sessions (participants ended the search task without arriving at satisfactory results – user perceived satisfaction). In the third section, total querying versus clicking behaviour and task completion time is provided. Querying versus clicking behaviour provides the total number of queries issued (effective and ineffective) and results clicked (links and sub-links) for each search task. This is to provide a representation of querying and clicking activity in relation to task completion time. All activities performed by participants in search sessions are manually observed and logged (no search activities were omitted). Analysis is performed after all a hundred and eighty participants completed the experiment.

3.7.4 Post-Experiment Interview

The post experiment interview took place after participants completed each search task. There are two parts to the post-experiment interview. The first part of the post-experiment interview is a structured interview relating to user-perceived subjective post-task difficulty (Li and Belkin, 2008) for the simulated situations. Participants rated their perception of task difficulty using one of three options: easy, neutral (neither easy nor difficult) or difficult. Participants may find searching for a medical task difficult because it took too long to locate results or returned results may contain technical jargon and may be difficult to understand. On the other hand, participants may find a task easy because they did not experience issues in relation to comprehending returned results or were able to locate relevant results quickly.

Participants were also asked to rate their overall perception of task difficulty of the simulated situations against their personal task. This is to ensure that participants did not find the simulated situations too difficult or too easy in comparison to their personal task. This also provides the ability to compare search behaviour obtained from the simulated situation with search behaviour demonstrated when searching on the personal task. Participants were asked to rate their perception of task difficulty of their personal task against the overall level of difficulty of the simulated situations using one of the three options: the overall task difficulty of the simulated situations is more difficult than the personal task, the overall task difficulty of the simulated situations is easier than the personal task or the overall task difficulty of the simulated situations is of the same level of difficulty with the personal task.

The second part of the interview is an unstructured interview. At this stage general feedback from the search session is obtained. Participants are encouraged to explain what search strategies worked/did not work, why they used certain search strategies and why they were dissatisfied with returned results (user-perceived perception – unsuccessful search sessions). The post-experiment interview questions are provided in Appendix F. In the next section, experiment phases conducted for this research study are provided.

3.8 Experiment Phases

In this section, the experiment phases are discussed. There are two phases to this research study. These stages are the: i) pilot test and ii) main experiment.

3.8.1 Pilot Test

A pilot test was conducted to test the interview questions, participants understanding of the simulated situations and the experiment methodology. A total of four non-medical professionals, four medical professionals and four medical students were part of the pilot test. As a result of the pilot test, simulated situations were refined and the interview questions fine-tuned. There were no new issues reported after the third pilot test participant for each category of participant. Hence, the pilot test was completed with a total of twelve participants. Results of the pilot test are not reported.

3.8.2 Main Experiment

In this phase, the experiment was re-run with a new set of participants consisting of sixty non-medical professionals, sixty medical professionals and sixty medical students. The purpose of the main experiment is to report results and to answer the research questions outlined for this research study. For the purpose of the main experiment theoretical saturation was achieved with thirty non-medical professionals, twenty medical students and twenty medical professionals. To further confirm results another thirty non-medical professional, forty medical professionals and forty medical students were recruited for the main experiment. To measure theoretical saturation, search behaviour demonstrated by participants is observed and recorded when searching across tasks. The open coding method (Strauss and Corbin, 1990) is used for this purpose. Search behaviour observed are fitted into categories as mentioned in Section 3.7.3 mainly: querying activities, search results interaction activities and total querying versus clicking behaviour and task completion time. The open coding process ended when no new search behaviour patterns emerged when searching across tasks for each category of participant (Task A1,A2,A3 for Non-Medical Professionals, Task B1,B2,B3 for Medical Professionals and Task C1,C2,C3 for Medical Students). Thus, theoretical saturation is achieved when no new search behaviour patterns emerge. Each category (non-medical professionals, medical professionals and medical students) is equally represented. A total of a hundred and eighty participants were part of the main experiment. Results of the main experiment are reported in Chapter 4. In the next section, the experiment procedure administered for this research study is presented.

3.9 Experiment Procedure

In this section the experiment procedure administered to conduct this research study is provided. Ethics approval for this research study was obtained from Monash University's Human Ethics Committee (approval project no: CF10/1457-2010000782). Participants who expressed interest to participate in this research study contacted the investigator and a meeting was set. Prior to the meeting, the investigator informs participants to prepare a personal task for the experiment.

At the meeting, participants were informed of the purpose of this research study. The investigator informs participants that the experiment is not to test their medical knowledge, expertise or about locating the correct answers to the scenarios. Participants are informed that their search activities will be observed and manually logged by the investigator. Participants are then handed the Explanatory Statement and asked to sign the Consent Form if they agree to participate in this research study. The Consent Form and Explanatory Statement are provided in Appendix G and H respectively.

Next, the investigator administers the pre-experiment interview. After the pre-experiment interview the *MedlinePlus* web page is loaded using the *Internet Explorer Browser v7.0* or *Mozilla Firefox v3.0* depending on a participant's preference. The machine used to conduct the experiment is a standard computer with an Intel Core Duo 2 processor with a speed of 2.66 GHz and 1.96GB of memory. The machine is installed with *Windows XP Professional* operating system and other standard software that are bundled with the installation.

Participants who have not used *MedlinePlus* before are given some time to familiarize themselves with the web site. The investigator informs participants that they are to search as normally as possible and that they may stop the search once they have found relevant result/s or wished to terminate the search because they have not arrived at relevant result/s (unsuccessful search sessions - user-perceived satisfaction). The instruction letter given to participants prior to the start of the search is provided in Appendix I. Then, the investigator provides participants with the first simulated situation. After completing the first simulated situation the post-experiment interview is conducted. Upon completing the post-experiment interview, the investigator provides participants with the second simulated situation. The same procedure is repeated for the third simulated situation and the personal task. Participants are handed the simulated situation one at a time and there is no time limit for each search task. Search history and cache is cleared

from the web browser after each search task. At the end of the experiment, participants are provided with a medium-sized notepad as a token of appreciation. In the next section, a brief description of interactions on *MedlinePlus* is presented.

3.10 A Brief Description of Interactions on MedlinePlus

MedlinePlus is a free and publicly available clinical medical domain managed by the American National Library of Medicine and the National Institutes of Health. The interface of *MedlinePlus* is similar to other publicly available clinical medical search domains on the Internet. A standard search interface is provided to users. While the retrieval strategy employed by *MedlinePlus* is basic text matching, there are search assisting features available to assist users which must be explicitly invoked. For example, to assist during the querying process, users might consider using available tab functions like *Health Topics*, *Drugs and Supplements* and *Tools and Cool Videos*. A *Medical Dictionary* function is available to assist users with medical terms. There are also functions available to assist users with refining search results such as *Refine by Keyword* or *Refine by Type*. These results refining assistance can only be invoked after search results are presented. While *MedlinePlus* only performs based text matching without utilising any background information retrieval strategies, users are provided with options to refine returned results and assist with querying assistance. However these activities must be explicitly invoked and are not automatically performed for the user. Thus, this still provides the ability to observe 'true' information searching behaviour.

In some cases after a user inputs a query, a user may be returned with zero search results. There are two reasons for this, either: i) the query input by the user is too specific and *MedlinePlus* was not able to locate results for the query entered or ii) due to spelling error. When users experience zero returned results due to spelling error, *MedlinePlus* attempts to correct the spelling error and asks the user to confirm a new search based on the correct spelling. If *MedlinePlus* is not able to correct the spelling error, the user has to input a new query to continue with the search. In the case where the query entered is too specific, no suggestions are provided and the user is left to input a new query. In the next section, a discussion on experiment reliability and validity is provided.

3.11 Experiment Reliability and Validity

In this section, issues in relation to experiment validity and reliability are provided. In relation to internal validity, the experiment was conducted at the researcher's office. Experiments were not conducted at the participant's office or work area. As such there was the ability to reduce unanticipated disruption throughout the duration of the experiment. This setup was able to increase internal validity of the experiment results. However, participants were not asked to switch off their mobile phones during the duration of the experiment. Receiving phone calls and text messages were not explicitly prohibited. Participants were not told to switch off their mobile phones as some participants (medical professionals and medical students) were required to be on standby. However, this situation did not occur often. As such internal validity of the experiment results is maintained. The simulated situations in this research study were limited to three for each category of participant. It is possible that if more simulated situations were provided to participants results obtained from the experiment may vary. It is also possible that issues such as fatigue, time constraint and work commitments may influence experiment results. To minimise issues with fatigue, time constraint and work commitments the researcher allowed participants to select a time and date convenient to them.

Similarly topics covered in the simulated situation may also influence experiment results. In this research study no particular topic was tested more than once. Hence participants had a variety of topics to search for. Variety was also provided to reduce boredom. However, there is a possibility that if different topics were covered in the simulated situation that the experiment results may differ. To minimise this effect, each simulated situation was developed with more than one search goal. This was to encourage participants to perform searches around the topic. In relation to external validity, it is not possible to generalise results of this research study. As such to reduce threats to external validity the recruitment of participants for this research study was conducted beyond the point of theoretical saturation.

In this research study, a pilot test was used to test the simulated situations and the pre and post interview questions. As a result of the pilot test, the simulated situations, pre and post experiment interview questions were fine-tuned. Furthermore participants were asked during the pre-experiment interview if the simulated situations presented to them were clear or if they had any trouble understanding the simulated situations. The descriptions provided in the simulated

situations were verified by two independent medical professionals for accuracy. In addition, the scenario provided in the simulated situation is based on real cases observed at a public hospital. Inferential statistical methods were used to report all findings and test results were verified more than once. These methods mentioned above were used to increase the reliability of the experiment results. In the next section, a chapter summary is provided.

3.12 Chapter Summary

After careful consideration of major research methodologies, a modified version of the sub-technique information seeking with the use of an information retrieval system and information seeking in context is utilised for this research study. A modified approach is necessary as this research study is based on information searching behaviour and not information seeking behaviour. This modified approach is named information searching with an information retrieval system in context. Information seeking behaviour encompasses not only search interactivity performed during the search process but also activities performed after the search process has ended. Information seeking methodologies also allows for the use of search intermediaries. Moreover, the sub-technique information seeking with the use of an information retrieval system employs the use of 'real-task'. In this research study simulated situations are utilised to provide a standard platform for search behaviour to be compared. System-focus methodologies and earlier sub-techniques within the archetypical interactive information retrieval studies do not cater for search interactivity and do not incorporate key revolutions within the information retrieval process.

This modified methodology is used to analyse how varying levels of task difficulty and topic familiarity influence search behaviour. It also provides information on demographic details that influence search behaviour when searching across varying levels of task difficulty and topic familiarity. Real users, observation of the interactive search process, simulated situations and personal tasks are utilised to account for the user-variables involved in the search process. Participants of this research study consisted of three main categories which are: non-medical professionals, medical professionals and medical students. These categories are chosen to represent typical medical searchers. Clinical simulated situations are developed for non-medical professionals and medical professionals while medical students were given clinical and theoretical simulated situations. Additionally, the use of personal tasks is employed to confirm

and validate search behaviour demonstrated when searching for the simulated situations. The domain where this experiment is conducted is a medical domain – *MedlinePlus*. *MedlinePlus* does not perform any background processing for the purpose of information retrieval thus 'true' information searching behaviour is obtained for analysis.

This research study consisted of two stages of experiments. These stages are: a pilot test and the main experiment. The pilot test is first conducted to test the instruments used for this research study. The main experiment is conducted to report results and answer the research questions outlined in Section 1.3. User perceived perception is obtained for task difficulty and topic familiarity and a quantitative analysis is performed based on search behaviour. Search sessions were segregated into query activities, search results interaction activity and total querying versus clicking behaviour and task completion time. Analysis is performed to determine how varying levels of task difficulty and topic familiarity influence search behaviour. Additionally, demographic influences are also studied in relation to search behaviour demonstrated when searching across varying levels of task difficulty and topic familiarity. In the next chapter, results of the main experiment are provided.

Chapter 4 Main Experiment Results

In this chapter results from the main experiment are presented. The aim of the main experiment is to seek answers to the research questions outlined for this research study (Section 1.3). Results obtained from the main experiment are discussed in relation to results of previous research studies. A total of sixty non-medical professionals, medical professionals and medical students participated in the main experiment. First, demographic details for each category of participant (non-medical professionals, medical professionals and medical students) are presented. This is followed by presentation of search session details. Search session details are presented in three sections. These sections are: i) query details, ii) search results interaction activity and iii) total querying versus clicking behaviour and task completion time. Following this, results based on participant's perception of clarity of simulated situations are provided. Next, study results are presented based on the affects of i) task difficulty, ii) topic familiarity and iii) demographic influence on search behaviour when searching across varying levels of task difficulty and topic familiarity. A summary is provided after each section and this is followed by s summary of collated results.

4.1 Demographic Details of Participants

In this section, demographic details of participants are presented in several sub-sections. These sub-sections are: basic demographic details, education and occupation details and search experience.

4.1.1 Non-Medical Professionals

A total of sixty non-medical professionals took part in the main experiment. Basic demographic details are presented in Table 6, occupation and education details are presented in Table 7 and search experience and perceived medical knowledge are presented in Table 8. Participants who fell in the 'others' nationality category are Indonesians, Burmese, Africans, Japanese, Indians and Bangladeshi.

Category	Details			
Gender	Male	Female		
	38	22		
Use of the English Language (%)	1st Language	2nd Language	3rd Language	
	55.0	25.0	20.0	
Nationality (%)	Malaysian	Middle Eastern	Sri Lankan	Others
	60.0	6.0	6.0	28.0
Age (years)	Max	Min	Mean	SD
	60	18	33.7	9.6

Table 6 Basic Demographic Details for Non-Medical Professionals (Note: SD - standard deviation)

Participants level of education and occupation details are provided in Table 7. Amongst working professionals, the highest qualification is a PhD and the lowest is an undergraduate degree. Working professionals accounted for the most number of non-medical professionals. This is followed by post-graduate students and under-graduate students.

Category	Education Type	% Value
Undergraduate Students (20.0% of total participants)	Business	10.0
	Information Technology	10.0
Post-Grad Students (25.0% of total participants)	Business	8.0
	Information Technology	9.0
	Health Science	5.0
	Engineering	3.0
Occupation Details		
Working Professionals (55.0% of total participants)	University Lecturers	18.0
	Administrators	10.0
	Engineers	10.0
	Managers	10.0
	Consultants	7.0

Table 7 Occupation and Education Details for Non-Medical Professionals

Table 8 provides search experiences and perceived medical knowledge for non-medical professionals. Search experience is divided into general search experience and medical search experience. Medical search experience is further divided into searching for medical information on general search engines

or on medical search engines. Out of the sixty non-medical professionals who participated in the main experiment, three non-medical professionals have never performed a medical search before.

Non-medical professionals from the health science discipline perform medical based searches for an average of three hours per day. They search for medical information only on medical search engines. Participants from the health science discipline searched for research material and treatment options for their clients. Non-medical professionals from other disciplines perform medical searches when there is a need to do so. Typically, they perform searches to obtain information on diagnosis, medical treatment options and general healthcare.

Category	Details			
Self-Rated Medical Knowledge (%)	Poor	Average	Expert	
	30.0	60.0	10.0	
General Search Experience (years)	Max	Min	Mean	SD
	16.0	2.0	10.3	3.5
Medical Search Experience (years)	10.0	0	6.2	3.5
Medical Search Experience On General Search Engines Only (75.0% of total participants) [years]	8.0	2.0	9.9	3.5
Medical Search Experience On Medical Search Engines Only (10.0% of total participants) [years]	8.0	1.0	6.2	3.5
Medical Search Experience on Medical Search Engines and General Search Engines (15.0% of total participants) [years]	5.0	1.0	5.0	2.0

Table 8 Search Experience and Perceived Medical Knowledge for Non-Medical Professionals

4.1.2 Medical Professionals

There were sixty medical professionals who participated in the main experiment. Basic demographic details, occupation and education details, general and medical search experience is presented in Tables 9, 10 and 11 respectively. Participants in the 'others' nationality category are Iranians, Bhutanese and Maldivians.

Category	Details			
Gender	Male	Female		
	14	46		
Use of the English Language (%)	1st Language	2nd Language		
	70.0	30.0		
Nationality (%)	Malaysian	Others		
	70.0	30.0		
Age (years)	Max	Min	Mean	SD
	45.0	26.0	30.5	6.1

Table 9 Basic Demographic Details for Medical Professionals

From Table 10 medical professionals consist of medical officers and medical officers who are undergoing specialist training. Most medical professionals perceived their medical knowledge as average.

Category	Details			
Medical Officer (%)	45.0			
Specialist in training (%)	55.0			
Years of Medical Practice	Max	Min	Mean	SD
	20.0	1.0	5.2	4.5
Perceived Medical Knowledge (%)	Average	Poor		
	85.0	15.0		

Table 10 Occupation Details and Perceived Medical Knowledge for Medical Professionals

Typically medical professionals search for research material, information for clinical cases and evidence based medicine. Medical professionals search for medical information for an average of two hours per week.

Category	Details			
General Search Experience (years)	Max	Min	Mean	SD
	20	3.0	10.2	4.3
Medical Search Experience (years)	15	1.0	7.2	4.8
Medical Search Experience on General Search Engines only (20.0% of participants) [years]	9.0	5.0	3.5	0.9
Medical Search Experience on Medical Search Engines only (40.0% of participants) [years]	8.0	1.0	3.0	0.3
Medical Search Experience on General Search Engines and Medical Search Engines (40.0% of participants) [years]	12.0	1.0	6.2	1.3

Table 11 General Search Experience and Medical Search Experience for Medical Professionals

4.1.3 Medical Students

A total of sixty medical students participated in the main experiment. Basic demographic details for medical students are presented in Table 12. Year of medical study and perceived medical knowledge are presented in Table 13 and details of search experience are presented in Table 14.

Category	Details			
Gender	Male	Female		
	16	44		
Use of English Language (%)	1st Language	2nd Language		
	40.0	60.0		
Nationality (%)	Malaysian	British	Middle Eastern	German
	65.0	15.0	15.0	5.0
Age (years)	Max	Min	Mean	SD
	26	19	22	2.1

Table 12 Basic Demographic Details for Medical Students

The number of medical students is evenly distributed across the year of medical study. However, there were no participants from the fourth year of study. While most medical degrees are for a duration of five years, some medical programmes require students to undergo 6 years of medical study. Most medical students rated their medical knowledge as average.

Category	Details				
Years of Medical Study (%)	1st	2nd	3rd	5th	6th
	20.0	20.0	20.0	20.0	20.0
Perceived Medical Knowledge (%)	Average			Poor	
	75.0			25.0	

Table 13 Year of Medical Study and Perceived Medical Knowledge for Medical Students

Medical students search for medical information mostly on general search engines. Students search for medical information to complete assignments or projects, to obtain more information after a lecture and to further understand information on diagnosis or treatment options for patients during clinical training. Most medical students perform medical searching only on general search engines. On average medical students spend an hour a week searching for medical information.

Category	Details			
General Search Experience (years)	Max	Min	Mean	SD
	5.0	1.0	9.2	2.6
Medical Search Experience (years)	6.0	1.0	3.5	1.2
Medical Search Experience On General Search Engines Only (80.0% of total participants) [years]	2.0	1.0	1.7	0.9
Medical Search Experience On Medical and General Search Engines (20.0% of total participants) [years]	3.5	1.0	4.6	1.2

Table 14 General and Medical Search Experience for Medical Students

4.2 Search Session Details of Participants

In this section, search session details are presented in three categories. These categories are: query details, search results interaction activity, total querying versus clicking behaviour and task completion time. The querying versus clicking behaviour provides a visual representation of these activities in relation to task completion time. Search sessions of non-medical professionals and medical students take into account their personal tasks. Medical professionals search sessions do not take into account their personal task. This is because medical professionals did not share their personal task for the purpose of the experiment. Participants were not asked to rate their familiarity with their personal task as they would already have some background

knowledge on their personal task. This may pre-influence search behaviour from a search or non-search related aspect. Search behaviour demonstrated when searching on a personal task is used for comparison against search behaviour demonstrated when searching across the simulated situations (for task difficulty only).

Search session details (query length, number of queries, task completion time) are not normally distributed, thus the Kruskal Wallis H-test is used to test for statistical significance. Mean rank values are provided along with the H-Test statistics for the number of queries, query length and task completion time in the following tables: Tables 15 and 17 (Section 4.2.1), Tables 18 and 20 (Section 4.2.2) and Tables 21 and 23 (Section 4.2.3). Thereafter, an unplanned Dunn's post-hoc test is performed. For search results interaction activity, test statistic values are not significant at $p<0.05$ for results clicked and sub-links clicked. Thus, mean or total values are used for discussion. Percentage values are reported for other aspects of query and search interaction activity because these interactions were not varied enough to be calculated based on test statistics. Percentage values are calculated based on the number of times these interactions are performed out of total search sessions (refer to Table 16, Section 4.2.1; Table 19, Section 4.2.1 and Table 21, Section 4.2.2). Natural language queries are only observed for search sessions performed by non-medical professionals. However, the percentage of natural language queries issued is very limited (2% - Table 15, Section 4.2.1) and does not warrant further investigation. (Note: In Task A2, the term URS&RPG used to describe the simulated situation is not considered as a query operator or medical query when issued by non-medical professionals. This is because the term is obtained from the simulated situation and did not originate from the user).

4.2.1 Non-Medical Professionals

Table 15 provides query details from search sessions conducted by non-medical professionals. Results of the H-test indicate there is significant difference amongst tasks for the number of queries issued and query length. A value of $H=21.87$, $p<0.001$ is obtained for the number of queries issued. The most number of queries are issued for Task A2 and the least number of queries are issued for Task P. A value of $H=15.94$, $p=0.0012$ is obtained for the query length. The longest queries are issued for Task A2 and the shortest queries are issued for Task P. Results of Dunn's pair-wise post hoc analysis reveals the median number of queries issued for all pair-wise comparison is different. The median query length for all pair-wise comparison is different.

The '+' query operator is used the most followed by the "..." query operator. There is no correlation between the types of query operator issued amongst tasks.

Personal Task
Thirty six participants shared their personal task (P) for the purpose of the experiment. Twelve participants perceived their personal task to be easier than the simulated situations. Twenty participants perceived their personal task to be of the same level of difficulty against the simulated situation and four participants perceived his/her personal task as harder than the simulated situation. These proportions provide an indication that non-medical professionals did not find searching for the simulated situations too easy or too difficult. Fifteen participants have searched for their personal task before and the rest have not searched for their personal task before. The longest a participant had spent searching on a personal task is six months and the shortest is a few days. Participants do not search for their personal task on a regular basis but do so as and when they remember to or when they feel a need to obtain updated information. A brief description of participant's personal task is provided in Appendix J.

Criteria\Task		A1 (N=60)	A2 (N=60)	A3 (N=60)	P (N=36)
# of queries issued per search session	Mean	2.8	3.7	2.6	1.9
	SD	1.5	1.9	1.8	1.4
	Median	3	4	2	1
	Min	1	1	1	1
	Max	8	8	10	6
	Test Statistics Mean # of Queries H=21.87, P<0.001	111.6	131.5	105.4	70.3
Query length per search session	Mean	8.5	8.5	6.5	5.8
	SD	5.9	6.5	5.3	6.1
	Median	7	7	5	3.5
	Min	1	2	1	1
	Max	26	32	21	19
	Test Statistics Mean Query Length H=15.94 p=0.0012	115.6	126.3	103.2	75.8
% of queries using query operator		15.0	22.0	10.0	0
% of queries re-issued		5.0	0	2.0	0
% medical queries		1.0	14.0	0	3.0
% queries without clicks		20.0	25.0	22.0	0
% natural language		0	0	2.0	0
% of ineffective queries	Spelling Error	2.0	2.0	0	0
	Query Too Specific	11.0	42.0	0	0
Querying Assistance					
% of usage Health Topics Tab		13.0	10.0	0	3.0
% of usage Videos & Cool Tools Tab		3.0	3.0	6.0	3.0
% of usage Drugs & Supplements Tab		16.0	3.0	6.0	3.0
% of usage Interactive Tutorial		3.0	3.0	6.0	3.0

Table 15 Query Details for Non-Medical Professionals (Note:# denotes number, SD denotes standard deviation)

Table 16 provides search results interaction behaviour of non-medical professionals. Mean values for the results and sub-links clicked are used to perform comparison. The most amount of interaction on the results page was observed for Task A1. Participants viewed results beyond the first page when searching for Task A1. The most number of unsuccessful search sessions is experienced when searching for Task A2 and results refining assistance was used the most when searching for Task A2.

Criteria\Task		A1 (N=60)	A2 (N=60)	A3 (N=60)	P (N=36)
# of search results clicked per search session	Mean	2.0	1.8	1.8	1.9
	SD	1.4	1.7	0.7	1.2
	Median	2	2	1	2
	Min	1	1	1	1
	Max	8	10	8	6
# of sub-links clicked per search session	Mean	1.8	1.4	2.3	1.0
	SD	1.3	0.6	1	1
	Median	1	2	2	1
	Min	1	3	1	1
	Max	4	3	4	1
% of usage Control-F (find)		19.0	12.0	4.0	3.0
% of participants clicked beyond the 1st results		21.0	3.0	10.0	0
% unsuccessful search sessions		15.0	35.0	3.0	8.0
Refining Search Results Assistance					
% of usage Refine by Keyword		5.0	25.0	5.0	0
% of usage Refine by Topic		0	2.0	2.0	0
% of usage Refine by Type		7.0	8.0	0	0

Table 16 Search Results Interaction Details for Non-Medical Professionals

Table 17 provides total querying versus clicking behaviour and task completion time for non-medical professionals. Results of the H-test indicate significant difference for task completion time. A value of H=15.92, p=0.0012 is obtained. The most amount of time is taken to complete Task A2 and the least amount of time is taken to complete Task P. Results of Dunn's post hoc test indicates, the median task completion time for all pair-wise comparison is different except between Task A3-P. Uneven querying versus clicking behaviour is observed for Task A2 where more queries are issued in comparison to result clicks.

Criteria\Task		A1 (N=60)	A2 (N=60)	A3 (N=60)	P (N=36)
Total Querying versus Clicking Behaviour		173 vs 164	195 vs 127	139 vs 131	76 vs 76
Task Completion Time Per Search Session (mins)	Mean	5.8	7.6	4.7	4.1
	SD	3.6	5.3	3.9	2.4
	Median	5	6	3.5	3.5
	Min	1	2	1	1
	Max	15	30	12	13
	Test Statistics Mean Task Completion Time H=15.92 p=0.0012	117.7	128.8	90.7	89.1

Table 17 Total Querying versus Clicking Behaviour and Task Completion Time for Non-Medical Professionals

4.2.2 Medical Professionals

Table 18 provides details of the querying activities of medical professionals. A value of H=13.76, p=0.001 is obtained for the number of queries issued. The most number of queries are issued for Task B3 and the least number of queries are issued for Task B2. Results of Dunn's unplanned post-hoc analysis indicate the median number of queries issued is different for all pair-wise comparison except for Task B1-B2. A value of H=9.87, p=0.0072 is obtained for query length. The longest queries are issued for Task B2 and the shortest queries are issued for Task B1. Results of Dunn's unplanned post-hoc analysis indicate difference in the median query length for Task B1-B2 only. Only the '+' query operator is used when searching across all tasks. Medical professionals did not share their personal task for the purpose of the experiment. They did not have a personal task at hand that they would like to search for. Thus, for medical professionals only results from the search sessions of simulated situations are provided.

Criteria\Task		B1 (N=60)	B2 (N=60)	B3 (N=60)
# of queries issued per search session	Mean	1.9	1.8	3.1
	SD	1.2	1.0	2.2
	Median	1	2	2.5
	Min	1	1	1
	Max	6	5	8
	Test Statistics Mean # of Queries H= 13.76 p= 0.001	82.0	78.7	110.8
Query length per search session	Mean	5.4	7.3	10.3
	SD	4.0	4.8	12.2
	Median	4	6	7
	Min	2	1	1
	Max	22	23	26
	Test Statistics Mean Query Length H=9.87, p=0.0072	76.0	105.9	89.6
% of queries using query operator		7.0	12.0	16.0
% of queries re-issued		3.0	0	8.0
% medical queries		65.0	16.0	14.0
% queries without clicks		34.0	15.0	41.0
% ineffective queries	Spelling Error	3.0	0	0
	Query Too Specific	30.0	20.0	75.0
Querying Assistance				
% of usage Drugs & Supplements Tab		0	0	36.0

Table 18 Query Properties for Medical Professionals

Table 19 provides search results interaction details of medical professionals. As the number of results clicked is limited, mean values are used for discussion. For the number of sub-links clicked, total values are used for comparison. More interactions were performed on the results page when searching for Task B3. Participants clicked beyond the first results page when searching for Task B3. The most number of unsuccessful search sessions was experienced and the most results refining assistance was used when searching for Task B3.

Criteria\Task		B1 (N=60)	B2 (N=60)	B3 (N=60)
# of search results clicked per search session	Mean	1.3	1.9	1.6
	SD	0.8	2.1	1.0
	Median	1	1	1.2
	Min	1	1	1
	Max	5	5	6
# of sub-links clicked per search session	Total	3	3	1
% of usage Control-F (find)		0	0	8.0
% of participants clicked beyond the 1st results page		14.0	0	19.0
% unsuccessful search sessions		27.0	13.0	37.0
Refining Search Results Assistance				
% of usage Refine by Type		0	0	17.0

Table 19 Search Results Interaction Activities for Medical Professionals

Table 20 provides querying versus clicking behaviour and task completion time for Task B1, B2 and B3. Results of the H-test indicate no significant difference for task completion time amongst tasks. The querying versus clicking behaviour for Task B3 is uneven with more number of queries issued in comparison to result clicks.

Criteria\Task		B1 (N=60)	B2 (N=60)	B3 (N=60)
Total Querying versus Clicking Behaviour		85 vs 73	88 vs 81	171 vs 87
Task Completion Time Per Search Session (mins)	Mean	2.8	3.0	3.8
	SD	1.5	1.8	2.0
	Median	3	2	2
	Min	1	1	1
	Max	8	8	15
	Test Statistics Mean Task Completion Time H=0.66, p=0.7189	87.5	94.9	89.1

Table 20 Total Querying versus Clicking Behaviour and Task Completion Time for Medical Professionals

4.2.3 Medical Students

Querying details are provided in Table 21. Results of the H-test indicate no significant difference amongst task for the number of queries issued. A value of H=9.33, p=0.0252 is obtained for query length.

The longest queries are issued for Task C3 and the shortest queries are issued for Task P. Results of Dunn's post hoc test indicate the median query length for all pair-wise comparison is different except for Task C1-C2. Only the '+' query operator is used in all search sessions. Medical students did not utilise any form of querying assistance in all search sessions.

Personal Task

Thirty eight participants shared their personal task (P) for the purpose of the experiment. Twenty participants perceived their personal task to be easier than the simulated situation. Seventeen participants perceived their personal task to be of the same level of difficulty against the simulated situation and one participant perceived his/her personal task as harder than the simulated situation. These proportions provide an indication that non-medical professionals did not find searching for the simulated situations too easy or too difficult. Twenty participants have searched for their personal task before and the rest have not searched for their personal task. The longest a participant had spent searching on a personal task is two weeks and the shortest is a few days. Participants do not search for their personal task on a regular basis but do so when they had the time. A brief description of participant's personal task is provided in Appendix K.

Criteria\Task		C1 (N=60)	C2 (N=60)	C3 (N=60)	P (N=38)
# of queries issued per search session	Mean	2.1	2.3	2.1	2.0
	SD	1.5	1.7	2.2	1.1
	Min	1	1	10	1
	Max	8	9	1	6
	Median	1.5	1	1	2
	Test Statistics Mean # of Queries H=0.38 p=0.9443	113.3	106.7	107.9	110.4
Query length per search session	Mean	4.8	5.0	4.8	4.3
	SD	5.0	3.7	3.9	2.3
	Median	3	4	4	4
	Min	3	2	3	2
	Max	18	18	28	12
	Test Statistics Mean Query Length H=9.33 p=0.0252	111.2	111.7	122.4	83.0
% of ineffective queries	Spelling Error	8.0	2.0	4.0	0
% medical queries		0	0	0	31.0
% of query operator		0	2.0	0	5.0
% queries without clicks		28.0	4.0	23.0	7.0
% queries re-issued		0	0	3.0	0
% Querying Assistance		0	0	0	0

Table 21 Querying Details for Medical Students

Table 22 provides medical students search results interaction activity. There is very little variation in the number of sub-links clicked, thus total values are provided for discussion. Mean values are used to discuss the number of results clicked. The most number of sub-links was clicked when searching for Task C2. The most number of unsuccessful search sessions was experienced and the most results refining assistance was utilised when searching for Task C3.

Criteria\Task		C1 (N=60)	C2 (N=60)	C3 (N=60)	P (N=38)
# of search results clicked per search session	Mean	1.3	1.5	1.3	1.2
	SD	1.0	0.6	0.7	0.4
	Median	1	2	1	1
	Min	1	1	1	1
	Max	3	4	3	2
# of sub-links clicked per search session	Total	5	9	4	1
% of usage Control-F (find)		2.0	0	3.0	0
% of participants clicked beyond the 1st results page		3.0	10.0	12.0	7.0
% unsuccessful search sessions		5.0	10.0	15.0	11.0
Refining Search Results Assistance					
% of usage Refine by Keyword		0	0	3.0	0

Table 22 Search Results Interaction Details for Medical Students

Table 23 provides total querying versus clicking behaviour and task completion time for medical students. A value of H=17.92, p=0.0005 is obtained for task completion time. The most amount of time is taken to complete Task C3 and the least amount time is taken to complete Task C1. The median task completion time for all pair-wise comparison is different except between Task C2-C3. In the next section, participants' perception of clarity of simulated situations is provided.

Criteria\Task		C1 (N=60)	C2 (N=60)	C3 (N=60)	P (N=38)
Total Querying versus Clicking Behaviour		79 vs 75	87 vs 85	64 vs 70	51 vs 50
Task Completion Time Per Search Session (mins)	Mean	2.3	4.5	3.2	3.2
	SD	1.4	3.2	1.9	1.9
	Median	2	4	3	3
	Min	1	1	1	1
	Max	7	15	15	15
	Test Statistics Mean Task Completion Time H=17.92 p=0.0005	80.3	121.1	122.0	117.5

Table 23 Total Querying versus Clicking Behaviour and Task Completion Time for Medical Students

4.3 Participants Perception of Clarity of Simulated Situations

All medical professionals had no issues in relation to clarity (understanding) the simulated situations provided. Three non-medical professionals expressed that the description provided in the simulated situation was not clear. Amongst reasons for this are: two non-medical professionals felt that simpler terms could be used to describe the simulated situations, one non-medical professional participant felt that the simulated situations could be written in a 'simpler style'. Five medical students expressed that the description provided in the simulated situations was not clear. Amongst reasons provided for this is because students 'have not studied the topic' or 'have not heard about a certain medical condition described in the task'. There is no co-relation amongst issues experienced in relation to a specific simulated situation. In general, participants did not have many issues to report in relation to clarity of simulated situations. Participants also did not express major issues in relation to understanding the simulated situation. As such un-clarity, poor understanding or construction of the simulated situations did not affect participant's information search behaviour, perception of task difficulty or topic familiarity. In the next section, participant's perception of task difficulty is provided.

4.4 Participants Perception of Task Difficulty

Participant's perception of task difficulty is presented in Table 24. A Chi-Square test is performed to determine if there is significant difference in relation to task difficulty amongst the three tasks (AX for non-medical professionals, BX for medical professionals and CX for medical students). Then, a standardised residuals test is performed thereafter. For non-medical professionals a value of x^2=23.43, p=0.0001 is obtained. The results of the standardised residuals test are used to determine significant difference in perception of task difficulty. Standardized residuals test results indicate non-medical professionals found Task A1 to be more difficult (r=2.19) in comparison to Task A2 and A3. Non-medical professionals also found Task A2 to be easier (r=2.78) in comparison to Task A1 and A3. For medical professionals a value of x^2 = 13.9, p=0.0076 is obtained. Results of the standardised residuals test indicate medical professionals found Task B3 to be easier (r=3.65) in comparison to Task B1 and B2. For medical students a value of x^2=13.9, p=0.0076 is obtained. Results of the standardised residuals test indicate medical students found Task C3 to be more difficult (r=2.1) in comparison to Task C1 and C2. Results obtained from the standardised residuals test are used to analyse search behaviour based on difficulty level. It is acknowledged that perception of task difficulty is based categorization of aggregated group perception rather than an individual's perception. This is done to capture the overall aggregated picture rather than a single individual's viewpoint which is bound to have variance and bias across individuals.

Task\Difficulty	Easy	Neutral	Difficult
A1	11	11	38
A2	32	12	16
A3	16	18	26
B1	10	21	29
B2	10	20	30
B3	33	10	17
C1	30	21	9
C2	19	31	10
C3	22	17	21

Table 24 Participants Perception of Task Difficulty (Note: Number denotes number of participants)

4.4.1 Analysis of Search Sessions Based on Task Difficulty – Non-Medical Professionals

The discussion for this section begins with search behaviour demonstrated when searching for an easy task. This is followed by a discussion of search behaviour demonstrated when searching on a difficult task.

<u>Easy</u>

When searching on an easy task non-medical professionals issued the most number of queries and the longest queries. The highest number of query operators, ineffective queries, queries without clicks and medical queries are also observed when searching on an easy task. When searching on an easy task non-medical professional's utilised the most amount of results refining assistance yet experienced the most number of unsuccessful search sessions. The highest task completion time is also observed when searching on an easy task. The querying versus clicking behaviour indicates an uneven pattern with more queries issued in comparison to results clicked when searching on an easy task.

An analysis on the use of medical terms in queries (medical query) found 75% of participants discovered medical queries as a result of thorough browsing and evaluation of returned results. These medical terms were found in pages and links in returned results. Once participants discovered the medical term, they continued to use the medical term through-out their search sessions. The remaining 25% of participants already knew the medical term based on previous search experience and knowledge. In the post experiment interview participants were asked what made them use medical terms in the query. Amongst answers provided are: participants felt the usage of medical terms would be more relevant in a medical based search, participants also thought medical terms would enable relevant or correct results to be obtained. Participants were able to demonstrate high cognitive ability (with the discovery and usage of medical terms) when searching on an easy task. This is because medical terms were also available in returned results pages when searching on other tasks (Task A1, A3 and P), however very few non-medical professionals discovered and used medical terms as part of their search sessions (1.0% for Task A1, 0% for Task A2 and 3.0% for Task P). While non-medical professionals issued the most number of queries when searching on an easy task, they did not rely on querying assistance. The post-experiment interview reveals that due to low task difficulty non-medical professionals were

capable and confident of issuing queries on their own without relying on querying assistance (even with high number of ineffective queries).

Non-medical professionals experienced the highest number of unsuccessful search sessions when searching on an easy task. The post-experiment interview reveals amongst reasons for participants to experience unsuccessful search sessions when searching on an easy task are: returned search results did not provide participants with sufficient information (50%), returned search results had too much unnecessary information which required participants to filter information (30%), returned search results required participants to click on too many links within the main page to obtain information (10%) and participants simply did not 'like' returned search results (10%). Non-medical professionals utilise results refining assistance when searching on an easy task to see if 'better' results could be obtained. However, the post-experiment interview reveals that the refining assistance was not able to provide much help. Furthermore non-medical professionals indicate that the refining assistance options provided was too basic. Results suggests that when searching on an easy task, participants are critical in determining suitability of results based on the way information is presented on the page and not just based on the content-value of a page. This indicates that besides the content-value of a page the manner in which the page is designed (too many links and the need to filter information) influenced participant's perception of suitability of results when searching on an easy task. There is also a need to provide better results refining assistance as non-medical professionals are dissatisfied with existing results refining features provided by *MedlinePlus*.

Non-medical professionals demonstrate high querying effort and issue medical queries when searching on an easy task, thus they demonstrate active technical query issuers search behaviour. They experienced the most number of unsuccessful search sessions, the most number of ineffective queries and took the longest time to complete searching on an easy task. These activities are categorised as slow and unproductive search behaviour. Non-medical professionals also demonstrate careful, thorough evaluation of results and used results refining assistance often, thus demonstrating critical results viewers search behaviour. Collectively, non-medical professionals searching on an easy task demonstrate unbalanced search behaviour. This is because while participants were active in issuing queries they were slow, unproductive and were critical when evaluating returned results.

Search Behaviour Name	Unbalanced		
Sub-Classification	Active Technical Query Issuers	Slow and Unproductive	Critical Results Viewers
Features	Most number of queries	Most unsuccessful search sessions	Most results refining assistance usage
	Longest queries	Most task completion time	Most queries without clicks
	Most query operators	Most ineffective queries	
	Most medical queries	Uneven querying versus clicking behaviour	

Table 25 Search Behaviour Demonstrated by Non-Medical Professionals When Searching on an Easy Task

Difficult

When searching on a difficult task, participants viewed results beyond the 1st page, re-issued queries and relied on querying assistance. Non-medical professionals report that they were not able to issue queries on their own (often re-issuing queries) and relied on querying assistance. Non-medical professionals also report that the querying assistance features were not helpful in reducing querying challenges experienced. Thus, they further experienced issues in locating relevant results. The post experiment interview reveals that participants were not able to determine relevance of returned results based on summary snippets and decided not to click on results links. Instead, non-medical professionals continued to view results beyond the 1st page in an effort to obtain relevant results. When searching on a difficult task participants were able to complete the search session successfully. The post-experiment interview reveals that while participants had trouble evaluating results, they ended search sessions successfully by selecting results 'they were able to comprehend'. The following verbal utterances were mentioned during the post experiment interview: 'i am not sure if these results are good', 'maybe there are better results', 'i don't know', 'i think this is okay'. (Note: 70% of non-medical professionals volunteered this information as it was not solicited as part of the post-experiment interview).

While non-medical professionals were able to successfully complete searching on a difficult task, they were not confident with the suitability of results (evidence from verbal utterance). This indicates that there is a need to provide participants with relevance indicators on a page in relation to the query entered by the searcher. Non-medical professionals demonstrate experiencing challenges when issuing queries thus this behaviour is named problematic query issuers. Non-medical professionals demonstrate viewing results beyond the 1st page, hence this

search behaviour is named active results viewers. Collectively, non-medical professionals searching on a difficult task demonstrate motivated search behaviour when searching on a difficult task. This is because while participants re-issued queries often and had to utilise querying assistance they still continued to view results beyond the 1st page.

Search Behaviour Name	Motivated	
Sub-Classification	Problematic Query Issuers	Active Results Viewers
Features	Most query re-issues	Most viewing results beyond the 1st page
	Most usage of querying assistance	

Table 26 Search Behaviour Demonstrated by Non-Medical Professionals When Searching on a Difficult Task

From an overall perspective search sessions from the personal task appear similar to the search sessions from the simulated situations (with the exception of no usage of query operators, viewing results beyond the 1st page and usage of results refining assistance in the personal task). Hence search sessions demonstrated when searching for the simulated situations are a representation of non-medical professionals 'real' search behaviour.

Results in Table 15, Section 4.2.1 show when searching on an easy task non-medical professionals utilise the most results refining assistance yet experienced the most number of unsuccessful search sessions. While participants were not satisfied with search results presented in the 1st page very few actually viewed results beyond the 1st result page. Non-medical professionals used results refining assistance to ensure that 'better' results will be made available on the 1st page. Even when no relevant results were available on the 1st page (even after results refining activities) participants did not review results beyond the 1st result page. The post-experiment interview reveals that participants either felt that it was not necessary to do so or they decided that they did not to view more results. The following feedback was obtained from the post-experiment interview as to why participants did not want to view results beyond the 1st page: "I don't think anything better is available", "I have done some filtering already so I doubt I will get more than this" and "I don't think I need to look any further", "I do not want to see any more results".

Non-medical professionals expect relevant results to be provided on the 1st result page as a result of their high querying effort. Results of previous research studies indicate the increase in task difficulty reduces a user's ability to locate all required information for a task. Users also relied on the search engine to perform automatic search assistance when searching on a difficult task (Bystrom and Javerlin, 1995). Results of this research study do not support results of previous research studies (Bystrom and Javerlin, 1995). This is because Bystrom and Javerlin (1995) state the increase in task difficulty reduces a user's ability to locate all required information for a task.

When searching on an easy task, non-medical professionals are more critical when evaluating returned search results. They also require summary snippets to provide them with sufficient information to decide if they should click on a link or not. Results in Tables 15 and 17, Section 4.2.1 indicate participants demonstrated high querying effort and spent the most amount of time to complete searching on an easy task. High querying effort performed by non-medical professionals was not always productive as participants experienced the most number of ineffective queries. This resulted in an uneven querying versus clicking behaviour demonstrated by non-medical professionals when searching on an easy task. Nevertheless, due to low task difficulty non-medical professionals were motivated to search on an easy task. Results of this research study do not support results of previous research studies (Vakkari, 1999, Gwizdka and Spence, 2006 and Liu et al. 2010). All three research studies (Vakkari, 1999, Gwizdka and Spence, 2006 and Liu et al. 2010) indicate similar findings. Vakkari (1999) states there are a relationship of factors that can be used to determine task difficulty. In 2006, Gwizdka and Spence (2006) state high search effort, low navigational speed and low search efficiency are good predictors to indicate that a user is searching on a difficult task. Liu et al. (2010) state high task completion time, issuing more queries and viewing more results are indicators of when a participant is searching on a difficult task. In addition, results in Table 25 indicate the most number of queries and the most number of query operators are issued when searching for an easy task. Results of this research study are dissimilar to results of previous research studies (Brystom, 2002 and Aula, Khan and Guan, 2010). This is because Brystom (2002) states as task difficulty increases users issue more queries and Aula, Khan and Guan (2010) state most query operators are issued when searching on a difficult task.

Participants experience issues in relation to query expression and evaluating returned results when searching on a difficult task. This indicates that when searching on a difficult task, participants require better querying assistance. While non-medical professionals were able to complete searching on a difficult task successfully they were not confident with the suitability of returned results. This indicates that there is a need to provide relevance indicators on results page to determine suitability of returned results when searching on a difficult task. Results of this research study indicate when searching across varying levels of task difficulty search behaviour demonstrated by non-medical professionals is dissimilar to non-medical based searching.

4.4.2 Analysis of Search Sessions Based on Task Difficulty – Medical Professionals

When searching on an easy task, medical professionals issued the highest number of queries, shortest queries, issued the most number of query operators, ineffective queries and queries without clicks but issued the least number of medical queries. Medical professionals also relied on querying assistance the most when searching on an easy task. Medical professionals performed high results viewing activity when searching on an easy task. Medical professionals also performed more interactions on the results page (Control-F Find) and viewed results beyond the 1st page. However, all these activities did not translate into a productive search session (the most number of unsuccessful search sessions). In addition, the querying versus clicking behaviour when searching on an easy task was uneven. More queries were issued in comparison to results clicked. The post experiment interview reveals medical professionals were unhappy with returned results because they were dissatisfied with information. This is because the page did not provide necessary information. Medical professionals demonstrate critical results evaluation activity. The post-experiment interview indicates that non-medical professional's perception of relevance of a page is evaluated based on the depth of content on the page. The post-experiment interview reveals that medical professionals did not issue medical terms in their search sessions because: medical terms were not necessary for this task and there were no medical terms that could be used to search for this scenario.

Analysis of observation logs indicates medical professionals demonstrate two types of high level search behaviour when searching on an easy task. The first type of sub-classification of search behaviour demonstrated is known as short and active query issuers. This is because medical professionals issued the most number of queries, most query operators and issued the shortest

queries when searching on an easy task. Collectively this search behaviour is named simple. This is because search behaviour demonstrated was quite basic. The second type of sub-classification of search behaviour demonstrated is known as unproductive but active results locaters. This is because medical professionals issued the most number of ineffective queries, used the most querying assistance, demonstrated uneven querying versus clicking behaviour, issued the most queries without clicks, issued the least number of medical queries and experienced the most number of unsuccessful search sessions. These activities were unproductive. On the other hand, medical professionals interacted on the results page and viewed results beyond the 1st page (active results locaters). Overall, this search behaviour is named tryer. This is because while medical professionals were experiencing issues in relation to issuing queries (most ineffective queries, most queries without clicks, uneven querying versus clicking behaviour) and demonstrate unproductive search behaviour (most number of unsuccessful search sessions), this did not stop medical professionals from viewing results beyond the 1st page and interacting on the results page. Hence, while experiencing difficulties medical professionals did not easily give up on the search. Descriptions for the two categories of search behaviour for medical professionals when searching on an easy task are provided in Table 27.

Search Behaviour Name	Simple	Tryer
Sub-Classification	Short and Active Query Issuers	Unproductive but Active Results Locaters
Features	Most number of queries	Most ineffective queries
	Shortest queries	Most querying assistance usage
	Most query operators	Most interaction on the results page
		Most viewing results beyond the 1st page
		Least medical queries
		Most queries without clicks
		Most unsuccessful search sessions
		Uneven querying versus clicking behaviour

Table 27 Search Behaviour Demonstrated by Medical Professionals When Searching on an Easy Task

Results in Table 19, Section 4.2.2 indicate, medical professionals experienced the most number of unsuccessful search sessions when searching on an easy task. Results of previous research studies indicate more search effort and time is spent when searching on a difficult task (Liu et al. 2010). Results in Table 20, Section 4.2.2 indicate task completion time is not influenced by task

difficulty. Results of this research study are dissimilar to results of previous research studies (Bystrom and Javerlin, 1995 and Eastman and Jansen, 2003). Bystrom and Javerlin (1995) state as task difficulty increases users find it difficult to obtain relevant results and relied on search assistance. Previous research studies indicate users relied on the search engine to perform automatic search assistance when searching on a difficult task (Bystrom and Javerlin, 1995 and Eastman and Jansen, 2003).

Results in Table 18, Section 4.2.2 indicate querying assistance is used the most when searching on an easy task. Querying assistance is used to obtain possible query suggestions. While medical professionals are considered domain experts and have high medical expertise, they relied on querying assistance when searching on an easy task. While there are two categories of search behaviour demonstrated (Table 27) search behaviour descriptions for both these categories are dissimilar to results of previous research studies (Vakkari, 1999, Gwizdka and Spence, 2006 Bystrom and Javerlin, 1995 and Eastman and Jansen, 2003). This indicates that medical professionals do not demonstrate similar search behaviour when searching on an easy task in comparison to non-medical based searching.   Results of this research study also show that medical professionals who demonstrate simple search behaviour issue the most number of queries and query operators when searching on an easy task (Table 27). Medical professionals who demonstrate the tryer search behaviour when searching on an easy task view results beyond the 1st page (Table 27). Results of this research study do not support results of previous research studies (Brystom, 2002), Aula, Khan and Guan, 2010 and Li and Belkin, 2008). Both these research studies (Brystom, 2002 and Aula, Khan and Guan, 2010) state the most number of queries and query operators are issued when searching on a difficult task whilst, the research study conducted by Li and Belkin (2008) state more sources are viewed when searching on a difficult task.

Participants who demonstrate simple search behaviour do not require any specific information retrieval strategies as existing techniques provided by *MedlinePlus* is able to support their search session. Participants who demonstrate tryer search behaviour require specific information retrieval strategies to increase search efficacy. While medical professionals demonstrate unproductive search behaviour (ineffective queries, usage of querying assistance, queries without clicks, unsuccessful search sessions and uneven querying versus clicking behaviour) this did not

stop them from performing active search interactions on the results page (usage of Control-F Find and continued to view results beyond the 1st page). The post-experiment interview reveals medical professionals are more concerned with locating results and not troubled by the querying challenges experienced. This indicates while medical professionals were experiencing challenges while issuing query, they were motivated to locate results.

Medical professionals demonstrate high querying activity and view results beyond the 1st page, but did not click on result links. The post-experiment interview indicates that medical professionals evaluate the relevance of a link based on summary snippets only. Information retrieval strategies have to design better results summary snippets to attract more clicks to result links. Encouraging more clicks to returned results will increase the chances of obtaining results (as opposed to only viewing summary snippets). The post-experiment interview reveals the high usage of querying assistance did not assist medical professionals at arriving at relevant results. This is because medical professionals found querying assistance unhelpful in providing alternative queries. This indicates medical professionals require better assisting features when searching on an easy task. The high number of ineffective queries experienced when searching on an easy task also indicates better assisting features is necessary.

4.4.3 Analysis of Search Sessions Based on Task Difficulty – Medical Students

When searching on a difficult task medical students issued the longest queries and took the most amount of time to complete the task. They demonstrate high usage of results refining activities and experienced the most number of unsuccessful search sessions. They also viewed results beyond the 1st results page. Search behaviour demonstrated when searching on the personal task is similar to search behaviour demonstrated when searching on the simulated situations (with the exception of medical queries being issued on the personal task).

Hence, search sessions demonstrated when searching for the simulated situations are a representation of medical students 'real' search behaviour. Table 28 provides a representation of search behaviour demonstrated by medical students when searching on a difficult task. The sub-classification of search behaviour demonstrated by medical students when searching on a difficult task is known as active results locaters and long query issuers (viewing results beyond the 1st page, using the most results refining activities and issuing the longest queries), slow (most task completion time) and unproductive (experiencing the highest number of unsuccessful search

sessions). Collectively, the search behaviour demonstrated by medical students when searching on a difficult task is known as novice. This is because while dynamic querying activity is observed, the time taken to complete the task was slow and the search outcome was unproductive.

Search Behaviour Name	Novice	
Sub-Classification	Active Results Locaters and Long Query Issuers	Slow and Unproductive
Features	Longest queries	Most task completion time
	Most viewing results beyond the 1st page	Most unsuccessful search sessions
	Most results refining activities	

Table 28 Search Behaviour Demonstrated by Medical Students When Searching on a Difficult Task

Results of this research study finds medical students utilise results refining assistance most often when searching on a difficult task. Medical students took the longest time to complete searching on a difficult task but did not issue the most number of queries when searching on a difficult task. Instead, medical students spent more time viewing results beyond the 1st page. Medical students also experienced many unsuccessful search sessions when searching on a difficult task. Liu et al. (2010) state high task completion time, issuing the most number of queries and viewing more results are indicators of when a participant is searching on a difficult task. Bystrom and Javerlin (1995) indicate more search assistance is utilised when searching on a difficult task. Li and Belkin (2008) state more sources are viewed when searching on a difficult task. Based on results in Table 21, 22 and 23, Section 4.2.3 search behaviour demonstrated by medical students when searching on a difficult task demonstrate similarities (Liu et al. 2010 – longest time, Vakkari, 1999 Gwizdka and Spence, 2006 – low search efficacy, Bystrom and Javerlin, 1995 – more search assistance and Li and Belkin, 2008 – viewing more sources) with results of previous research studies. As such when searching on a difficult medical task, medical students demonstrate similar search behaviour in comparison to when searching on a difficult non-medical task.

The post-experiment interview revealed medical students experienced many unsuccessful search sessions because they were unsure of the relevance of returned results. Medical students took the

most amount of time and issued the longest queries when searching on a difficult task. Medical students did not click on returned results often but they did view results beyond the 1st page and use the most results refining assistance. Medical students reveal that they experience issues expressing queries and in determining suitability of returned results. While medical students experienced issues in relation to issuing queries they did not rely on querying assistance. No specific explanation is provided as to why medical students did not utilise querying assistance. Medical students viewed results beyond the 1st page, used results refining assistance often but did not click on result links. This indicates medical students evaluate returned results based on summary snippets only. The post-experiment interview reveals that medical students also experienced issues in determining the suitability of returned results as they had to use results refining assistance often. Unfortunately, usage of results refining assistance was not helpful because medical students felt that the results refining assistance was not providing them with streamlined results. While the querying versus clicking behaviour was even, the high task completion time indicates medical students spent more time viewing results (viewing results beyond the 1st page but not issuing queries or clicking on result links). This indicates that there is a need to provide medical students with better querying assistance. In addition, providing some indication on the relevance of returned results will encourage medical students to click on more results. This will help to increase the number of results clicks in an effort to reduce the number of unsuccessful search sessions.

4.5. Summary – The Affects of Task Difficulty on Search Sessions

Non-medical professionals are not considered domain experts nor do they have high medical knowledge. Medical professionals are participants who have high medical knowledge and are considered domain experts. On the other hand, medical students are not yet considered domain experts nor have they acquired high domain knowledge. While participants of this research study (non-medical professionals, medical professionals and medical students) do not fit into the same category based on domain expertise and medical knowledge, it is possible that a non-medical professional may find searching for a medical task easy. This indicates the general notion of non-medical experts do not find searching for a medical task to be easy is not an accurate depiction.

Non-medical professionals and medical professionals demonstrate dissimilar search behaviour when searching on a task of similar level of difficulty. When searching on an easy task non-

medical professionals demonstrate unbalanced search behaviour. Medical professionals demonstrate two high level categories of search behaviour, simple and tryer search behaviour when searching on an easy task. Non-medical professionals searching on a difficult task demonstrate the motivated search behaviour. However, there are some similarities in sub-classification of search features amongst typical medical searchers. These similarities are more pronounced amongst non-medical professionals and medical professionals when searching on an easy task. Similarities are less pronounced amongst non-medical professionals and medical students when searching on a difficult task. For example, when searching on an easy task, non-medical professionals and medical professionals demonstrate the following similar features: issuing the most number of queries, most number of query operators, most ineffective queries, experiencing the most unsuccessful search sessions and demonstrating uneven querying versus clicking behaviour. When searching on a difficult task, non-medical professionals and medical students demonstrate viewing results beyond the 1st page.

While similar features are observed when searching on a similar level of task difficulty, the reason/s for demonstrating these features are for different rationale. For example, non-medical professionals experienced the most number of unsuccessful search sessions when searching on an easy task because returned search results did not provide participants with sufficient information (50%), returned search results had too much unnecessary information which required participants to filter information (30%), returned search results required participants to click on too many links within the main page to obtain information (10%) and participants simply did not 'like' returned search results (10%). On the other hand, medical professionals experienced the most number of unsuccessful search sessions when searching on an easy task because the relevance of a page is evaluated based on the depth of content on a page. Thus, classification of search behaviour based on task difficulty without taking into account the identity of the searcher may not provide an accurate account of search level difficulty. General classifications of typology of search behaviour (without taking into account the identity of searcher) would further result in an inaccurate information retrieval strategy provided to a medical searcher.

Results of this research study finds search behaviour demonstrated by non-medical professionals (Tables 25 and 25, Section 4.4.1) and medical professionals (Table 27, Section 4.4.2) are

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dissimilar in relation to results of previous research studies based on task difficulty (Liu et al. 2010, Aula, Khan and Guan, 2010, Li and Belkin 2008, Gwizdka and Spence, 2006, Brystom 2002, Vakkari, 1999 and Bystrom and Javerlin, 1995). However, search behaviour demonstrated by medical students (Table 28, Section 4.4.3) is similar in relation to results of previous research studies (Liu et al. 2010, Li and Belkin, 2008, Gwizdka and Spence, 2006, Vakkari, 1999 and Bystrom and Javerlin, 1995). This indicates that there is a need to develop new behaviour profiles based on description of search behaviour when searching across varying levels of task difficulty for non-medical professionals and medical professionals.

Non-medical professionals demonstrate active querying behaviour but they are critical when evaluating returned results and are unproductive (high number of unsuccessful search sessions) when searching on an easy task. When searching on a difficult task, non-medical professionals demonstrate viewing results beyond the 1st page to see if relevant results could be obtained. This indicates that non-medical professionals require better design of results summary snippets, a well-designed results page, better querying and results refining assistance and relevance indication to experience a productive search session. Medical professionals who demonstrate tryer search behaviour when searching on an easy task issued the most number of ineffective queries and viewed results beyond the 1st page. This indicates medical professionals require better querying and results refining assistance as well as better presentation of summary snippets. Medical students demonstrate novice search behaviour when searching on a difficult task (most number of unsuccessful search sessions, viewing results beyond the 1st page and used the most results refining assistance). This indicates medical students require better querying and results refining assistance and relevance indication of returned results. In the next section, results based on topic familiarity are presented and discussed.

4.6 Participants Perception of Topic Familiarity

Participant's perception of topic familiarity is presented in Table 29. A Chi-Square test is performed to determine if there is significant difference in relation to topic familiarity amongst the three simulated situations (AX for non-medical professionals, BX for medical professionals and CX for medical students). A standardised residuals test is performed thereafter. For non-medical professionals a value of x^2=37.27, p<0.001 is obtained. For medical professionals a value of x^2=18.97, p=0.0008 is obtained and for medicals students a value of x^2=14.51, p=0.0058

is obtained. Results of the standardised residuals test are used to determine significant difference in perception of topic familiarity. Standardized residuals results indicate non-medical professionals are more likely to be unfamiliar with Task A2 (r=4.26) in comparison to Task A1 and A3. Medical professionals are more likely to be unfamiliar with Task B2 (r=2.18) in comparison to Task B1 and B3 and medical students are more likely to be somewhat familiar with Task C1 (r=2.35) in comparison to Task C2 and C3. It is acknowledged that perception of task difficulty is based on categorization of aggregated group perception rather than an individual's perception. This is done to capture the overall aggregated picture rather than a single individual's viewpoint which is bound to have variance and bias across individuals. Results from the standardised residuals test are used to perform analysis on search sessions based on topic familiarity.

Task\Topic Familiarity	Familiar	Somewhat Familiar	Not Familiar
A1	36	16	8
A2	21	8	31
A3	35	20	5
B1	55	2	3
B2	40	0	20
B3	44	1	15
C1	23	25	12
C2	40	10	10
C3	32	12	16

Table 29 Participants Perception of Topic Familiarity (Note: Number denotes number of participants)

4.6.1 Analysis of Search Sessions Based on Topic Familiarity – Non-Medical Professionals

Non-medical professionals demonstrate high querying effort when searching on an unfamiliar topic (most number of queries, longest queries, highest usage of query operators and medical queries). They also demonstrate highest usage of results refining assistance. Unfortunately, these active search behaviour interactions were not productive as non-medical professionals experienced many unsuccessful search sessions, took the most amount of time to complete searching on the topic and demonstrate uneven querying versus clicking behaviour when searching on an unfamiliar topic. Non-medical professionals demonstrate active technical query

issuers. This is because of the most number of medical queries issued, longest queries, most number of queries and most usage of query operators. They also demonstrate active results refiners behaviour with the usage of the most results refining activity but were slow (most task completion time) and unproductive (uneven querying versus clicking behaviour and the most number of unsuccessful search sessions). Collectively, search behaviour demonstrated by non-medical professionals when searching on an unfamiliar topic is named as comfortable. This is because while non-medical professionals took the longest time and experienced the most number of unsuccessful search sessions, they demonstrated technical and active querying behaviour and results refining search behaviour. Table 30 provides a representation of search behaviour demonstrated by non-medical professionals when searching on an unfamiliar topic.

Search Behaviour Name	Comfortable	
Sub-Classification	Technical and Active Query Issuers and Results Refiners	Slow and Unproductive
Features	Longest queries and most queries	Most task completion time
	Most query operators and medical queries	Most unsuccessful search sessions
	Most search results refining assistance usage	Uneven querying versus clicking

Table 30 Search Behaviour Demonstrated by Non-Medical Professionals When Searching on an Unfamiliar Topic

Results in Table 16, Section 4.2.1 indicate the most number of unsuccessful search sessions are experienced when searching on an unfamiliar topic. Results of this research study supports results of previous research studies in relation to the inability to locate results when searching on an unfamiliar topic (Allen 1991, Hsieh-Yee,1999, Hoelsher and Strube, 2000 and Bhavnani, 2002). Non-medical professionals were able to issue medical queries when searching on an unfamiliar topic. This behaviour is dissimilar to results of previous of research studies (Allen, 1991, Alia et al. 2008 and Vakkari, 2003). Non-medical professionals issued the longest queries and the most number of queries when searching on an unfamiliar topic. This behaviour is also dissimilar to results of previous research studies (Alia et al. 2008 and Zhang et al. 2005). As such, search behaviour demonstrated by non-medical professionals is dissimilar to results of previous research studies (Table 3, Section 2.5 - with the exception of the high number of unsuccessful search sessions).

When searching on an unfamiliar topic, non-medical professionals demonstrate high querying and results refining activity, but these activities did not translate into a productive search session. Amongst reasons as to why non-medical professionals were dissatisfied with returned results is because: returned results were difficult to comprehend (30%) and returned results had too many links and too much information (45%). Other participants were not able to provide specific reasons as to why they were dissatisfied with returned results (25%). The post-experiment interview reveals non-medical professionals were dissatisfied with results refining assistance because they found them too basic and unhelpful. The most number of medical queries are issued when searching on an unfamiliar topic. The observation logs indicate that non-medical professionals were able to issue medical terms in a query because they discovered the medical term based on thorough evaluation of content on the results page.

While unfamiliar with the topic, non-medical professionals were able to demonstrate high cognitive ability with the discovery of medical terms. Medical terms were also available on returned results when searching for Task A1, A3 and P. However, very few non-medical professionals discovered these medical terms when searching for Task A1, A3 and P (Table 15, Section 4.2.1). These medical terms were then used in subsequent search sessions in an effort to obtain relevant results. Non-medical professionals were motivated to search on an unfamiliar topic. The post-experiment interview reveals non-medical professionals did not experience any challenges in issuing queries when searching on an unfamiliar topic. This is exhibited by the high querying activities and the ability to issue medical term queries.

They also utilised the most results refining assistance (although dissatisfied with the performance of the results refining assistance) and spent the most amount of time when searching on an unfamiliar topic. However, they were not able to complete searching on an unfamiliar topic successfully (the most number of unsuccessful search sessions). This indicates information retrieval strategies have to develop methods to reduce querying effort, improve results refining assistance, increase results clicking activities and reduce task completion time for non-medical professionals when searching on an unfamiliar topic.

4.6.2 Analysis of Search Sessions Based on Topic Familiarity – Medical Professionals

Medical professionals issued the least number of queries, longest queries and experienced the least number of ineffective queries when searching on an unfamiliar topic. They also clicked on

the most number of search results, experienced the least number of queries without clicks and the least number of unsuccessful search sessions. The search behaviour demonstrated by medical professionals was productive because they experienced successful search sessions in the shortest time. Although unfamiliar with the topic, medical professionals were active results clickers and effective query issuers. Search behaviour demonstrated by medical professionals when searching on an unfamiliar topic is named fruitful query issuers. This is because of the least number of queries, longest queries and least number of ineffective queries issued. Medical professionals demonstrate active results clickers behaviour by clicking on the most number of search results and issuing the least number of queries without clicks. Medical professionals also demonstrate productive search behaviour because they experienced the least number of unsuccessful search sessions. Collectively, the search behaviour demonstrated by medical professionals when searching on an unfamiliar topic is known as expert. Description of search behaviour demonstrated by medical professionals when searching on an unfamiliar topic is provided in Table 31. This is because search behaviour demonstrated did not exhibit any indication of wasteful activities.

Search Behaviour Name	Expert		
Sub-Classification	Fruitful Query Issuers	Active Results Clickers	Productive
Features	Least number of queries	Most search results clicked	Most successful search sessions
	Longest queries	Least queries without clicks	
	Least number of ineffective queries		

Table 31 Search Behaviour Demonstrated by Medical Professionals When Searching on an Unfamiliar Topic

Results in Table 18 and 19, Section 4.2.2 show medical professionals issued the least number of queries and clicked on the most number of returned results when searching on an familiar topic. In relation to medical based searching, results of previous research studies indicate biomedical experts issue the least number of queries when searching on a familiar topic and results clicking activity was not significant based on topic familiarity (Karimi et al. 2011). This indicates when searching on an unfamiliar topic, search behaviour for medical information searching and bio-medical information is dissimilar. In relation to non-medical based searching, medical

professionals demonstrate dissimilar search behaviour based on topic familiarity. Results of previous research studies indicate the longest queries were issued (Alia et al. 2008) and more successful search sessions were experience (Allen, 1991 and Cole et al. 2010) when searching on a familiar topic. Results of this research study do not support results of previous research studies (Karimi et al. 2011, Allen, 1991, Cole et al. 2010 and Alia et al. 2008).

Medical professionals demonstrate expert search behaviour when searching on an unfamiliar topic. As such, it is unnecessary to provide medical professionals with specific information retrieval strategies when searching on an unfamiliar topic. Existing methods on *MedlinePlus* are able to support the search sessions of medical professionals when searching on an unfamiliar topic. Medical professionals were able to demonstrate high search efficacy when searching on an unfamiliar topic.

4.6.3 Analysis of Search Sessions Based on Topic Familiarity – Medical Students

Medical students issued the most number of ineffective queries and experienced the least number of unsuccessful search sessions when searching on a somewhat familiar topic. They also issued the most number of queries without clicks and ineffective queries, but took the least time amount of time to complete searching on a somewhat familiar topic. This indicates medical students experience issues in relation to issuing effective queries. They also demonstrate low results clicking activity (most queries without clicks) when searching on a somewhat familiar topic. The post-experiment interview reveals medical students evaluate the relevance of returned results based on reading summary snippets. Search behaviour demonstrated by medical students when searching on a somewhat familiar topic is fast and productive (least task completion time and the most number of successful search sessions) but problematic query issuers (most number of ineffective queries) and fussy result clickers (most queries without clicks). Description of search behaviour demonstrated when searching on a somewhat familiar topic is provided in Table 32. Collectively this search behaviour is named uncertain. This is because while medical students were fast and productive they experience issues in relation to issuing queries and were unable to decide on the relevance of results.

Search Behaviour Name	Uncertain		
Sub-Classification	Fast and Productive	Problematic Query Issuers	Fussy Result Clickers
Features	Least task completion time	Most ineffective queries	Most queries without clicks
	Most successful search sessions		

Table 32 Search Behaviour Demonstrated By Medical Students When Searching on a Somewhat Familiar Topic

Results of previous research studies focus on search behaviour demonstrated when searching on a familiar and unfamiliar topic. There is limited amount of information on search behaviour demonstrated when searching on a somewhat familiar topic. Thus, search behaviour demonstrated by medical students when searching on a somewhat familiar topic is compared against results of previous research studies when searching on a familiar or unfamiliar topic (non-medical based searching). Results of this research study indicate search behaviour demonstrated when searching on a somewhat familiar topic (Table 32) is dissimilar to results of previous research studies (Table 3, Section 2.5).

Medical students were fast and productive in their search sessions but issued many ineffective queries and experienced many queries without clicks. As such information retrieval strategies have to implement better querying assistance techniques to reduce the number of ineffective queries experienced by medical students. Similarly, there is a need to provide relevance indication of returned results so that medical students will experience less number of queries without clicks. While medical students experienced the most number of successful search sessions when searching on a somewhat familiar topic there is a need for information retrieval strategies to increase search efficacy (reduce the number of ineffective queries and queries without clicks). One method to increase search efficacy is by providing query suggestions and designing better presentation of results summary snippets.

4.7 Summary – The Affects of Topic Familiarity on Search Sessions

Non-medical professionals, medical professionals and medical students are of different backgrounds (domain expertise, knowledge and search experience) and have different perceptions of topic familiarity. Non-medical professionals and medical professionals demonstrate dissimilar search behaviour when searching on a similar topic familiarity level. Non-medical professionals demonstrate comfortable search behaviour when searching on an

unfamiliar topic. On the other hand, medical professionals demonstrate expert search behaviour when searching on an unfamiliar topic. While both non-medical professionals and medical professionals were unfamiliar with a topic the search behaviour demonstrated by medical professionals does not require any specific information retrieval strategies. This is because medical professionals demonstrate high search efficacy when searching on an unfamiliar topic. While non-medical professionals demonstrate comfortable search behaviour there are search activities within the sub-classification of this search behaviour (unproductive) which requires the development of specific information retrieval strategies

There is a need to provide non-medical professionals with specific information retrieval strategies to reduce unproductive search behaviour (unsuccessful search sessions). Medical students demonstrate uncertain search behaviour when searching on a somewhat familiar topic. This means there is a need to provide medical students with specific information retrieval strategies to reduce wasteful search activities (minimise querying issues and encourage more result clicks). Non-medical professionals, medical professionals and medical students demonstrate a uniform search behaviour when searching across varying levels of topic familiarity. There are no similarities within the sub-classification of search features amongst non-medical professionals, medical professionals and medical students when searching across varying levels of topic familiarity. As such, identification methods are not necessary when searching across varying levels of topic familiarity.

Results of this research study indicate that there is a need to develop new behaviour profiles based on description of search behaviour when searching across varying levels of topic familiarity for medical based searches. Without this new search behaviour profiles medical information retrieval strategies will not be able to infer search behaviour demonstrated. This will result in the provision of an inappropriate information retrieval strategy to the searcher. As a result a medical searcher experiences reduced search satisfaction. In the next section, demographic influence on search behaviour based on task difficulty and topic familiarity are provided.

4.8 Demographic Influence on Search Behaviour

In this section, search behaviour demonstrated when searching across varying levels of task difficulty and topic familiarity is discussed in relation to demographic influence. This is to allow for an understanding of what type of demographic variables influence the search behaviour of typical medical searchers (non-medical professionals, medical professionals, medical students) when searching across varying levels of task difficulty and topic familiarity. Demographic variables obtained from the pre-experiment interview are used to provide linkage between the searcher and search behaviour demonstrated when searching across varying levels of task difficulty and topic familiarity. For detailed analysis medical professionals were separated into two categories: medical professionals pursuing post-graduate education (specialist in training) and medical professionals not pursuing post-graduate education (medical officers) – Table 10, Section 4.1.2. None of the medical professionals who participated in this research study are specialist.

In the next section, demographic influence on search behaviour when searching across varying levels of task difficulty for non-medical professionals, medical professionals and medical students are provided. This is followed by a scrutiny of demographic influence for search behaviour when searching across varying levels of topic familiarity.

Participants are first separated into clusters depending on the perception of task difficulty and topic familiarity. Then, an Anova test is conducted to determine significant demographic variables that influence search behaviour. Thereafter depending on the number of clusters obtained, a T-test or Bonferroni test is conducted to determine significant difference amongst clusters. A summary is provided after each section (task difficulty/topic familiarity).

4.8.1 Demographic Influence on Search Behaviour Based on Task Difficulty

In this section, demographic influence on search behaviour when searching across varying levels of task difficulty is provided for non-medical professionals, medical professionals and medical students. Demographic influence for non-medical professionals, medical professionals and medical students are analysed in relation to results of the Chi-Square and standardised residuals test (Table 24, Section 4.4).

4.8.1.1 Non-Medical Professionals Task Difficulty – Easy

Thirty two participants perceived searching for Task A2 as easy and the rest found searching for Task A2 as neither easy, neutral nor difficult (neither). As such participants were manually separated into two clusters (Table 24, Section 4.4). Participants in Cluster 1 consisted of participants who found searching for Task A2 easy and participants in Cluster 2 consisted of participants who found searching for Task A2 as neither. Results of the Anova and T-test are provided in Table 33.

Demographic Influence	Anova Test Results	T-test Results
Age	F=9.43, p=0.003	T=3.05, p=0.003
Occupation (O)	F=6.33, p=0.015	T=2.51, p=0.0015
General Search Experience (GSE)	F=7.94, p=0.007	T=2.82, p=0.007

Table 33 Demographic Influence on Search Behaviour for Non-Medical Professionals

Results in Table 33 indicate similar demographic variables influence search behaviour for the two clusters. Age, occupation (O) and general search experience (GSE) are demographic variables that significantly influence search behaviour when searching across varying levels of task difficulty. Further details of these demographic influences for the two clusters are provided in Table 34 (Note: SD=standard deviation).

Demographic Influence/Cluster		Cluster 1 [Easy]	Cluster 2 [Neither]
GSE (years)	Mean	18.1	9.2
	SD	3.6	4.5
O (%)	Student	35.0	65.0
	Administrator	50.0	50.0
	Academic	65.0	35.0
	Manager	32.3	67.8
	Engineer	50.0	50.0
	IT Analyst	0	100
Age (years)	Mean	30.0	39.8
	SD	10.3	9.6

Table 34 Details of Demographic Influence on Search Behaviour for Non-Medical Professionals

When searching on an easy task, participants involved in the academic field with an average age of 30 and an average general search experience of 18.1 years demonstrate unbalanced search behaviour.

4.8.1.2 Non-Medical Professionals Task Difficulty – Difficult

Thirty eight participants perceived searching for Task A1 as difficult and the rest found searching for Task A1 as neither easy, neutral nor difficult (neither) – Table 24, Section 4.4. As such participants were manually separated into two clusters. Participants in Cluster 1 consist of participants who found Task A1 difficult and participants in Cluster 2 consist of participants who found Task A1 as neither. Results of the Anova test indicate similar demographic variables influence the search behaviour of participants in both clusters. Results of the Anova and T-test are provided in Table 35. Further details on the demographic influence of the two clusters are provided in Table 36.

Demographic Influence	Anova Test Results	T-test Results
General Search Experience (GSE)	F=6.63, p=0.0013	T=2.63, p=0.011
Occupation (O)	F=6.23, p=0.015	T=2.04, p=0.0015
Age	F=14.34, p=0.000	T=3.78, p=0.000

Table 35 Demographic Influence on Search Behaviour for Non-Medical Professionals

Demographic Influence/Cluster		Cluster 1 [Difficult]	Cluster 2 [Neither]
GSE (years)	Mean	8.9	4.8
	SD	6.8	2.0
O (%)	Student	46.8	53.2
	Manager	34.3	65.7
	IT Analyst	100	0
	Engineer	3.1	96.9
	Academic	6.25	93.7
	Mean	35.1	22.3
Age (years)	SD	9.1	11.4

Table 36 Details of Demographic Influence on Search Behaviour for Non-Medical Professionals

Older (mean age = 35.1 years) and more experienced general searchers (mean = 8.9 years) from the information technology field demonstrate motivated search behaviour when searching on a difficult task.

4.8.1.3 Medical Professionals Task Difficulty – Easy

Thirty three participants perceive searching for Task B3 as easy. When searching on an easy task there were two categories of search behaviour demonstrated by medical professionals. Twenty one participants demonstrate simple search behaviour while twelve participants demonstrate tryer search behaviour (Table 24, Section 4.4). As such medical professionals were manually separated into three clusters. The first cluster consists of participants who demonstrate simple search behaviour and the second cluster are participants who demonstrate tryer search behaviour. The third cluster is for participants who found searching for Task B3 as neither easy, neutral nor difficult (neither). The Anova test results indicate similar demographic variables influence the search behaviour of participants for all three clusters. Results of the Anova and Bonferroni test are provided in Table 37. Further details of the demographic variables for the three clusters are provided in Table 38. (Note: PPG – pursuing post-graduate education, NPG-not pursuing post-graduate education).

Demographic Influence	Anova Test Results	Bonferroni Test Results (Significant Difference Amongst Clusters)
Medical Search Experience (MSE)	F=8.02, p=0.001	All pair-wise comparison at p<0.05
Education Type (ET)	F=13.75, p=0.000	All pair-wise comparison at p<0.01
Age	F=9.94, p=0.000	All pair-wise comparison at p<0.01
Medical Year Practice (MYP)	F=7.81, p=0.001	All pair-wise comparison at p<0.05

Table 37 Demographic Influence on Search Behaviour for Medical Professionals

Demographic Influence/Cluster		Cluster 1 [Easy – Simple]	Cluster 2 [Easy - Tryer]	Cluster 3 [Neither]
MSE (years)	Mean	6.6	7.8	4.4
	SD	2.1	3.4	0.7
ET (%)	PPG	38.5	61.5	0
	NPG	46.4	38.4	15.2
Age (years)	Mean	27.0	31.0	25.7
	SD	4.6	5.7	2.6
MYP (years)	Mean	4.2	7.7	4.1
	SD	2.2	4.2	2.4

Table 38 Details of Demographic Influence on Search Behaviour for Medical Professionals

Participants with an average of 6.6 years of medical search experience, not pursuing post-graduate education with an average age of 27 years and have been practicing medicine for an average of 4.2 years demonstrate simple search behaviour when searching on an easy task. Participants with an average of 7.8 years of medical search experience, pursing post-graduate education, with an average age of 31 years and with an average of 7.7 years of medical practice demonstrate tryer search behaviour when searching on an easy task. While the same demographic variables influence all three clusters medical professionals who demonstrate simple search behaviour are younger and less experienced medical professionals, medical searchers and not pursuing post-graduate education. Medical professionals who demonstrate tryer search behaviour are older, more experienced medical professionals, medical searchers and pursuing post-graduate medical education.

4.8.1.3 Medical Students Task Difficulty – Difficult

Twenty one medical students perceived searching for Task C3 as difficult while the remaining thirty nine perceived searching for Task C3 as neither easy, neutral or difficult (neither). Medical students were manually separated into two clusters. Cluster 1 consisted of participants who found searching for Task C3 difficult while participants in Cluster 2 found searching for Task C3 as neither (Table 24, Section 4.4). The Anova test results indicate similar demographic variables influence participants in both clusters. Results of the Anova and T-test are provided in Table 39.

Demographic Details	Anova Test Results	T-test Results
Age	F=5.29, p=0.025	Not Significant

Table 39 Demographic Influence on Search Behaviour for Medical Students

Results in Table 39 indicate that demographic variables do not influence the search behaviour of medical students when searching across varying levels of task difficulty. In the next section a summary of demographic influence on search behaviour when searching across varying levels of task difficulty is provided.

4.8.2 Summary – Demographic Influence on Search Behaviour Based on Task Difficulty

For non-medical professionals, age, occupation and general search experience are common demographic variables that influence search behaviour when searching across varying levels of task difficulty. This indicates basic type demographic variables (age) and specific type demographic variables (occupation and general search experience) influence search behaviour of non-medical professionals when searching across varying levels of task difficulty. Non-medical professionals with an average age of 30 years, average general search experience of 18.1 years and who are academics demonstrate unbalanced search behaviour when searching on an easy task. Non-medical professionals with an average age of 35.1 years and working in the Information Technology field with an average general search experience of 8.9 years demonstrate motivated search behaviour when searching on a difficult task.

Medical professionals demonstrate two different categories of search behaviour when searching on an easy task. However, regardless of the type of search behaviour demonstrated similar demographic variables influence the search behaviour of medical professionals when searching across varying levels of task difficulty. Medical search experience, education type, age and medical year of practice influence the search behaviour of medical professionals when searching across varying levels of task difficulty. Medical type demographic variables (medical search experience, education type and medical year of practice) influence the search behaviour of medical professionals in comparison to basic demographic variables (age) when searching across varying levels of task difficulty. Older medical professionals with an average age of 31, with an average medical search experience of 7.8 years, an average medical years of practice of 7.7 years and who are pursuing post-graduate education demonstrate tryer search behaviour when searching on an easy task. Younger medical professionals with an average age of 27, with an average years of medical practice of 4.2 years, with an average medical search experience of 6.6 years and not pursuing post-graduate education demonstrate simple search behaviour when searching on an easy task.

Results of this research study finds for medical based searching age influences medical searching behaviour of non-medical professionals and medical professionals when searching across varying levels of medical task difficulty. This indicates that age is a universal demographic

influence for non-medical professionals and medical professionals when searching across varying levels of medical task difficulty. Specific demographic variables such as occupation and general search experience also influence the search behaviour of non-medical professionals when searching across varying levels of task difficulty. Medical type demographic variables which are: medical search experience, education type and medical year of practice influence the search behaviour of medical professionals when searching across varying levels of task difficulty. Demographic variables do not influence the search behaviour of medical students when searching across varying levels of task difficulty.

Results of previous generalist type research studies in relation to demographic influence on search behaviour indicate gender and age are the most common demographic influence on search behaviour (Zanden and Hann 2011, Weber and Castillo 2010, Jones et al. 2007, Hu, Zeng and Niu, 2007). Results of this research study are partly similar to results of previous research studies (Zanden and Hann 2011, Weber and Castillo 2010, Jones et al. 2007, Hu, Zeng and Niu, 2007). This is because age is a common demographic variable that influences search behaviour for non-medical professionals and medical professionals when searching across varying level of task difficulty. However, specific type (occupation, general search experience - non-medical professionals) and medical type (medical years of practice, medical search experience and education level - medical professionals) demographic variables also influence search behaviour when searching across varying levels of task difficulty. In the next section, demographic variables that influence search behaviour when searching across varying levels of topic familiarity is provided.

4.8.3 Demographic Influence on Search Behaviour Based on Topic Familiarity

In this section demographic influence on search behaviour when searching across varying levels of topic familiarity is provided for non-medical professionals, medical professionals and medical students. The influence of demographic variables on search behaviour is analysed based on results of the Chi Square and standardised residuals test results (Table 29, Section 4.6).

4.8.3.1 Non-Medical Professionals Topic Familiarity – Not Familiar

Thirty one participants perceived to be unfamiliar with the topic described in Task A2 while the remaining participants perceived searching for Task A2 as neither familiar, somewhat familiar or unfamiliar (neither). Participants were manually separated to two clusters. Cluster 1 consists of

participants who found searching for Task A2 unfamiliar and Cluster 2 consists of participants who found searching for Task A2 as neither (Table 29, Section 4.6). Results of the Anova test indicate there is no significant demographic influence on search behaviour when searching across varying levels of topic familiarity. This indicates when searching across varying levels of topic familiarity demographic variables did not influence search behaviour of non-medical professionals.

4.8.3.2 Medical Professionals Topic Familiarity – Not Familiar

Twenty participants perceived to be unfamiliar with Task B2 while the rest found Task B2 to be neither familiar, somewhat familiar or unfamiliar (neither). Participants were manually separated into two clusters. Participants in Cluster 1 found searching for Task B2 as unfamiliar and participants in Cluster 2 found searching for Task B2 as neither (Table 29, Section 4.6). Results of the Anova and T-test are provided in Table 40. Similar demographic variables influence the search behaviour of participants in both clusters.

Demographic Influence	Anova Test Results	T-test Results
Age	F=4.43, p=0.04	T=2.10, p=0.04

Table 40 Demographic Influence on Search Behaviour for Medical Professionals

Further details of the demographic influence on clusters are provided in Table 41. Older medical professionals (mean age = 31.5 years) demonstrate expert search behaviour when searching on an unfamiliar topic.

Demographic Details		Cluster 1 [Unfamiliar]	Cluster 2 [Neither]
Age	Mean	31.5	28.5
	SD	5.7	4.8

Table 41 Details of Demographic Influence on Search Behaviour for Medical Professionals

4.8.3.3 Medical Students Topic Familiarity – Somewhat Familiar

Twenty five participants perceived to be somewhat familiar with Task C1 while the rest were neither familiar, somewhat familiar or unfamiliar with Task C1 (neither). Participants were manually separated into two clusters. Cluster 1 consists of participants who were somewhat

familiar with Task C1. Participants in Cluster 2 consist of participants who found Task C1 as neither (Table 29, Section 4.6). Results of the Anova and T-test are provided in Table 42. Results of the Anova test provided in Table 42 indicate similar demographic variables influence the search behaviour of participants in both clusters.

Demographic Details	Anova Test Results	T-test Results
Gender	F=4.77, p=0.033	T=2.18, p=0.033

Table 42 Demographic Influence on Search Behaviour for Medical Students

Further details of the demographic influence on clusters are provided in Table 43. More female medical students demonstrate uncertain search behaviour when searching on a somewhat familiar topic.

Demographic Details		Cluster 1 [Somewhat Familiar]	Cluster 2 [Neither]
Gender (%)	M	15.0	85.0
	F	100	0

Table 43 Details of Demographic Influence on Search Behaviour for Medical Students

In the next section a summary of demographic influence when searching across varying levels of topic familiarity are provided.

4.8.4 Summary – Demographic Influence on Search Behaviour Based on Topic Familiarity

Demographic variables did not influence the search behaviour of non-medical professionals when searching across varying levels of topic familiarity. For medical professionals age is the only demographic influence on search behaviour while for medical students gender is the only demographic influence on search behaviour when searching across varying levels of topic familiarity. Basic type demographic variables influence the search behaviour of medical professionals and medical students when searching across varying levels of topic familiarity. Results of this research study is similar with results of previous non-medical based generalist research studies (Weber and Castillo 2010, Zanden and Hann 2011, Jones et al. 2007, Hu, Zeng

and Niu, 2007) where gender and age are major demographic influence on search behaviour. Older medical professionals (mean age=31.5) demonstrate expert search behaviour when searching on an unfamiliar topic. More female medical students demonstrate uncertain search behaviour when searching on a somewhat familiar topic. Medical type, basic or specific type demographic variables do not influence the search behaviour of non-medical professionals when searching across varying levels of topic familiarity. In the next section, collated results are provided.

4.9 Summary – Collated Results

In this section, results from individual sections (task difficulty, topic familiarity and demographic influence) are brought together to provide a unified view. Table 44 shows an amalgamated view of results based on the search behaviour demonstrated and demographic influence when searching across varying levels of task difficulty and topic familiarity.

Participant Category	Task Difficulty/Topic Familiarity Level	Search Behaviour Name	Demographic Influence	Demographic Details
Non-Medical Professionals	Easy	Unbalanced	Age	30 years
			GSE	18.1 years
			Occupation	Academic
Non-Medical Professionals	Difficult	Motivated	Age	35.1 years
			GSE	8.9 years
			Occupation	Information Technology Field
Medical Professionals	Easy	Simple	MSE	6.6 years
			NPG	
			Age	27 years
			MYP	4.2 years
		Tryer	MSE	7.8 years
			PPG	
			Age	31 years
			MYP	7.7 years
Medical Students	Difficult	Novice	N/A	
Non-Medical Professionals	Not Familiar	Comfortable	N/A	
Medical Professionals	Not Familiar	Expert	Age	31.5 years
Medical Students	Somewhat Familiar	Uncertain	Gender	More Female Students

Table 44 Collated Results for Search Behaviour Demonstrated Based on Task Difficulty/Topic Familiarity and Demographic Influence

Table 44 shows that medical professionals demonstrate dissimilar search behaviour when searching on an easy task. Regardless of topic familiarity and task difficulty, similar demographic details influence search behaviour (with the exception of medical students when searching on a difficult task and non-medical professionals when searching on an unfamiliar topic). Age is a major basic demographic influence on search behaviour when searching across varying levels of task difficulty and topic familiarity.

Participants demonstrate dissimilar search behaviour when searching across varying levels of task difficulty and topic familiarity. This indicates that task difficulty and topic familiarity influence the search behaviour of non-medical professionals, medical professionals and medical students in an unalike manner. Mean values for age, GSE and MSE are provided in the demographic detail section. In the next chapter a discussion of results and research contributions are provided. (Note: GSE = general search experience, MSE = medical search experience, PPG = pursuing post-graduate education, NPG = not pursuing post-graduate education, MYP = medical years of practice, N/A= not applicable). In the next chapter, a discussion of results and research contributions are provided.

Chapter 5 Discussion and Research Contributions

In this chapter, results obtained from the main experiment are discussed succinctly in relation to the affects of task difficulty and topic familiarity on search behaviour. This is followed by a summary of demographic influence on search behaviour when searching across varying levels of topic familiarity and task difficulty. Finally, the chapter concludes with a discussion of theoretical and practical contributions.

5.1 The Affects of Task Difficulty on Search Behaviour

In this section a summary of search behaviour demonstrated by non-medical professionals, medical professionals and medical students when searching across varying levels of task difficulty is provided. Based on the summary, comparison against results of previous research studies is provided. Only direct comparison is performed (e.g. search behaviour on a difficult non-medical task with difficult medical task). The discussion for non-medical professionals is provided first. This is then followed by the discussion for medical professionals and medical students

5.1.1 Non-Medical Professionals

When searching on an easy task non-medical professionals demonstrate unbalanced search behaviour. This is because while non-medical professionals were active in issuing queries (most number of queries, longest queries, most number of query operators) they also demonstrate unproductive search behaviour (highest task completion time, most number of unsuccessful search sessions, most number of ineffective queries) and critical results viewing (queries without clicks and most number of results refining assistance - Table 25, Section 4.4.1).

Non-medical professionals demonstrate motivated search behaviour when searching on a difficult task. When searching on a difficult task non-medical professionals demonstrate problematic query issuers search behaviour (most number of query re-issues and highest usage of querying assistance) but active results viewers search behaviour (viewing results beyond the 1st page). This indicates while non-medical professionals experienced querying issues, they continued to view more returned results and did not limit viewing of results to the 1st page only (Table 26, Section 4.4.1). This indicates non-medical professionals do not demonstrate similar

search behaviour when searching across varying levels of task difficulty. However, non-medical professionals demonstrate a uniform search behaviour when searching on a task of the same level of difficulty.

In both situations (when searching on an easy task or difficult task) results of this research study do not support results of previous research studies (Bystrom and Javerlin, 1995, Vakkari, 1999, Brystom, 2002, Eastman and Jansen, 2003, Gwizdka and Spence, 2006, Li, 2008 and Liu et al. 2010 and Aula, Khan and Guan, 2010). Results of previous research studies indicate when searching on a difficult task more queries (Bystrom 2002) and query operators (Aula, Khan and Guan, 2010) are issued. Results of this research study finds the most number of queries and query operators are issued when searching on an easy task. Results of previous research studies indicate high task completion time is observed when searching on a difficult task (Li 2008 and Liu et al. 2010). Results of this research study finds the most is taken to complete searching on an easy task. Previous research studies indicate low navigation speed (Vakkari, 1991 and Gwidzka, 2006) and high failure rate (Brystom, 2002) is observed when searching on a difficult task. Results of this research study finds non-medical professionals experienced high failure rate (unsuccessful search sessions) and high navigation speed (uneven querying versus clicking behaviour, high task completion time and more queries without clicks) when searching on an easy task. This indicates when searching across varying levels of task difficulty non-medical professionals do not demonstrate similar search behaviour as non-medical searching (based on similar level of difficulty). As such, there is a need to develop new search behaviour profiles based on description of search behaviour for medical based searching. Without this new search behaviour profiles relevant information retrieval strategies will not be provided to non-medical professionals. This will result in an unsatisfactory search experience.

Non-medical professionals demonstrate unproductive and critical results viewers search behaviour sub-classification when searching on an easy task. On the other hand, when searching on a difficult task non-medical professionals demonstrate problematic query issuers search behaviour sub-classification. This indicates information retrieval strategies have to develop strategies to increase search efficacy of non-medical professionals when searching on an easy and difficult task. These design initiative are discussed in detail in Section 5.4.2.

5.1.2 Medical Professionals

Medical professionals demonstrate two types of search behaviour when searching on an easy task. One type of search behaviour demonstrated is simple. The other type of search behaviour demonstrated is tryer. Medical professionals who demonstrate the simple search behaviour issued the most number of queries, the most number of query operators and the shortest queries. Medical professionals who demonstrate tryer search behaviour were active at locating results (most interaction with the results page and viewing results beyond the 1st page) but were also unproductive because they issued the most number of ineffective queries, queries without clicks, experienced the most number of unsuccessful search sessions and demonstrated uneven querying versus clicking behaviour. This indicates medical professionals do not demonstrate a uniform search behaviour when searching on an easy task. Results of previous research studies indicate a uniform search behaviour is demonstrated when searching on a difficult task (Table 2, Section 2.4). Results of this research study finds a non-uniform search behaviour is demonstrated by medical professionals when searching on an similar level of task difficulty (easy).

Results of this research study finds that search behaviour demonstrated by medical professionals when searching on an easy task (simple and tryer search behaviour) does not support results of previous research studies. Medical professionals who demonstrate simple search behaviour issue the most number of queries, query operators and the shortest queries (Table 27, Section 4.4.2). Results of previous research studies indicate the most number of queries (Brystom, 2002) and query operators (Aula, Khan and Guan, 2010) are issued when searching on a difficult task. Medical professionals who demonstrate the tryer search behaviour are unproductive (most ineffective queries, most unsuccessful search sessions, most queries without clicks, uneven querying versus clicking behaviour) but are active results locaters (most interaction on results page and viewing results beyond the 1st page – Table 27, Section 4.4.2). Results of previous research studies indicate most unsuccessful search sessions (Bystrom 2002) and most sources are viewed when searching on a difficult task (Li and Belkin 2008 and Liu et al. 2010). This indicates results of this research study do not support results of previous research studies (Brystom, 2002, Li and Belkin 2008 and Liu et al. 2010 and Aula, Khan and Guan, 2010). As such, there is a need to develop new search behaviour profiles based on description of search behaviour for medical based searching. Existing strategies on *MedlinePlus* are sufficient to support the search sessions of medical professionals who demonstrate simple behaviour when

searching on an easy task. This is because medical professionals who demonstrate simple search behaviour when searching on an easy task do not exhibit any wasteful search activity. However for medical professionals who demonstrate tryer search behaviour there is a need to provide specific information retrieval strategies to reduce unproductive search activities (most ineffective queries, most unsuccessful search sessions, most queries without clicks, uneven querying versus clicking behaviour - Table 27, Section 4.4.2). These strategies are necessary in order for medical professionals to experience a productive search session. These strategies will be further discussed in Section 5.4.2.

5.1.3 Medical Students

When searching on a difficult task medical students demonstrate novice search behaviour. Medical students demonstrate active results locaters and long query issuers (viewing results beyond the 1st page, most results refining activity and the longest queries) but were slow (most task completion time) and unproductive (highest number of unsuccessful search sessions – Table 28, Section 4.4.3). A uniform search behaviour is demonstrated by medical students when searching on a difficult task.

Results of this research study find search behaviour demonstrated by medical students when searching on a difficult task support results of previous research studies (Table 2, Section 2.4). Medical students experienced the most number of unsuccessful search sessions, took the most time to complete searching on a difficult task and viewed results beyond the 1st page. The description of search behaviour demonstrated when searching on a difficult task is similar to results of previous research studies (Brystom, 2002 – most unsuccessful search sessions, Li, 2008 and Liu et al. 2010 – most task completion time and viewing more sources - Li and Belkin 2008). This indicates medical students demonstrate the same search behaviour traits when searching on a difficult medical task as to when searching on a difficult non-medical task. This indicates that there is no need to develop new search behaviour profiles based on description on search behaviour for medical students.

The high usage of results refining activity, highest task completion time and highest number of unsuccessful search sessions indicate medical students experience search challenges when searching on a difficult task. As such medical students require specific information retrieval strategies to encourage high number of result clicks, reduce task completion time and reduce the

number of unsuccessful search sessions. These strategies will be discussed further in Section 5.4.2. In the next section, the affects of topic familiarity on medical search behaviour are provided.

5.2 The Affects of Topic Familiarity on Search Behaviour

In this section, search behaviour of non-medical professionals, medical professionals and medical students are summarised based on when searching across varying levels of topic familiarity. Results obtained from this research study are compared with results of previous research studies (e.g. search behaviour on a familiar non-medical task with familiar medical task). The discussion for medical professionals takes into account results of previous research studies in relation to bio-medical searching. The discussion for non-medical professionals is provided first. This is followed by the discussion for medical professionals and medical students.

5.2.1 Non-Medical Professionals

When searching on an unfamiliar topic, non-medical professionals demonstrate comfortable search behaviour. While non-medical professionals demonstrate unproductive search features (most task completion time, most unsuccessful search sessions and uneven querying versus clicking behaviour) they still managed to demonstrate technical active query issuers (most number of queries, longest queries, most query operators and the most number of medical queries) and active results refiners (most usage of results refining assistance). This indicates while non-medical professionals experienced issues in relation to unproductive search features they still managed to remain comfortable throughout the search session by demonstrating technical active query issuers and results refiners. A uniform search behaviour is demonstrated by non-medical professionals when searching on an unfamiliar topic.

Results of this research study finds search behaviour demonstrated by non-medical professionals when searching on an unfamiliar topic does not support results of previous research studies (Table 3, Section 2.5). Results of this research study finds non-medical professionals issue the longest queries, the most number of queries and issue medical queries when searching on an unfamiliar topic. Results of previous research studies indicate more specific and technical vocabulary is used when searching on a familiar topic (Allen, 1991, Hsieh Yee,1999, Hoelsher and Strube, 2000, Bhavnani, 2002 and Alia et al. 2008). Results of previous research studies state

more queries and longer queries are issued when searching on a familiar topic (Zhang et al. 2005 and Alia et al. 2008). This indicates that there is a need to develop new search behaviour profiles based on description of search behaviour based on medical based searching. Information retrieval strategies require new search behaviour profiles to determine classification of search behaviour. With this classification the information retrieval strategy will be able to detect typology of search behaviour based on familiarity level, only then will relevant information retrieval strategies be provided to the searcher.

Results of this research study finds when searching on an unfamiliar topic, non-medical professionals demonstrate unproductive search features (most task completion time, most unsuccessful search sessions and uneven querying versus clicking behaviour). As such there is a need to develop specific information retrieval strategies for non-medical professionals to reduce these unproductive search features. These strategies are important in order for non-medical professionals to complete searching on an unfamiliar topic successfully. These initiatives will be discussed further in Section 5.4.2.

5.2.2 Medical Professionals

Medical professionals demonstrate expert search behaviour when searching on an unfamiliar topic. Medical professionals demonstrate fruitful query issuing and active results clicking behaviour when searching on an unfamiliar topic. They were also productive as they experienced the least number of unsuccessful search sessions when searching on an unfamiliar topic (Table 30, Section 4.6.2). A uniform search behaviour is demonstrated by medical professionals when searching on an unfamiliar topic. Results of this research study finds medical professionals demonstrate high search efficacy when searching on an unfamiliar topic.

As such mechanisms available on *MedlinePlus* are sufficient to support the search behaviour of medical professionals when searching on an unfamiliar topic. This research study finds search behaviour demonstrated by medical professionals when searching on an unfamiliar topic do not support results of previous non-medical based research studies (Allen 1991, Hsieh Yee, 1991, Bhavnani 2002, Alia et al. 2008 and Cole et al. 2011). Allen (1991), Hsieh Yee (1991) and Bhavnani (2002) state when searching on a familiar topic, participants found more results. Cole et al. (2011) states participants are able to locate best results when searching on a familiar topic. Results of this research study finds medical professionals were able to complete searching

successfully when searching on an unfamiliar topic. Alia et al. (2008) state when searching on a familiar topic, participants issued the longest queries. Results of this research study finds the longest queries are issued by medical professionals when searching on an unfamiliar topic.

In relation to bio-medical based research studies, results of this research study also do not support results of previous bio-medical based research studies (Karimi et al. 2011). Karimi et al. (2011) state the least number of queries are issued when searching on a familiar topic and results clicking activities are not significant. Results of this research study finds medical professionals issued the least number of queries and clicked on the most number of results when searching on an unfamiliar topic. As such, there is a need to develop new search behaviour profiles based on description of search behaviour. Without this a medical professional's search experience will degrade because information retrieval strategies will not be able to provide relevant assistance based on familiarity level.

5.2.3 Medical Students

Medical students demonstrate uncertain search behaviour when searching on a somewhat familiar topic. Medical students were fast and productive (least task completion time, most successful search sessions) but were also problematic query issuers (most ineffective queries) and fussy results clickers (most number of queries without clicks). A uniform search behaviour is demonstrated by medical students when searching on a somewhat familiar topic.

Results of this research study finds search behaviour demonstrated by medical students when searching on a somewhat familiar topic is dissimilar to results of previous research studies when searching on a familiar or unfamiliar topic. Results of previous research studies indicate participants are able to locate more results (Allen 1991, Hsieh-Yee, 1999 and Bhavnani 2002) and locate best results (Cole et al. 2011) when searching on a familiar topic. Results of this research study finds medical students are able to complete searching successfully when searching on a somewhat familiar topic. This indicates medical students demonstrate dissimilar search behaviour when searching on a somewhat familiar topic in comparison to when searching on a familiar or unfamiliar topic. As such, there is a need to develop new search behaviour profiles based on description of search behaviour for a medical based search.

While medical students were somewhat familiar with a topic, they were able to complete searching on the topic in shortest time and experienced the most number of successful search sessions. However, medical students issued the most number of ineffective queries and experienced the most number of queries without clicks when searching on a somewhat familiar topic. Thus, there is a need to provide medical students with specific information retrieval strategies to minimise these search challenges (high number of ineffective queries and queries without clicks). These design initiatives will be further discussed in Section 5.4.2. In the next section, demographic influence on search behaviour when searching across varying levels of task difficulty and topic familiarity are provided.

5.3 Demographic Influence on Search Behaviour

In this section demographic influence on search behaviour when searching across varying levels of task difficulty and topic familiarity for non-medical professionals, medical professionals and medical students are provided. Demographic influence when searching across varying levels of task difficulty is presented first followed by topic familiarity.

5.3.1 Task Difficulty

When searching across varying levels of task difficulty, search behaviour of non-medical professionals is influenced by age, occupation and general search experience. Non-medical professionals with an average age of 31, working as academics and with an average general search experience of 18.1 years demonstrate unbalanced search behaviour when searching on an easy task. Non-medical professionals with an average age of 35 years, working in the Information Technology field and with an average general search experience on 8.9 demonstrate motivated search behaviour when searching on a difficult task. Basic (age) and specific demographic variables (general search experience and occupation) influence the search behaviour of non-medical professionals when searching across varying levels of task difficulty.

More medical type demographic variables (medical search experience, medical years of practice, education type – pursuing post–graduate education/not pursing post-graduate education) influence the search behaviour of medical professionals in comparison to basic demographic variables (age) when searching across varying levels of task difficulty. Specifically, medical professionals with an average medical search experience of 6.6 years, not pursuing post-graduate

medical studies, with an average age of 27 years and with an average of 4.2 years of medical practice demonstrate simple search behaviour. Medical professionals who are pursuing post-graduate education, with an average medical search experience of 7.8 years, with an average age of 31 years and average of medical years of practice of 7.2 years demonstrate tryer search behaviour. Demographic variables do not influence the search behaviour of medical students when searching across varying levels of task difficulty.

Results of this research study finds age is a common demographic variable that influences medical search behaviour of non-medical professionals and medical professionals when searching across varying levels of task difficulty. This indicates non-medical professionals and medical professionals share a common demographic influence (age) when searching across varying levels of task difficulty. This finding supports results of previous research studies where age (Weber and Castillo 2010, Zanden and Hann 2011, Jones et al. 2007 and Hu, Zeng and Niu, 2007) is a major demographic variable that influences non-medical based search behaviour.

In addition, results of this research study indicate specific demographic variables (occupation and general search experience) influence the search behaviour of non-medical professionals when searching across varying levels of task difficulty. More medical type demographic variables (medical year of practice, medical search experience and education level) influence the search behaviour of medical professionals when searching across varying levels of task difficulty. This indicates more specific demographic variables in comparison to basic demographic variables influence the search behaviour of non-medical professionals when searching across varying levels of task difficulty. Similarly, more medical type demographic variables in comparison to basic type demographic variables influence the search behaviour of medical professionals when searching across varying levels of task difficulty.

Results of this research study finds that demographic variables did not influence the search behaviour of medical students when searching across varying levels of task difficulty. This indicates medical students search behaviour when searching across varying levels task difficulty is not influenced by demographic variables.

5.3.2 Topic Familiarity

Results of this research study finds demographic variables did not influence the search behaviour of non-medical professionals when searching across varying levels of topic familiarity. Age influenced the search behaviour of medical professionals when searching across varying levels of topic familiarity. Medical professionals with an average age of 31.5 demonstrate expert search behaviour when searching on an unfamiliar topic. For medical students gender is the only demographic variable that influences search behaviour when searching across varying level of topic familiarity. More female medical students demonstrate uncertain search behaviour when searching on a somewhat familiar topic. This indicates when searching across varying levels of topic familiarity only basic type demographic variables influence the search behaviour of medical professionals (age) and medical students (gender).

Results of this research study finds that basic demographic variables influence the search behaviour of medical professionals (age) and medical students (gender) when searching across varying levels of topic familiarity. This finding is similar to results of previous research studies where basic demographic variables such as age (Hu, Zeng and Niu, 2007, Webber and Castillo, 2010 and Liao and Fu 2012) and gender (Lahore et al. 2002, Lorigo et al. 2006, Hu, Zeng and Niu, 2007, Jones et al. 2007 and Zanden and Hann 2011) influence non-medical based search behaviour. In the next section, research contributions are provided.

5.4 Research Contributions

In this section, research contributions based on results of this research study are provided. Research contributions are separated into two categories. These categories are: theoretical and practical contributions. Theoretical contributions are provided first followed by practical contributions.

5.4.1 Theoretical Contributions

Results obtained from the main experiment provide several research contributions in relation to better understanding medical information searching behaviour when searching across varying levels of task difficulty and topic familiarity. It also provides information on the demographic influence on search behaviour when searching across varying levels of task difficulty and topic familiarity. These theoretical research contributions are further explained below.

5.4.1.1 Search Behaviour Demonstrated Based on Task Difficulty

Non-medical professionals demonstrate unbalanced search behaviour when searching on an easy medical task and demonstrate motivated search behaviour when searching on a difficult medical task. Description of sub-classifications provided in Tables 25 (easy) and 26 (difficult), Section 4.4.1 indicate the search behaviour demonstrated by non-medical professionals when searching on an easy and difficult task is dissimilar to results of previous research studies (Bystrom and Javerlin, 1995, Vakkari, 1999, Brystom, 2002, Eastman and Jansen, 2003, Gwizdka and Spence, 2006, Li, 2008 and Liu et al. 2010 and Aula, Khan and Guan, 2010). Non-medical professionals demonstrate a uniform type of search behaviour when searching on an easy and difficult task.

On the other hand, medical professionals demonstrate two types of high-level search behaviour when searching on an easy task. These two high level search behaviours are known as: simple and tryer. This indicates that for medical based searching it is possible that more than one type of high level search behaviour is demonstrated when searching across varying level of task difficulty. Results of previous research studies (Table 2, Section 2.4) indicate a uniform search behaviour is demonstrated when searching across varying levels of task difficulty. While a non-uniform search behaviour may not be demonstrated by all categories of typical medical searchers (non-medical professionals, medical professionals and medical students), results of this research study finds medical professionals demonstrate non-uniform search behaviour when searching on an easy task. Medical professionals demonstrate two types of search behaviour when searching on an easy task. Both descriptions of this search behaviour (simple and tryer) are dissimilar to results of previous research studies (Brystom, 2002, Li and Belkin 2008 and Liu et al. 2010 and Aula, Khan and Guan, 2010). Medical students demonstrate novice search behaviour when searching on a difficult task. Sub-classification of search behaviour demonstrated by medical students (Table 28, Section 4.4.3) indicates medical students demonstrate similar search behaviour as reported in results of previous research studies (Table 2, Section 2.4). Previous research studies state the most number of unsuccessful search sessions (Brystom, 2002), the most task completion time (Li, 2008 and Liu et al. 2010) and most sources are viewed (Li and Belkin, 2008) are indications of search behaviour demonstrated when searching on a difficult task. Results of this research study also show that medical students demonstrate these search behaviour traits (most number of unsuccessful search sessions, most task completion time and viewing of more sources) when searching on a difficult task. Medical students demonstrate a

uniform search behaviour when searching on a difficult task. This indicates that there is a need to develop search behaviour profiles based on descriptions of search behaviour for medical based searching for non-medical professionals and medical professionals.

Non-medical professionals and medical professionals do not demonstrate similar overall search behaviour when searching on a task of similar level of difficulty. Non-medical professionals demonstrate unbalanced search behaviour when searching on an easy task whilst medical professionals demonstrate simple and tryer search behaviour when searching on an easy task. However, similarities in sub-classification of search behaviour demonstrated by non-medical professionals and medical professionals when searching on an easy task and similarities in sub-classification of search behavior demonstrated by non-medical professionals and medical students when searching on a difficult task prompt the need for searcher identification methods to be implemented. This initiative will be discussed further in Section 5.4.1.3.

5.4.1.2 Search Behaviour Demonstrated Based on Topic Familiarity

Non-medical professionals demonstrate comfortable search behaviour when searching on an unfamiliar topic. Medical professionals demonstrate expert search behaviour when searching on an unfamiliar topic. Medical students demonstrate uncertain search behaviour when searching on a somewhat familiar topic. This indicates that each category of typical medical searchers (non-medical professionals, medical professionals and medical students) demonstrate a uniform search behaviour when searching across varying levels of topic familiarity. There are no similarities in search behaviour sub-classification amongst typical medical searchers when searching on a similar level of topic familiarity.

The sub-classification of search behaviour demonstrated by non-medical professionals when searching on an unfamiliar topic (Table 39, Section 4.6.1) state medical professionals demonstrate issued the longest queries, the most number of queries and the most number of medical terms in a query. Results of this research study do not support findings in relation to results of previous research studies. Results of previous research studies indicate when searching on a familiar topic, participants issued the most number of queries (Zhang et al. 2005), the longest queries (Alia et al. 2008), were more familiar with technical terms (Allen 1991 and Alia et al. 2008) and found more results when searching on a familiar topic (Allen 1991, Hsieh-Yee, 1999 and Bhavnani, 2002). Results of this research study finds these search traits (longest

queries, most number of queries, most medical terms in a query and the most number of unsuccessful search sessions) are demonstrated when searching on a familiar topic.

Results of this research study finds that medical professionals also demonstrate dissimilar search behaviour based on bio-medical searching. In relation to bio-medical searching, results of previous research studies state the least number of queries are issued when searching on a topic of high familiarity. Moreover, results clicking activity was not significant when searching on a topic of high familiarity (Karimi et al. 2011). Results of this research study do not support findings of previous research studies. The least number of queries and the most number of results was clicked when searching on an unfamiliar topic (Table 30, Section 4.6.2). Results of this research study finds medical students completed searching on a somewhat familiar in the least amount of time, experienced the most number of successful search sessions, issued the most ineffective queries and experienced the most queries without clicks (Table 31, Section 4.6.3). These search traits are dissimilar to results of previous research studies (Table 3, Section 2.5). This indicates that there is a need to develop new search behaviour profiles based on descriptions of search behavior demonstrated when searching across varying levels of topic familiarity. A new search behaviour profile is necessary because without it medical information retrieval strategies will be unable to ascertain search behaviour based on topic familiarity when searching on a medical domain. The search behaviour profiles based on descriptions of search behaviour when searching across varying levels of topic familiarity will enable the information retrieval strategy to provide accurate strategies to the medical searcher.

5.4.1.3 Identification of the Searcher

Medical professionals demonstrate two high level types of search behaviour when searching on an easy task: simple and tryer (Table 27, Section 4.4.2). Furthermore, the sub-classification of search behaviour of non-medical professionals when searching on an easy task bears some resemblance with the search behaviour of medical professionals who demonstrate the simple search behaviour. Both non-medical professionals (Table 25, Section 4.4.1) and medical professionals (Table 27, Section 4.4.2 simple search behaviour) issued the most number of queries, queries without clicks, experienced the most number of unsuccessful search sessions and demonstrated uneven querying versus clicking behaviour when searching on an easy task. Non-medical professionals (Table 26, Section 4.4.2) and medical students (Table 28, Section 4.4.3)

demonstrate a similar search feature when searching on a difficult task. Non-medical professionals and medical professionals demonstrate viewing results beyond the 1st page when searching on a difficult task. These similarities in sub-classification of search behaviour demonstrated by different categories of medical searchers when searching on a similar level task difficulty indicates that an identification method is necessary to first determine the identity of the searcher.

In addition, while non-medical professionals and medical professionals demonstrate more resemblance in sub-classification of search behaviour when searching on an easy task in comparison to non-medical professionals and medical students when searching on a difficult task, the reason/s for demonstration of search behaviour is not the same. For example, when searching on an easy task medical professionals experience the most number of unsuccessful search sessions because they felt returned results did not contain enough information (Section 4.4.2). On the other hand, non-medical professionals were dissatisfied with returned results when searching on an easy task because returned results: contained insufficient information, had too much unnecessary information, required too many clicks to arrive at information or they simply did not like returned results (Section 4.4.1).

This indicates that some type of identification method is necessary to first determine who the searcher is. Only after identification of the searcher, matching against typology of search behaviour can be conducted to determine search behaviour based on task difficulty. In the case where typology of search behaviour is matched first without determining the identity of the searcher then it is likely that an inaccurate information retrieval strategy will be provided to a searcher. This will lead to reduced search satisfaction amongst typical medical searchers. In relation to topic familiarity, non-medical professionals and medical professionals do not demonstrate similar sub-classification of search behaviour when searching on a similar level of topic familiarity (Table 29, Section 4.6.1 and Table 30, Section 4.6.2). As such the need for searcher identification is only necessary for typical medical searchers when searching across varying levels of task difficulty.

5.4.1.4 Evaluation of Returned Results
Typical medical searchers exhibit different evaluation criterion when determining the relevance of returned results. Non-medical professionals evaluate the relevance of returned results based on

the design of the page and content value of the page when searching on an easy task. When searching on a difficult task non-medical professionals and medical students were not confident with the suitability of preferred returned results. While non-medical professionals completed searching on a difficult task successfully, they had difficulty in determining the suitability of returned results (based on verbal utterances provided by non-medical professionals when searching on a difficult task Section 4.4.1). Medical students also experienced difficulties in determining suitability of returned results when searching on a difficult task (Section 4.4.3). Medical professionals who demonstrate tryer search behaviour when searching on an easy task evaluated returned results based on content-value. This indicates non-medical professionals exhibit a diverse set of evaluation criterions when searching on an easy task. Non-medical professionals are more critical when evaluating returned results when searching on an easy task in comparison to when searching on a difficult task. Non-medical professionals and medical students only had one evaluation criteria to determine relevance of returned results when searching on a difficult task. This indicates non-medical professionals and medical students are less critical when evaluating results when searching on a difficult task.

When searching on an unfamiliar topic, non-medical professionals evaluated returned results based on the page design and content-value of the page. Particularly, non-medical professionals were unhappy with the high level of technical content on a page when searching on an unfamiliar topic. Medical professionals and medical students did not have any particular evaluation criteria when evaluating returned results when searching on an unfamiliar topic (medical professionals) and somewhat familiar topic (medical students). This indicates when searching on an unfamiliar topic non-medical professionals place importance not only on the content value of a page but also on the design of results pages. Results of this research study finds non-medical professionals are more critical when evaluating returned results when searching across varying levels of task difficulty as opposed to when searching across varying levels of topic familiarity. Content-value is a key factor used by medical professionals when determining relevance of returned results when searching across varying levels of task difficulty.

5.4.1.5 Demographic Influence on Search Behaviour
Basic demographic variables of participants influence the search behaviour of medical professionals (age) and medical students (gender) when searching across varying levels of topic

familiarity. While the domain and search tasks used to perform this research study is medical based only basic type demographic variables influenced the search behaviour of medical professionals and medical students when searching across varying levels of topic familiarity. Demographic variables did not influence the search behaviour of non-medical professionals when searching across varying levels of topic familiarity. One reason for this is because familiarity with a topic required participants to 'know' something about the topic which may not be directly related to the demographic variables of participants. Familiarity with a topic could arise from conversation with friends or from reading an article. These reasons are not linked to any demographic variables. Results of this research study supports findings of results of previous research studies which indicates age (Hu, Zeng and Niu, 2007, Webber and Castillo, 2010 and Liao and Fu 2012) and gender (Lahore et al. 2002, Lorigo et al. 2006, Hu, Zeng and Niu, 2007, Jones et al. 2007 and Zanden and Hann 2011) are demographic variables that influence non-medical based information search behaviour.

When searching across varying levels of task difficulty basic, specific and medical type demographic variables influence the search behaviour of non-medical professionals and medical professionals. However, demographic variables did not influence the search behaviour of medical students. When searching across varying levels of task difficulty, age is a common demographic influence amongst non-medical professionals and medical professionals. Results of this research study supports results of previous research studies (Hu, Zeng and Niu, 2007, Webber and Castillo, 2010 and Liao and Fu 2012). Aside from age, specific type demographic variables influence the search behaviour of non-medical professionals (occupation, and general search experience) while more medical type demographic variables influence the search behaviour of medical professionals (medical search experience, medical years of practice and education type) when searching across varying levels of task difficulty.

5.4.2 Practical Contributions

In this section, research contributions and signposts for the development of better information retrieval strategies and improved human computer interaction experience when searching on medical domains are provided. Specifically, these practical contributions are related to the aspect of search behaviour demonstrated by typical medical searchers when searching across varying levels of task difficulty and topic familiarity.

While these practical contributions may be specific to the domain where the experiment is performed - *MedlinePlus*, this does not mean that these design suggestions cannot be implemented on other medical domains. These practical contributions are provided below:

5.4.2.1 The Need for Domain Specific Search Behaviour Profiles

Results of this research study finds when searching across varying levels of task difficulty non-medical professionals and medical professionals demonstrate dissimilar search behaviour in relation to results of previous research studies. When searching across varying levels of topic familiarity, non-medical professionals, medical professionals and medical students demonstrate dissimilar search behaviour in comparison to results of previous research studies. This indicates that there is a need to develop specific search behaviour profiles based on description of search behaviour when searching across varying levels of task difficulty and topic familiarity. Without this search behaviour profile medical information retrieval strategies will not be able to infer level of task difficulty or topic familiarity based on search behaviour. As a result, an inaccurate information retrieval strategy will be provided to the searcher. An inaccurate information retrieval strategy will not reduce search challenges experienced by typical medical searchers. Neither will it enhance the search experience of typical medical searchers. While this is the case for medical domains it could be possible that other 'expert-type' domains also require the construction of new search behaviour profiles when searching across varying levels of task difficulty and topic familiarity.

5.4.2.2 The Need For Identification of the Searcher

Medical professionals demonstrate two high level types of search behavior when searching on an easy task. Sub-classifications of search behaviour demonstrated by non-medical professionals and medical professionals when searching on an easy task bare some resemblance. Likewise, the sub-classification of search behaviour demonstrated by non-medical professionals and medical students when searching on a difficult task also demonstrate one common search feature. This indicates that there is a need to first identify a searcher before matching typology of search behaviour based on task difficulty. Only after identification of the searcher relevant information retrieval strategies can be provided based on typology of search behavior.

As such medical domains have to implement explicit identification methods to allow the searcher to identify them. One method of doing this is by using a generic login method as such: non-

medical professional, medical professional or medical student. This identification method is not intrusive and ensures privacy. More experienced medical professionals (years of medical practice and medical search experience) and medical professionals pursuing post-graduate education demonstrate dissimilar search behaviour when searching on an easy task in comparison to less experienced medical professionals and medical searchers who are not pursuing post-graduate education. As such, the login method for medical professionals will require a 2nd level identification based on years of medical practice and education level. This 2nd level identification method for medical professionals will allow for tighter identification of a medical professional. This will allow for the information retrieval strategy to provide streamlined search assistance to medical professionals.

5.4.2.3 Design for Better Results Summary Snippets with Relevance Indication

Non-medical professionals (when searching on an easy and difficult task), medical professionals (tryer behaviour when searching on an easy task) and medical students (when searching on a somewhat familiar topic) judge the relevance of a link by reading and viewing result summaries (not clicking on links). Currently, *MedlinePlus* presents result summaries in the following style: i) returns result links ii) provides summary snippets of returned results where term/terms used in a query are highlighted within the snippet and iii) the Uniform Resource Locater (URL) source address of the link. This method of presenting returned results based on summary snippets and highlighting terms used in the query in the summary snippet is commonly used in general search engines. However this approach is clearly inadequate when used on medical domains. This is because of the low number of clicks on returned results. As such, better design and presentation of summary snippets is necessary to attract searchers to click on links. Instead of only presenting result summaries and highlighting terms, other methods of relevance indication of returned results are required. This will increase the number of result clicks, reduce the number of uneven querying versus clicking behaviour, reduce search time and effectively reduce the number of unsuccessful search sessions.

One such method is to provide users with relevance indication features of returned search results. Relevance indication features such as relevance scores which shows how many people have selected a link and timing which provides when a page was last updated. Relevance score features are able to provide more information on returned results. This will encourage more

clicks on returned results. In addition, relevance indication features can also include features like relevance value of the returned results. This can be done by matching terms (or weighted terms) found on a result page against the query. This will provide information on the relevance of returned pages against a query. Besides relevance value calculations which are performed using statistical functions (weighted scores), users should be allowed to vote on the relevance of returned results using user relevance indicators such as the 'like' voting system. This is a technique commonly utilised on many social networking sites. This strategy of providing users with relevance indicators (relevance scores, relevance value and user relevance ratings) will encourage medical searchers to further investigate a link based on ratings provided by other searchers (user relevance value), based on statistical functions (relevance value) or based on clicking activity of other searchers and up-datedness of a page (relevance score).

5.4.2.4 The Need for Better Querying and Search Results Refining Assistance

Querying and results refining activities are used often by non-medical professionals when searching on an easy task, difficult task and unfamiliar topic. Medical professionals (tryer) search behaviour also use assisting features when searching on an easy task and medical students use them when searching on a difficult task. The post experiment interview reveals that querying and results refining assistance provided by *MedlinePlus* is unsatisfactory (post-experiment interview for non-medical professionals and medical professionals). Currently, *MedlinePlus* provides two types of results refining features. These features are: *Refine by Keyword* and *Refine by Type*. *Refine by Keyword* allows users to view returned results based on specific sub-topics related to the query. *Refine by Type* allows users to view returned results based on specific categories. In reality both these refining methods are the same.

Hence, better options are necessary. Amongst better options that should be made available are: Search Within Results and Clustering. Both these features are available on certain general search engines. Search Within Results allows users to narrow down returned search results to specific keywords or terms. This will reduce the need to view too many results as Search Within Results narrows returned results to only display a limited set of results as specified by the keyword or a specific term. Clustering helps to reduce the number of pages from the same site. Pages from the same site will contain almost similar information. This is similar to providing users with the same results. In search sessions observed, *MedlinePlus* does not perform Clustering as most

returned results in the result pages are from different pages of the same site. Querying assistance provided by *MedlinePlus* is not immediately noticeable to users. Current options to perform querying assistance are *Health Topics, Drugs and Supplements and Videos and Cool Links*. Currently, *MedlinePlus*, does not provide alternative query term or medical term query suggestions. Previous research studies indicate the use of a medical term is pertinent in experiencing a satisfactory medical search session (Liu and Lu, 2009 and Spink et al. 2004). As such providing medical term query suggestions and alternative query suggestions will assist users. Medical term query suggestions will help provide context to allow the information retrieval strategy to better identify a users search goal. Providing context is important during a medical search session as this will enable relevant results to be returned to the user (Nadkarni, 2002). This initiative will help reduce search challenges reported in previous research studies in relation to un-fulfilment of search goals (Bath, 2008 and Hersh and Hickam, 1998).

A possible method to implement alternative query suggestions is by providing the option to perform Related Searches. The Related Searches option will allow query suggestions similar to the query entered by the user to be displayed. This option will allow typical medical searchers to use the suggested term to form a new query or to supplement an existing query. The Related Searches option will provide typical medical searchers with a variety of possible queries to fulfil their search goal.

5.4.2.5 Design of Results Page

Typical medical searchers have various criterions when considering the relevance of returned results. Medical professionals (when searching on an easy task) and non-medical professionals (when searching on an unfamiliar topic) evaluate the relevance of returned results based on the design of the page and content of a page. This indicates that there is a need to pay special attention to the design of results page. Specifically pages that have too much unnecessary information and pages that took too many clicks to get to necessary information are amongst major reasons as to why non-medical professionals are discontented with returned results. Results of this research study do not provide any indication on what is required in designing a good results page. As such a new research study is required in relation to identifying what features are necessary for the design of a good result page.

While information retrieval strategies are unable to control the content-value of a page it is possible to separate returned results into categories such as: simple, intermediate and advance. This provides the ability for medical professionals and non-medical professionals to select a suitable category of returned results. It also provides the ability for medical professionals and non-medical professionals to switch between categories when they find one category too easy or too difficult. This can be done by getting medical experts or medical librarians to manually separate returned results.

When searching on a difficult task non-medical professionals were not confident with selected results. This indicates that confidence ratings are necessary to assist non-medical professionals when evaluating returned results. This initiative is also necessary for several others scenarios: medical students when searching on a difficult task and for non-medical professionals when searching on an unfamiliar topic. One method of providing confidence ratings is by supplying information on the match percentage value of the query against returned results. This match percentage value provides information for non-medical professionals and medical students in order to increase confidence level when selecting results. The match percentage value can be displayed on the top of the result page. One method to calculate the percentage match value is by calculating the number of times the query input by the user appears on the page. Match percentage value can also include synonyms words (in relation to the input query) during the calculation process. In the next chapter, a summary of research contributions and concluding remarks for this research study are presented.

Chapter 6 Summary and Conclusion

In this chapter, research contributions are summarized. Then, limitations of this research study and direction for future research are provided.

6.1 Summary of Research Contributions

Non-medical professionals demonstrate unbalanced search behaviour when searching on an easy task and demonstrate motivated search behaviour when searching on a difficult task. Medical professionals demonstrate two high level types of search behaviour when searching on an easy task: simple and tryer. Medical students demonstrate novice search behaviour when searching on a difficult task. This indicates that non-medical professionals and medical students demonstrate a uniform search behaviour when searching on an easy and difficult task. Medical professionals do not demonstrate a uniform search behaviour when searching on a easy task.

Results of this research study finds that search behaviour demonstrated by non-medical professionals and medical professionals are dissimilar to results of previous research studies. The search behaviour of medical students is similar to results of previous research studies. This indicates that there is a need to develop search behaviour profiles based on descriptions of search behaviour for non-medical professionals and medical professionals when searching across varying levels of task difficulty. Without this search behaviour profiles an information retrieval strategies will not be able to infer level of task difficulty based on search behaviour. This will then result in an inappropriate information retrieval strategy provided to the searcher.

In relation to topic familiarity, non-medical professionals demonstrate comfortable search behaviour when searching on an unfamiliar topic. Medical professionals demonstrate expert search behaviour when searching on an unfamiliar topic and medical students demonstrate uncertain search behaviour when searching on a somewhat familiar topic. This indicates that categories of typical medical searchers demonstrate a uniform search behaviour when searching on an unfamiliar topic (non-medical professionals and medical professionals) and somewhat familiar topic (medical students). Results of this research study finds search behaviour demonstrated by typical medical searchers when searching across varying levels of topic familiarity is dissimilar to results of previous research studies. This indicates that new search

behaviour profiles based on descriptions of search behaviour is necessary for appropriate identification of search behaviour when searching across varying levels of topic familiarity. Without this new search behaviour profile it is likely that typical medical searchers will be provided with a less than satisfactory information retrieval strategy during a search session. This will led to reduced search satisfaction.

Basic type demographic variables influence the search behaviour of medical professionals (age) and medical students (gender) when searching across varying levels of topic familiarity. When searching across varying levels of topic familiarity, the search behaviour of non-medical professionals is not influenced by demographic variables. Results of this research study is similar to results of previous research studies which indicate age (Hu, Zeng and Niu, 2007, Webber and Castillo, 2010 and Liao and Fu 2012) and gender (Lahore et al. 2002, Lorigo et al. 2006, Hu, Zeng and Niu, 2007, Jones et al. 2007 and Zanden and Hann 2011) are major demographic influences on search behaviour.

Age is also a common demographic influence for non-medical professionals and medical professionals when searching across varying levels of task difficulty. However, when searching across varying levels of task difficulty, age is not the only demographic variable that influences search behaviour. Specific type demographic variables such as general search experience and occupation also influence the search behaviour of non-medical professionals when searching across varying levels of task difficulty. Medical type demographic variables such as medical years of practice, education type and medical search experience influence the search behaviour of medical professionals when searching across varying levels of task difficulty. Results of previous research studies (Table 5, Section 2.6) do not indicate that specific and medical type demographic variables are able to influence search behaviour. In addition, results of this research study finds that demographic variables do not influence the search behaviour of medical students when searching across varying levels of task difficulty.

The sub-classification of search behaviour amongst non-medical professionals and medical professionals (tryer) when searching on an easy task bares some similarities in search features. Similarly, the search behaviour of non-medical professionals and medical students when searching on a difficult task also bears some resemblance. However, these similarities in search traits are not for the same reason/s. The similarities in search behaviour amongst typical medical

searchers when searching across varying levels of task difficulty make it is necessary to first identify the searcher before matching typology of search behaviour based on task difficulty. As such, basic login identification methods are necessary to identify a medical searcher. In addition, there is a need to provide a 2nd level login for medical professionals. This is because medical professionals who are more experienced (more years of medical practice and years of medical searching) and pursuing post-graduate medical education demonstrate dissimilar search behaviour in comparison to less experienced medical professionals who are not pursuing medical education when searching on an easy task. A 2nd level login for medical professionals will allow for tighter profiling of search behaviour and appropriate provision of information retrieval strategies. Identification of a searcher is not needed when searching across varying levels of topic familiarity because sub-classification of search behaviour amongst typical medical searchers does not indicate any similarities in search features.

Non-medical professionals (when searching on an easy and difficult task), medical professionals (tryer behaviour when searching on an easy task) and medical students (when searching on a somewhat familiar topic) judge the relevance of a link by reading and viewing result summaries (not clicking on links). Judging relevance of returned results based on summary snippets led to other wasteful search activities amongst typical medical searchers. One such wasteful search activity is in relation to issuing the most number of queries without clicks demonstrated by non-medical professionals when searching on an easy task and by medical students when searching on a somewhat familiar topic. The most number of queries without clicks was also demonstrated by medical professionals (tryer) when searching on an easy task. This indicates that there is a need to provide medical searchers with better design and presentation of results summary snippets. As such, providing medical searchers with additional information such as relevance scores, relevance value and user relevance ratings will increase the possibility of results clicks (reducing the number of queries without clicks). Relevance scores provide information on timing details of when the page was last updated and the number of clicks the page has received. Relevance value provides information on weighted score of the page against the query entered whilst user relevance indicators provides information on the number of 'likes' a page has received.

Non-medical professionals utilise querying and results refining assistance often when searching on an easy task, difficult task and unfamiliar topic. Medical professionals (tryer search behaviour) also use assisting features when searching on an easy task and medical students use results and querying assistance often when searching on a difficult task. The post experiment interview reveals that non-medical professionals, medical professionals and medical students found querying and results refining assistance provided by *MedlinePlus* to be unsatisfactory. As such better querying and results refining assistance are necessary to increase search satisfaction. To provide better querying assistance the following strategies are suggested: alternative query term (related searches) and medical term suggestion. As for results refining assistance, the following strategies are recommended: Search Within Results and Clustering. Medical term suggestion provides medical terms to the searcher. Alternative query suggestion allows for similar query suggestions to be provided to the user. Search Within Results allows for streamlining of returned results whilst Clustering minimises different pages from the same site to be provided to the user.

Typical medical searchers demonstrate different results evaluation criterions when determining suitability of returned results. Medical professionals (when searching on an easy task) and non-medical professionals (when searching on an unfamiliar topic and easy task) evaluate the relevance of a page based on content value. While information retrieval strategies are unable to the control content-value of a page it is possible to separate returned results into categories such as: simple, intermediate and advance. This will provide the ability for medical professionals and non-medical professionals to view results based on the level of technicality of a page. When searching on a difficult task and on an unfamiliar topic, non-medical professionals were not confident with selected results. Medical students also demonstrate unconfident search behaviour while evaluating results when searching for a difficult task. One method of increasing a searchers confidence level of returned results is by supplying information on the match percentage value of the query against returned results. Match percentage values are calculated based on the number of times the query (or synonym terms) appears on the results page.

Design of the results page is also used as criteria to determine the relevance of returned results. This is an evaluation criteria used by medical professionals who demonstrate the tryer search behaviour when searching on an easy task and by non-medical professionals when searching on

an easy task and unfamiliar topic. Results of this research study are unable to determine the user-perceived criterions of a well-designed results page. This aspect requires further study. In the next section, limitations of this research study are provided.

6.2 Limitations

This research study provides many interesting findings; however there are also limitations that should be acknowledged. Medical professionals did not provide their personal task for the purpose of this research study. Thus, search sessions demonstrated on the simulated situations are not verified against the personal task for a reflection of 'true' search behaviour. While non-medical professionals and medical students provided their personal task for the purpose of this research study the number of personal task provided was not equal to the number of participants. Only thirty six personal tasks were provided by non-medical professionals and thirty eight personal tasks were provided by medical students. However, the number of personal tasks provided by non-medical professionals and medical students were more than thirty (more than half the number of participants), thus provides sufficient data for analysis. Furthermore, not all levels of task difficulty and topic familiarity were available for the categories of typical medical searchers. Only search behaviour when searching for the following categories was available for analysis: search behaviour when searching on a difficult task (non-medical professionals, medical students), an easy task (non-medical professionals and medical professionals), somewhat familiar topic (medical students) and on an unfamiliar topic (non-medical professionals and medical professionals). In all cases (except for non-medical professionals when searching across varying levels of task difficulty) analysis is only based on one task for difficulty/familiarity level for each category of participant.

Results obtained from this research study cannot be generalised. It is limited to the population of study and the domain used to perform this research study. While this research study focuses on the search behaviour demonstrated by typical medical searchers when searching across varying levels of task difficulty, topic familiarity and the demographic variables that influence search behaviour, it is possible that other search-related factors could also influence search behaviour. For example, while the pre-experiment interview focuses on online methods of obtaining medical information (using a general search engine/medical search engine) it is possible that participants may be familiar with a medical topic based on information obtained from non-online

methods such as from conversation with friends, family members or from reading books or magazines. Similarly, while the focus of this research study is confined to *MedlinePlus* it is possible that if there were no restrictions on the domain used, typical medical searchers may demonstrate dissimilar search behaviour when searching across varying levels of task difficulty and topic familiarity. Demographic influence on search behaviour when searching across varying levels of task difficulty and topic familiarity may also vary if participants were allowed to use a search engine of their choice.

There are a few modifications necessary in order to improve the experimentation technique utilised in this research study. During the post-experiment interview, some participants were not able to explain why they used certain search strategies. This resulted in limited information obtained for the explanation of search behaviour. One such method to overcome this problem is by prompting participants to explain their search strategy throughout the search process, instead of waiting to do the interview at the end of the search process. In addition, the post-experiment interview did not elicit information on why participants were satisfied with returned results or what criterions do typical medical searchers use to determine suitability of results. This is especially the case when searching on a successful search session. Eliciting this information will enable the development of a set of criterions necessary for the design of a well put together results page.

While participants provided their perceived perception of task difficulty and topic familiarity further information on why they rated simulated situations the way they did was not obtained. This information will determine why medical searchers found a task difficult, easy or neutral (likewise for topic familiarity). This will provide information on what factors influence perceptions of task difficulty and topic familiarity. In this research study, only task completion time is analysed. Time spent on each result page clicked and time spent viewing returned results (without clicking) was not taken into account. Time spent on individual results page and time spent viewing results (without clicking) will allow for better understanding of how task difficulty and topic familiarity influence results viewing activity. In the next section, concluding remarks and future direction for this research study is provided.

6.3 Conclusion and Future Direction

Results obtained from this research study suggest new research direction involving the use of new and existing data. Existing data can be used to determine what type of queries is issued by typical medical searchers when performing a medical search. Existing data can be analysed from a qualitative aspect in relation to changes in between queries and the overall classification of search behaviour based on task difficulty and topic familiarity. Specifically, examining how keywords, stop-words, medical terms and structured queries are used to form a query and the transition between these types of queries throughout a search session. This will allow for identification of search behaviour based on task difficulty and topic familiarity from a qualitative aspect. In addition, there is an opportunity to examine search patterns of successful and unsuccessful search sessions. This will allow for the identification of search behaviour patterns when searching on a successful and unsuccessful search session. Identification of search behaviour patterns will enable possible detection of a successful or unsuccessful search session. As such, when a possible unsuccessful search session is detected, signals can be sent to the information retrieval strategy to play a more active role in supplying necessary techniques to assist the user to complete the search task successfully.

The focus of this research study is only limited to information searching. It would be interesting to analyse information seeking behaviour of typical medical searchers. Specifically, how do typical medical searchers re-find information, use information obtained from a search session and how do they use search intermediaries (medical librarians, friends, colleagues) in a medical search session. This information will enable a comprehensive understanding of medical information searching. Similarly, new data can be collected to determine changes in pre and post perception of task difficulty and topic familiarity. In this research study task difficulty is taken into account as a post-search factor and topic familiarity is taken into account as a pre-search factor. It will be inspiring to examine if perception of task difficulty and topic familiarity can change during the search process. This will provide information on what search factors cause participants to change their perception of task difficulty and topic familiarity.

More importantly, future work will involve designing and developing the research contributions outlined in Section 5.4.2. The development of research contributions outlined in Section 5.4.2 is separated into several steps based on priority-level. The first step entails the development of

basic login identification methods of typical medical searchers and the development of search behaviour profiles based on task difficulty and topic familiarity. This step has highest priority because of its significance in relation to results of previous research studies. Results of this research study finds medical information searching based on task difficulty and topic familiarity is dissimilar to results of previous research studies (except for medical students based on task difficulty). Furthermore medical professionals demonstrate dissimilar search behaviour when searching on an easy task. When searching on the same level of task difficulty, non-medical professionals, medical professionals and medical students demonstrate some similarity in search features. As such, identification methods are necessary to allow for better matching of typology of search behaviour. This step has highest priority also because these initiatives need to be in place before the search process starts.

The second step involves the development of better querying and results refining assisting strategies. This involves implementing Clustering and Search Within Results strategies for results refining assistance and alternative query suggestion (related searches) and medical term suggestion strategies for querying assistance. This step has medium priority because these initiatives assist users during the search process. The final step involves the design and presentation of better results summary snippets using relevance scores, relevance value, user relevance ratings, the separation of returned results into categories (simple, intermediate, advance) based on the level of technical content on a page and providing match percentage of the query against returned results (to increase confidence level). This step is low priority because these initiatives assist users towards the end of the search process when returned results are evaluated. While Section 5.4.2 outlines new design initiatives based on results of this research study, it is possible that other types of design initiatives and information retrieval strategies could also improve the human computer interaction experience when searching on a medical domain. In addition whilst the search activities in this research study were confined to *MedlinePlus*, it would be worthy to studying how task difficulty, topic familiarity and demographic variables influence the search behaviour of typical medical searchers when searching on other publicly available medical domains. This will provide an understanding how typical medical searchers perform medical searching on other medical domains and further substantiate the theoretical and practical contributions drawn out in Sections 5.4.1 and 5.4.2.

There is also a need to conduct a new research study to obtain information on criterions of a well-designed medical results page. This requires an extensive interview with participants to identify what features does typical medical searchers look for to qualify a result page as a well-designed page. In this research study task difficulty and topic familiarity are analysed as standalone components. Since task difficulty and topic familiarity are key factors in influencing medical search behaviour, it would be interesting to see if there is a relationship between task difficulty and topic familiarity when searching for medical information. This will allow for better understanding of medical search behaviour in relation to determining which factor is more dominant (task difficulty/topic familiarity) in influencing search behaviour.

In conclusion, this research study contributes to better understanding of typical medical searchers medical information searching behaviour. In particular, the focus is on aspects of task difficulty, topic familiarity and demographic influence on search behaviour. This research study has theoretical contributions for better understanding and explanation of medical search behaviour when searching across varying levels of i) task difficulty, ii) topic familiarity and iii) the demographic variables that influence search behaviour when searching across varying levels of task difficulty and topic familiarity. It also provides practical contributions for the design of better user centric information retrieval strategies and improvements to the human-computer interaction experience on a medical domain.

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Appendix

Appendix A Pre-Experiment Interview Questions

Pre-Experiment Interview
Details About Participant:

Age:	Native Language:
Gender:	Education Level:
Education Type:	*Year of Study (medical):
Medical Knowledge: (Poor/Average/Expert)	Nationality:
General Search Experience in Months or Years:	*Medical Years of Practice:
Occupation:	*Specialist/In Training/GP/Others:
Education Type:	

Medical Search Experience:

1. Have you performed a medical search before?

2. How long have you been performing medical based searches for?

3. What are reason/s to have performed a medical search? What type of information do you look for?

4. How often do you perform a medical search?

5. How long do you spend searching for medical information in a week?

6. Where was this search conducted on a medical search engine/or on a general search engine?
   6i) Where do you most often perform a medical search; on a medical search engine/general search engine
   6ii) Can you estimate how much time in a week is spent searching for medical information on a medical search/general search engine?

7. Topic Familiarity of Task 1,2 and 3: Familiar/Somewhat Familiar/ Not Familiar

8. Was the description provided in the simulated situation for Task 1, 2, 3 clear?
   Clear   Somewhat Clear   Unclear
      8i) Could you explain why you found the simulated situation unclear/somewhat clear?

(End)

Appendix B Simulated Situations For Non-Medical Professionals

Task A1:

Simulated work task scenario: Today morning after getting out of bed you noticed that you could not move your neck. You could not move it to the left or right. There is swelling on the left side of your neck. The swelling seems to be near lymphatic nodes. You are also experiencing some pain near the neck area. You want to find out what is wrong.

Indicative Request: Find for an instance, information to inform you of your condition, what can be done to relief you of this condition and why are you experiencing this pain at the neck.

Task A2:

Simulated work task scenario: Your colleague had just undergone a health test and found out that his kidney is enlarged and there is a stricture. A procedure called URS&RPG was performed. After this procedure, he then experienced urine retention. He is in pain and has been told that surgery is required. You are concerned for your colleague and would like to use MedlinePlus to provide him with some information.

Indicative Request: Find for an instance, information to provide to your colleague of his condition, why is he experiencing this condition? Try to help him locate possible alternatives to treat his condition. Is surgery the only option?

Task A3:

Simulated work task scenario: Yesterday at the mall you witnessed a child about the age of five having fits/seizure. The child's parents who were nearby were in a state of shock. On arriving home, you were curious about the situation at the mall and would like to find out more about the child's condition. Use MedlinePlus to help you find out what could have been done to assist the child.

Indicative Request: Find for an instance, information advising you of what first aid measures you could have taken to assist the child and what are some possible reasons for the child to be experiencing this condition.

Appendix C Simulated Situations For Medical Professionals

Task B1:

> Simulated work task scenario: As part of your review of patient files you came across one with the following description:
>
> > A 50 year old patient presents to the emergency department with chest pain. He appears sweaty, feels nauseated and seems to be short of breath. An EKG is obtained. The heart rhythm is Left Bundle Branch Block.
>
> You were curious of the patient's condition and would like to find out more about what can be done to treat this patient.
>
> Indicative Request: Find for an instance information to inform you of what are some possible causes for the patient to experience this condition and what treatment options are available for him.

Task B2:

> Simulated work task scenario: While you were on rounds at the paediatric ward, a mother of a 15 day old infant son reports to you that her son has started having episodes of vomiting with the emesis "shooting out of his mouth" after feeding. She also reports that the infant appears hungry, continues to feed, and has not gained any weight. The mother wants to know what is wrong with her son. You would like to help the mother better understand her son's condition.
>
> Indicative Request: Find for an instance, information to inform the mother of her son's condition, why is her son having these symptoms and what can be done to treat her son.

Task B3:

> Simulated work task scenario: While you were on hospital rounds a patient asked you this question –
>
> > "Why is dopamine a frequently used drug in critically ill patients?"
>
> You obliged and told the patient that you will provide some information the following day.
>
> Indicative Request: Find for an instance basic information to inform your patient as to why is dopamine given to critically ill patients and the benefits of giving them this drug.

Appendix D Simulated Situations For Medical Students

Task C1:

Simulated work situation: As part of your study of medicine it has been discussed why arterial blood gases (ABG's) are important. Now you want to learn more about this ABG's, why is it important and how is this test conducted.

Indicative Request: Find for an instance, information about why do we need to perform ABG's, how would you conduct an ABG test and what is included in ABG's.

Task C2:

Simulated work task situation: As part of your medical training, you have been tagging a senior doctor in the accident and emergency ward in a hospital. Yesterday, you observed a case where a mother brought in a toddler who appears to be choking but conscious. You were curious of the situation and would like to use MedlinePlus to learn how to treat the toddler according to the symptoms described.

Indicative Request: Find for an instance, information to treat the toddler according to the symptoms mentioned above and to learn more about the toddler's condition.

Task C3:

Simulated work task situation: As part of your medical training, you have been asked to complete morning rounds in a hospital ward. A medical officer (MO) doctor presents to you a case where a patient is recovering from acetaminophen or paracetamol poisoning. The MO has asked you to find out possible ways to best treat this patient and to report your findings the following day.

Indicative Request: Find for an instance, information on MedlinePlus to help you come up with step/s to treat the patient.

Appendix E Interview Questions for Personal Task

1. What is your personal task about?

2. Can you provide a brief description about it?

3. Why is searching for this task important to you?

4. Have you searched for your task before?

5. How long have you been searching for your task?

6. Do you search for your personal task on a regular basis?

Appendix F Post-Search Task Interview Questions

1. Did you find searching for this task: Easy/Neutral/Difficult?

2. I noticed you used (*these strategies*) in your search sessions. Could you explain why (*these strategies were used*). Did you find using (*these strategies*) useful/not useful? Can you explain why?

*querying assistance * results refining assistance * non-clicking *medical terms * ineffective queries *beyond 1st page *others

3. You experienced unsuccessful search sessions. Can you explain why you are not happy with returned results?

4. How do you rate searching for your personal task against the overall perception of task difficulty of the simulated situations? (searching for my personal task was easier than the simulated situations/searching for my personal task was of the same level of difficulty with the simulated situations/searching for my personal was harder than the simulated situations)

Appendix G Consent Form

MONASH University

Consent Form

Title: Understanding Medical Information Searching

NOTE: This consent form will remain with the Monash University researcher for their records

I agree to take part in the Monash University research project specified above. I have had the project explained to me, and I have read the Explanatory Statement, which I keep for my records. I understand that agreeing to take part means that:

List all procedures

I agree to be interviewed (pre and post)	☐ Yes	☐ No
I agree for activities to be logged and observed	☐ Yes	☐ No
I agree to make myself available for a further interview if required	☐ Yes	☐ No

I understand that my participation is voluntary, that I can choose not to participate in part or all of the project, and that I can withdraw at any stage of the project without being penalised or disadvantaged in any way.

I understand that any data that the researcher extracts from the interview / focus group / questionnaire / survey for use in reports or published findings will not, under any circumstances, contain names or identifying characteristics.

I understand that I will be given a transcript of data concerning me for my approval before it is included in the write up of the research.

I understand that any information I provide is confidential, and that no information that could lead to the identification of any individual will be disclosed in any reports on the project, or to any other party.

I understand that data from the interviews and observation logs will be kept in a secure storage and accessible to the research team. I also understand that the data will be destroyed after a 5 year period unless I consent to it being used in future research.

Participant's name:

Signature: Date:

MONASH University

18th May 2010
Explanatory Statement

Title: Understanding Medical Information Searching.

This information sheet is for you to keep.
My name is Anushia Inthiran and I am conducting a research project with Dr. Saadat a Senior Lecturer in the School of Information Technology and Prof. Pervaiz a Professor in the School of Business towards a PhD at Monash University. This means that I will be writing a thesis and several conference and journal papers for publication. You have been selected as a participant for this research study in response to the call for participants sent through email.

The aim of this study is to improve the search experience when searching on a medical domain. I am conducting this research to understand medical information searching. By participating in this survey you will help provide input to improve search strategies and the human computer interaction experience when searching on a medical domain.

The study involves the completion of interviews, collection of search sessions and a non-intrusive observation of user search behaviour. Total time taken for this process will not exceed 45 minutes. There is no inconvenience or harm related to you by participating in this research.

Being in this study is voluntary and you are under no obligation to consent to participation. However, if you do consent to participate, you may only withdraw prior to *start of the search activity.* Your name will not be linked to any information that you provide. The information that you provide is only limited to answers in the pre-experiment interview. It will not be possible for you to be identified in the final thesis or subsequent publications or presentations. Storage of the data collected will adhere to the University regulations and kept on University premises in a locked cupboard/filing cabinet for 5 years. A report of the study may be submitted for publication, but individual participants will not be identifiable in such a report. No information will be released to any other party. If you would like to be informed of the aggregate research finding, please contact Anushia at ▮▮▮▮▮▮▮▮▮▮▮▮▮▮▮▮ Thank you.

If you would like to contact the researchers about any aspect of this study, please contact the Chief Investigator:	If you have a complaint concerning the manner in which this understanding medical information searching research is being conducted, please contact: Project Number: CF10/1457-2010000782
Dr. Saadat M Alhashmi Tel ▮▮▮▮▮▮▮ Fax: ▮▮▮▮▮▮ Email:▮▮▮▮▮▮▮▮▮▮▮▮▮▮	Executive Officer Monash University Human Research Ethics Committee (MUHREC) Building 3 Room 111 Research Office Monash University VIC 3800 Tel: +61 3 9905 2052 Fax: +61 3 9905 3831 Email: muhrec@adm.monash.edu.au

Dear Participant,

Thank you for your willingness to take part in this study for the purpose of understanding medical search behaviour conducted on MedlinePlus.

As part of this research study you will be provided with 3 scenarios that describe situations which invite you to search for information by using MedlinePlus (http://www.nlm.nih.gov/medlineplus/). Your search has to be confined to MedlinePlus only.

You will first be interviewed prior to the search, then the simulated situations will be provided to you and you may begin to search task. You may stop searching once you have found satisfactory search results or unable to locate suitable result/s based on your perception of suitability/relevance. You will then be interviewed before proceeding to the next simulated situation. Upon completion of the interview, you may proceed with the next task. Your personal task will be rotated with the simulated situations.

Once again, thank you for your participation.

Best regards,

Anushia

Appendix J Non-Medical Professionals Personal Task Description

Participant 1: I have been having pain at the neck for quite some time now. I have already been to the doctor and the doctor says I have osteoporosis at the neck. At times it is very painful and I have to lie down. I want to know more about this condition.	Participant 11: I want to know about dandruff and what I can to do mange this.
Participant 2: My friend in my home country recently died from some disease called sickle cell anemia. I was just told about it yesterday by my parents. I want to know about this disease because I have not heard of it before.	Participant 12: I have been doing some research on the drug called penicillin, I want use MedlinePlus to see what else I can find out.
Participant 3: I am interested to lose weight, I think I am obese. I want to know what can I do to manage safe weight reduction.	Participant 13: I seem to have water retention at my legs. Especially now after my delivery. It hurts sometimes and I want to know what is happening. Is this normal?
Participant 4: I have eczema on my skin. I have been having it for years now. I am on medication but would like to know more about it.	Participant 14: My son has a birth mark on his body. I want to know if it is advisable to remove it?
Participant 5: I seem to be having menopause although I am in my mid 40's. The doctor says this is quite normal. However I am concerned and want to know if there are signs for early menopause.	Participant 15: I have white spots or pigmentation spots on my skin. Lately the spots have increased. Some people call this Michael Jackson's disease – let's see what information can be obtained from MedlinePlus.
Participant 6: A few days ago I had diarrhea but I don't know why. I did not eat anything weird and only I had it in my family.	Participant 16: I want to know if colostrum can reduce the chances of heart attacks.
Participant 7: I want to know more about the formation of gald bladder stones. My husband recently went for surgery to get them removed.	Participant 17: My friend is trying to get pregnant for some time now. She says there is something call an anti-pregnancy virus. I want to know if there is such a thing.
Participant 8: I have high cholesterol and want to know what changes in lifestyle I have to make. I already exercise regularly.	Participant 18: I seem to suffer from migraine often. I know there are certain foods that I cannot take because it will cause the migraine attack. What I want to know is why these food triggers my migraine.
Participant 9: My brother suffers from spinal cord injury. He has been bed-ridden for 6 years after a bad car accident. I know that nothing can be done but I would like to know how to care for him better	Participant 19: I think my mother has early signs of Parkinson syndrome. I want to know what these signs are so I can determine what to do.
Participant 10: I always have irregular periods. Why is this so?	Participant 20: My father is diabetic and recently cut his foot. He is old and now I am afraid this wound will take a long time to heal. Is there anything he can do to heal faster.

Participant 21: I seem to suffer from reflux after a meal. I want to if I can take medication to reduce this symptom	Participant 29: I suffer from sleep apnea. I understand this can be dangerous is certain conditions. Surgery has been suggested. I want to is surgery can really help.
Participant 22: My 45 year old cousin is pregnant for the first time. I understand that this is a very risky pregnancy. I want to know what time of complications can arise.	Participant 30: I recently underwent a keyhole surgery to repair a torn muscle. I want to know how to take care of myself better, post-surgery.
Participant 23: I am prone to sepsis as I am diabetic. I want to know if there are ways to minimise infection.	Participant 31: Are there certain foods I can consume to improve my immune system. Do vitamins really help.
Participant 24: I want to know what cancer markers are.	Participant 32: Are there any side-effects from taking aspartame?
Participant 25: Why is the intake of aspirin encouraged in the elderly for blood thinning?	Participant 33: What are early signs of Alzheimer's?
Participant 26: Is it advisable to take flu shots?	Participant 34: The pressure in my eye seems to be fluctuating. The doctor has diagnosed this as early signs of glaucoma.
Participant 27: What is the best way to reduce burn scars?	Participant 35: How does Cancer spread from one organ or part of the body to other parts?
Participant 28: I seem to have swelling at endocrine area under my arm pits. I notice this happens before my menses cycle. I would like to know why this swelling occurs, is my immune system weak?	Participant 36: What can I do to reduce water retention. Why isn't access water excreted from the body.

Appendix K Medical Students Personal Task Description

Participant 1: My teacher asked me to find out more about anorexia nervosa. We studied about it today during lecture.	Participant 16: Why do patients need to go for physiotherapy for cervical spondylosis.
Participant 2: I want to know how to treat vomiting and possible causes of this.	Participant 17: I want to know more about Hershberger disease. There is a patient in the ward that suffers from this.
Participant 3: I was on rounds today and witnessed a baby born with jaundice, I want to know more about why this happens.	Participant 18: What are causes of Hepatitis C. What treatment can be offered?
Participant 4: My patient was complaining about knee pain. So I just want to look it up.	Participant 19: This morning I had a patient who could not move his thumb on the right hand. He says there is pain and he can't bend it. Is this carpal tunnel syndrome?
Participant 5: Patient with vertigo and nausea was in the ward. What is this vertigo?	Participant 20: What are anti-histamines, are they effective in treating all types of allergies.
Participant 6: I want to know how to advise my patients that have diabetics on how to eat better and healthier.	Participant 21: How do I differentiate between COAD and asthma symptoms?
Participant 7: I just learnt about Glasgow coma scale today. I want to know more about this. I did not know there are scales for coma.	Participant 22: I have been asked to diagnose a patient who seems to be suffering from hypertension. I want to confirm the symptoms.
Participant 8: A girl just came in today experiencing a miscarriage. The doctor asked me to find out more about this.	Participant 23: Today I learnt about a drug called Lisinopril. I want to learn about what else can this drug do.
Participant 9: A patient asked the doctor if there are side effects of removing tonsils as he always suffers from sore throat. I want to know if there are any side effects.	Participant 24: Celebrex is a common drug consumed to athletics. However research says that this drug can also cause heart attacks. Is this true?
Participant 10: Today I learnt about blood work and blood count. I want to find out what else can blood work tell us.	Participant 25: What are treatment options for bone cancer?
Participant 11: A patient came in this morning with menorrhagia, I want to know how to treat her.	Participant 26: Can Meniscus injections relieve knee pain?
Participant 12: I want to know how to assess cosmetic breast surgery after cancer treatment	Participant 27: In some cases patients who suffer from food poisoning also experience fever. What is the relationship between food poisoning and having a temperature?
Participant 13: Can adults suddenly get asthma attacks? What are the causes for this?	Participant 28: I saw a patient today who was brought in because of an overdose of psychotropic drugs. What are psychotropic drugs?
Participant 14: What can be done to treat migraine, will drugs really help?	Participant 29: Why do patients need to go for physiotherapy for cervical spondylosis.
Participant 15: I want to find out about peripheral neuropathy. I have heard about it but don't know much about it.	Participant 30: Why do doctors recommended that stomach ulcers be operated on for removal?

Participant 31: Are there medication options of patients with Hepatitis C? Is it the same type of treatment with Hepatitis A and B?	Participant 35: Is rubella still a common disease? Does it only take place in females?
Participant 32: What are precautionary measures that a medical practitioner should take when dealing with a HIV positive patient.	Participant 36: Skin infections as a results of a tattoos may lead to hepatitis type disease. Can type of treatment can be offered to the patient.
Participant 33: Flush is common term used when performing dressing. I would like to know what does flush mean.	Participant 37: Is it possible that blood type can change when a patient with lupus withdraws medication?
Participant 34: Is atopic dermatitis caused by allergies?	Participant 38: How are auto immune diseases occur in the human body?