Understanding Exploratory Search in Seeking Health Information

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Abstract

The general public increasingly uses the Internet to access health information, but finding and discovering the right information remains problematic. We hypothesise that health websites do not have the features and the design required for obtaining health information, particularly the lack of support for exploratory search.

This research aims to improve the design of consumer health websites and health information seeking applications with an in-depth understanding of health information seeking behaviours. In this thesis, we will present a study that investigates the behaviours observed in health information seeking. The results suggest that exploratory search is used in health information seeking, in addition to the commonly used focused search approach. Moreover, people are found adopting and switching between search approaches for different scenarios. These findings are conceptualised into a model describing health information seeking behaviours.

Based on the model of health information seeking behaviours, we present a design for supporting the heterogeneous and shifting behaviours and improving the user experience. A proof-of-concept health website named Better Health Explorer was created to illustrate the design. We will discuss the rationale of the design, the features of this website, as well as how these features support health information seeking in this dissertation.

Finally, we will report on an evaluation on this website. The evaluation shows a positive impact on health information seeking after incorporating the elements from our proposed design, and highlights the necessity of designing for different health information seeking behaviours. More importantly, we have consolidated six design considerations that are crucial in supporting health information seeking behaviours. These design considerations should be applied in future designs of health websites, and are worthy to investigate further in future research.
Declaration

This is to certify that:

i. the thesis comprises only my original work towards the PhD except where indicated in the Preface;

ii. due acknowledgement has been made in the text to all other material used;

iii. the thesis is fewer than 100,000 words in length, exclusive of tables, maps, bibliographies and appendices.

Cheong Iao Pang
June 2016
Preface

This research is my independent work under the supervision of Assoc. Prof. Shanton Chang, Assoc. Prof. Karin Verspoor and Dr. Jon Pearce.

In my PhD candidature, I entirely carried out the planning, the data collection, the software implementation and the data analysis of this research.

The publications about this research were jointly written with my supervisors, who have expressed their permissions for incorporating parts of these publications into this thesis. I was responsible for the main writing of these publications.

Assoc. Prof. Shanton Chang assisted me to liaise with the Department of Health and Human Services of the Victoria State Government for their support of this research.
Publications

The following peer-reviewed publications were published in the candidature:


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### Abbreviations

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<th>Description</th>
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<td>BHC</td>
<td>Better Health Channel</td>
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<tr>
<td>BHX</td>
<td>Better Health Explorer</td>
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<tr>
<td>HCI</td>
<td>Human-computer interaction</td>
</tr>
<tr>
<td>HISB</td>
<td>Health information seeking behaviour</td>
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<tr>
<td>ISP</td>
<td>Information search process</td>
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<tr>
<td>IR</td>
<td>Information retrieval</td>
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<td>NLP</td>
<td>Natural-language processing</td>
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<td>UI</td>
<td>User interface</td>
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Chapter 1. Introduction

1.1. Introduction

The Internet has changed the way people find health information, or *health information seeking*. The use of online health information is very common among Internet users (Fox & Duggan 2013). Nevertheless, literature shows that *health information seekers* (defined as people who look for health information) face a number of difficulties in different aspects, such as findability (Eysenbach 2005; Toms & Latter 2007), accessibility (Johnson & Case 2012), readability (Eysenbach 2005; Lam & Lam 2012), and disengaging experiences (Palotti et al. 2016).

To understand the ways that people find health information, we have to introduce the concept of *exploratory search*, which is an important part of health information seeking. Search engines (e.g. Google, Yahoo!, Bing, etc.) are dominant for finding online health information (Fox & Duggan 2013). However, finding health information is different from general searching. For example, health-related searches
involve certain degree of uncertainty (Wilson 1997), and lay-people do not possess enough knowledge about the health and medical discipline (Keselman et al. 2008). Also, different scenarios cause health information seekers to demand different types of information (Alzougool et al. 2013). These make health information seeking even more complicated and harder, as it is hard to specify these criteria in search engines. Also, the uncertainty in the process of searching often triggers exploratory search (White & Roth 2009), which requires learning and foraging in a wider scope of information (Marchionini 2006). Again, mainstream search engines do not directly support exploratory search (White et al. 2006). These issues highlight the opportunities for rethinking the approaches and the technological support of health information seeking.

An example can illustrate the problems in health information seeking. Imaging a woman with a cough and runny nose who would like to find some information about her health issues. She does not know the exact sickness nor the most accurate keywords for her situation. Then, she simply inputs “cough and runny nose” into Google. Skimming the list of search results, she does not know which one is right and decides to read a few pages. At this moment she is doing exploratory search because she has little idea about what specific illness that her symptoms may correspond to. She jumps back and forth among web pages and the search results, clicks on some links and learns more knowledge, before getting a rough idea about the possible sickness (for example: flu). With this information, she may go back to Google and focus on information about flu. Soon, she needs to search for other aspects of flu, e.g. treatments of flu, and read another bunch of web pages. While she finally obtains the information, the process would be tedious and repetitive, and the user experience would be unsatisfactory.

Besides, the disparities between the characteristics of health information seeking behaviours and the provision of online health information add complexity to finding and accessing health information. For instance, health websites present information that does not match the levels of health literacy of readers; they may be too simple for the readers or too hard to understand (Cline & Haynes 2001; Birru et al. 2004; Lam & Lam 2012). Usability problems and a lack of perceived usefulness cause users
feel less engaged and less persistent with health websites (Eysenbach 2005; Hardiker & Grant 2011). Being consistent with other work (Nordfeldt et al. 2013; Alzougool et al. 2013; van Gemert-Pijnen et al. 2011; Lee et al. 2015), these examples suggest the importance of designing health websites according to users’ needs.

This research aims at understanding these behaviours, identifying challenges in online health information seeking from a user perspective, and systematically designing web technologies that better serve different health information seeking behaviours, and thus improving user experience. In addition, as current literature acknowledges exploratory search in the health context and the lack of its support, we seek to understand the role of exploratory search and the feasible design for supporting it in the process of health information seeking.

The investigation involves multiple disciplines, including human-computer interaction (HCI), interaction design, information science and software engineering. As an information science research, health information seeking behaviours were studied and conceptualised with the lens of designing. From the HCI and interaction design perspectives, the user-centred design approach is used to inform the design for health information seeking. Finally, software engineering techniques are used to create a proof-of-concept software for demonstrations and evaluations.

### 1.2. Background and Motivation

The emergence of the Internet has transformed the way of obtaining information, including health and medical information. Now, a large amount of health information, ranging from healthy lifestyle advice to medical details of diseases, is conveniently available from various sources such as official government websites, private health service websites and online community forums. As reported in different studies, many Internet users choose to search for health information on the Internet and the number of such users has been increasing (Fox and Jones, 2009; Fox
Chapter 1. Introduction

and Duggan, 2013). Based on this trend, research aiming at improving the user experience of accessing health information will benefit a substantial amount of users.

While searching for general information has been studied much in academia (Broder 2002; Silverstein et al. 1999; Johnson et al. 2004; Rose & Levinson 2004), searching for health information requires different focuses and more considerations. Health information seeking presents a set of complex challenges that involve both human and technological factors, as outlined below:

1. Varying levels of digital and health literacy of seekers
2. Limitations of keyword-based search engines in the health context
3. The characteristics of health information seeking behaviours
4. The different design of consumer health websites

First of all, search engines are the most intuitive and popular options for people who need to access information on the Internet, including online health information. Researchers have discovered that a majority of web surfers use search engines as the starting point for their journeys of hunting for health information (Fox & Duggan 2013; Spink et al. 2004). However, using search engines for health information causes more problems than people may think. Keyword-based search engines have been shown to be limited and unsatisfactory for online health information (Keselman et al. 2008; Luo et al. 2008). Another particular problem with keyword search is that lay-people are often unable to describe health problems with accurate terminology (Keselman et al. 2008; Luo et al. 2008; Chapman et al. 2003). Moreover, health-related searches often introduce uncertainty (Wilson 1997; Johnson & Case 2012). Users may not have a clear diagnosis at the time of searching, or they may only see parts of the syndromes, thus they have little idea about the things that need to be searched. Apparently search engines are not the best tools for these scenarios, as they are designed to best handle known-item searches (Singer et al. 2011).

Secondly, when people search under uncertainty, such as in the process of health information seeking, people will take the exploratory search approach to find information (White & Roth 2009). Comparing with other search approaches, exploratory search adds learning and foraging experiences into the search process,
and seekers are often found engaging with discovering a wider scope of information (Marchionini 2006). As exploratory search is not supported well by search engines (White et al. 2006), health information seekers need to perform exploratory search in more complicated ways. For example, they need to try different search queries and update the keywords frequently along the query reformulation process. While relevant and useful information exists, seekers often fail to discover. Therefore, this dissertation argues that supporting exploratory search is one of the key aspects in assisting health information seeking behaviours.

Several design problems are also burdens for health information seeking. Health websites are found to provide health information that does not match the level of health literacy of the targeted audience (Cline & Haynes 2001; Birru et al. 2004; Lam & Lam 2012). Usability issues lower the engagement and satisfaction of using health websites (Hardiker & Grant 2011; Eysenbach 2005). Some design of health websites uses a cluttered layout and makes the content difficult to read; or the user interface is difficult to use and navigate. These examples reinforce the importance of considering the characteristics of health information seeking behaviours, which have been suggested in previous research (Alzougool et al. 2013; Nordfeldt et al. 2013; van Gemert-Pijnen et al. 2011; Lee et al. 2015), in the design of consumer health websites.

The background discussed above outlines how people look for health information, as well as the weaknesses and difficulties with the current approach. These issues are the motivations of this research, and the outcomes will contribute to deliver a better user experience for health information seeking. Next, the research questions for guiding this research will be framed and further discussed.

### 1.3. Research Questions

The main research goal is to design web technologies that better support the information seeking behaviours exposed from health information seekers, as well as the search approaches used within the process. In this regard, the key research question of this project is:
RQ: How can web technologies be designed to facilitate diverse information seeking behaviours within the health context?

In order to approach this main research question, three categories of sub-questions are decomposed. In the following section, the aims of these research components and the associated research sub-questions will be explained.

1.3.1. Understanding Health Information Seeking Behaviour

People demonstrate different behaviours in the hunting of health information, even for the same scenario. Current research has not revealed yet in detail how to design for the diverse health information seeking behaviours. On the other hand, the behaviours exposed in the process of health information seeking can be affected by multiple factors, such as information needs, search goals, the targets in search instances, etc. Before looking into the design of improving the user experience in health information seeking scenarios, we need to understand how people generally conduct their searches, and how they move forward and forage for more knowledge in the health information seeking process.

To guide this phase of research, these research sub-questions are composed:

RQ1-1: What factors have impact on the behaviour of health information seekers?

RQ1-2: How do health information seekers demonstrate their information seeking behaviours in terms of their usage patterns?

Research sub-question RQ1-1 looks into the factors causing people to use different search approaches in the health information seeking process. In some circumstances, for example, when the health issue links to a family member, people take the exploratory search approach in the seeking process. This causes people to behave differently and changes the ways of searching. In this regard, the factors that drive such changes are thoroughly examined for supporting both health information
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seeking behaviours and different search approaches.

Another goal of this research phase, as directed by RQ1-2, is to analyse the usage patterns (such as search queries, page reading, link following, etc.) that occur in the health information seeking process. The usage patterns display the user interactions and duration of engagement with web-based information systems, such as search engines and health information websites. Also, these patterns illustrate how exploratory search and other search approaches can be observed with user interactions and usage data. The understanding of the activities and patterns of health information seekers helps in identifying design opportunities for supporting different search approaches in the health information seeking context.

1.3.2. Designing for Health Information Seeking Behaviours

Based on the literature review, while there are many existing theoretical frameworks in the information science and health information systems disciplines, they are rarely purposed for designing interactive technologies. To bridge this gap, this research develops a model for informing design guidelines of web technologies in this research phase, with the following research sub-question:

RQ2-1: What is a model of health information seeking behaviour that will support the design of interactive technologies?

Furthermore, designing for web technologies needs concrete plans and requirements to guide the design and implementation. Merely theoretical frameworks are not sufficient for these purposes. Therefore, this phase of the PhD research also targets at deriving the feasible design principles, from the conceptualised model from RQ2-1, which are useful to the designers of building health websites. Also, this research phase also explores the possible designs and features for facilitating effective health information seeking. As such, an additional research sub-question is posed:

RQ2-2: What are the design requirements for a consumer health website for better supporting health information seeking behaviours?
1.3.3. Evaluating and Summarising the Design

The last phase of this research is to evaluate the design proposed in previous studies, to understand the impact of the design, and to generalise design considerations for future health websites. In addition, this part of the research is to trial the support for exploratory search with new interaction techniques, as well as to validate the new design. The evaluation provides reflections and evidences for supporting the previous findings in this dissertation. The research sub-question for this phase is:

\[ \text{RQ3-1: How can the design of consumer health websites support the full range of health information seeking behaviours?} \]

The research sub-question drives two goals in this research phase. First of all, the analysis identifies the factors that are effective and successful for different types of health information seeking behaviour. This provides reflections and empirical justifications for the design formulated in the prior studies. On the top of that, this research aims to identify the types of improvements needed for the current user interfaces of consumer health websites, in order to support different health information seeking behaviours.

1.4. Aim and Scope

The broad contribution of this research is positioned in online health information seeking. Health information seeking is an umbrella term that covers different kinds of components (such as information needs, search activities, health websites and apps) and involves different groups of users (such as medical practitioners, patients, general consumers). Despite this diversity of components and user groups, we have restricted our focus in this research to a smaller scale, which will be explained below.

Firstly, the scope of this research remains in the consumer health informatics discipline. The online health information investigated in this thesis refers to web-based health information targeting at the general audience, i.e. people without
medical expertise or professional knowledge. Secondly, the subjects investigated are lay-people with the ability to use and search on the Internet, instead of user groups with expertise (e.g. health professionals or researchers).

We solely investigate and conceptualise health information seeking behaviours on desktop computers in this research, although we are aware that using mobile phones for accessing online health information is another ongoing trend (Lim et al. 2011; Boruff & Storie 2014; Pandey et al. 2013). A study shows that 31% of the U.S. adults have used mobile phones to look for health or medical information (Fox & Duggan 2013). Younger people tend to use phones more for this purpose (Fox & Duggan 2013; Glynn et al. 2013). However, since this research aims to gain an understanding of basic information seeking behaviour without the distractions and limitations imposed by mobile devices, and the mobile environment is still undergoing rapid changes, we exclude mobile health from the focus of this research.

Additionally, mobile health apps and self-management apps have become another interest of the health informatics discipline after the dominance of smartphones (Taki et al. 2015; Cho et al. 2014; Heffernan et al. 2014; Heffernan et al. 2016). However, rather than seeking for health topics in the entire scope of the web, these apps often provide information about a specific topic or purpose, including but not limited to: cancers (Bender et al. 2013; Heffernan et al. 2014; Heffernan et al. 2016), parenting (Taki et al. 2015; Scott et al. 2015), and smoke- quitting (Ploderer et al. 2014; Paay et al. 2015). As mobile apps often target a specific cohort of people, instead of the general audience, we do not investigate mobile apps in our studies.

The goals of this research are identifying design improvements and supporting different health information seeking behaviours, including the exploratory search activities, by obtaining a deeper understanding of how people currently find health information. We focus on people’s information seeking behaviours and their interactions with health websites, rather than identifying and classifying different kinds of information seekers as other research does (Chin et al. 2009; Hersh 2009; Higgins et al. 2011; Chin & Fu 2012; Agree et al. 2015).
While there are other research directions that are relevant to health information seeking, such research does not fall within our research scope, including: addressing trust issues in health searches (Sillence et al. 2006; Kalinov et al. 2010), improving the quality of the content on the Internet (Commission of the European Communities 2002; Boyer 2013), allowing users to identify quality health websites (Boyer et al. 1998; Eysenbach 2005), and even aesthetics of designing websites and interactive technologies (Reinecke et al. 2013; Kim 2014).

After defining our research scope, in the next section, we will further explain our research design and methodologies used in our studies.

1.5. Research Design

1.5.1. Design-oriented Research

This research mainly follows the design-oriented research approach (Zimmerman et al. 2007; Fallman 2005; Fallman 2007). This research approach consists of multiple stages, which start with understanding and defining the research problem. Then, researchers design a solution for the problem and build an artefact with the design. Finally, the artefact will be tested and evaluated against human users. The results collected in the evaluations can be used as reflection to refine and improve the design. The lessons learnt from the process are generalised as new knowledge and contribute to academia (Obrenović 2011). These stages are not necessary in a linear sequence but iteratively (Easterday et al. 2014).

In the design-oriented approach, design is the means through which we seek to produce new knowledge by involving design activities in the research process (Fallman 2005). Artefacts are designed and created to provide concrete embodiments of theory and technical opportunities (Zimmerman et al. 2007). Design-oriented research can produce knowledge that normally could not be generated by other theoretical analysis or traditional empirical approaches, as it systematically enquires
Chapter 1. Introduction

into a real-world context (Obrenović 2011). From the HCI perspective, the contributions of the research should be novel integrations of theory, technology, user needs, and context, instead of refinements of existing products in literature or commercial markets (Zimmerman et al. 2007).

Similarly, Design Science is a research method that focuses on designing artefact using iterative research cycles (Hevner et al. 2004). In this project we choose the design-oriented research method over the Design Science method because of the better perspective provided by the design-oriented method. Design Science is often used in the information systems area to investigate the impact of the artefact inside an organisation, while the design-oriented approach looks at the interaction between people and the artefact. The research angle of the design-oriented approach is more appropriate for a project with a HCI focus.

The user-centred design process is adopted as the design component in the design-oriented research approach. This design process iteratively involves users and stakeholders in both design and development stages. The needs of users performing certain tasks are studied thoroughly before building a design in each iteration (ISO 2010). The advantage of the user-centred design process is to produce a deeper understanding of psychological, organizational, social and ergonomic factors that affect the use of technology, and such factors can be obtained through the design and evaluation stages in each iteration (Abras et al. 2004).

1.5.2. Research Outline

To make the entire research more manageable and achievable, a preliminary study as well as three phases of investigations were undertaken within the timeframe of the PhD degree. Each research phase contains multiple sub-questions and a number of studies for exploring the answers to these sub-questions. The preliminary study and three research phases are outlined in Table 1-1 (next page).
### Table 1-1: Research phases defined in this PhD thesis

<table>
<thead>
<tr>
<th>Phase</th>
<th>Research Goals</th>
<th>Methodologies</th>
<th>Data Collected</th>
<th>Outcomes</th>
</tr>
</thead>
</table>
| Pre.  | Obtaining an overview of health information seeking behaviours | - Descriptive analysis  
- Computational analysis | - Website statistics  
- Search keywords | - Types of information searched  
- How do people search |
| 1     | Build an in-depth understanding of health information seeking behaviour | - Lab-based observation  
- Qualitative | - Interviews  
- Activity logs  
- Screen recordings | - Search approaches used  
- Behavioural patterns  
- Factors for choosing search approaches |
| 2     | Design for health information seeking behaviours | - Qualitative  
- User-centred design | (Use data from Phase 1) | - Model of seekers  
- Design principles  
- Prototype website |
| 3     | Evaluation of design and generalising the results | - Lab-based observation  
- Mixed-method | - Interviews  
- Activity logs  
- Screen recordings  
- Survey responses | - Insights for future design  
- Performance of the design  
- Effectiveness of the design |
The preliminary study reviews the visitor statistics of a live consumer health website. The study uses descriptive and computational analyses to gain an overview of Australian health information seekers, e.g. what they search in the website, and how they use the website for health information seeking. The findings highlight directions and points of emphasis for the subsequent phases of research.

The first research phase mainly takes a qualitative approach to understanding health information seeking behaviours with the current web technologies. We conduct a lab-based experiment and ask participants to search on the web with pre-defined health scenarios. In the experiment, web activity logs and screen recordings are captured for analysing the patterns of health information seeking behaviours. In order to gain richer feedback from the study, a retrospective semi-structured interview is conducted for each participant after the search tasks.

The second phase includes both theoretical and technical work for designing for health information seeking behaviours. A model for describing health information seeking behaviours is formulated by applying qualitative analysis techniques to the findings from the first phase of research. Next, the analysis will summarise the characteristics of different types of seekers into design requirements to guide the implementation process. After that, a proof-of-concept website for demonstrating an application of our design is created in this research phase. This website can show the feasibility of applying the design principles with the widely-used web design approaches. Additionally, the website can provide an opportunity for carrying out evaluations against the design principles in the next stage of research.

Lastly, the third phase of this research is an evaluation of the design principles. The evaluation is mainly conducted through a lab-based experiment using a mixed research method. In the lab experiment, participants need to use the proof-of-concept website (the technical product from the previous research phase) to find health information. They will also use a traditional health website with the same content for comparison purposes. After using both the prototype website and the health website, participants are invited to express the motivations and thoughts. Questionnaires are used to capture the magnitude of certain emotional properties
and self-assessment in the seeking process. In addition, we carry out interviews after the search tasks. Qualitative data such as screen recordings and interview transcripts are used for further data analyses. Both qualitative and quantitative data are used for generalising design considerations for future health information websites and health information seeking applications.

1.5.3. Methodologies

We use lab-based observational experiments in different research phases. This type of study can capture all types of information in the course of information seeking, such as web browsing activities, navigation traits, screen recordings, etc. Lab studies generally follow this protocol: participants will be given a task description, followed by performing the task on a computer. At some points of the study, semi-structured interviews are also used to gain the thoughts of information seekers. A similar approach has been used in a number of other research projects about health information seeking (Eysenbach & Köhler 2002; Hansen et al. 2003; Birru et al. 2004; Buhi et al. 2009; Haak & Hooijdonk 2010).

For data analysis, this research uses multiple methodologies to gain insights from the data obtained in the studies. Qualitative data such as interviews and video recordings is processed with thematic analysis methods. Thematic analysis is a common methodology to identify themes (i.e. patterns) associating with research questions in qualitative data (Braun & Clarke 2006; Greg et al. 2012). Web browsing and searching activity logs are another kind of qualitative data. They are coded based on the nature of actions, and then a sequence of actions will be grouped into a category which shares similar patterns. Similar analysis strategies are used in a previous study. (Perez et al. 2015). Additionally, a grounded theory approach is taken to construct or extend existing theories and models (Martin & Turner 1986), with the new findings emerging from the data collected.

For the evaluation phase, prior work from multiple areas is referenced to design the studies. Taking exploratory search as an example, we refer to a number of methods
of evaluating exploratory search in other research (Kraaij & Post 2006; Kules et al. 2009; Singer et al. 2011; Wildemuth & Freund 2012; Klouche et al. 2015). Key factors of exploratory search, for instance uncertainty, degree of exploration, creativity and knowledge discovery are measured in the evaluation (Hendahewa & Shah 2015). Besides, usability assessments are also important components in the evaluations. Usability is assessed with the guidance of standard questionnaires, such as the System Usability Scale (SUS) (Brooke 1996), and the User Engagement Scale (UES) for exploratory search (O’Brien & Toms 2013).

1.6. Contributions

This section outlines the major contributions of this research. These contributions are grouped into four areas as presented below.

1.6.1. Search Approaches in Health Information Seeking

This research investigates different search approaches that occurred in the duration of health information seeking. The distinction between focused search and exploratory search is identified using literature review. The thesis aims to understand the use of the two approaches in health information seeking, what factors change the two approaches used in the process, when seekers adopt a certain type of search approaches, and how different search approaches diversify the actual information seeking behaviours. Additionally, since current search engines do not adequately support the exploratory search approach, seekers develop their own strategies to perform exploratory search. This study aims to summarise the behavioural patterns of the strategies for handling exploratory search without a proper supportive environment. In general, these findings contribute to a more complete understanding of search approaches in health information seeking, as well as highlight directions for the design of health websites for supporting exploratory search.
1.6.2. Model of Health Information Seeking Behaviours

This research conceptualises different health information seeking behaviours into a model. While there are a number of existing models describing both general and health information seeking behaviour, few of them have a focus of aiding the design process. Therefore, the focus of this model is to capture a combination of the characteristics of health information behaviours, in terms of the behavioural patterns recorded during the seeking process, for guiding the design of health websites and health information seeking applications. Each type of health information seeking behaviours is expected to demonstrate certain characteristics. These characteristics can be used as requirements to formulate the actual design, which satisfy the particular needs of information seekers.

1.6.3. Design and Implementation

This research will produce a list of design requirements to guide the implementation of a testing consumer health website, with the focus on catering for various health information seeking behaviours. These requirements capture the activities of seekers that arise in the course of searches, as well as techniques that can assist in the use and switching among different search approaches. This part of the research will also investigate the practical user interface designs which satisfy different user behaviours exposed in the process of health information seeking.

Additionally, the design phase of this research implements a prototype website that assembles the design discussed above. The website showcases a number of user interface elements that comply to the design for health information seeking behaviours, showing that the design could be applied to an empirical setting. Furthermore, this website serves the purposes of carrying on the evaluation phase of research and demonstrating possible future applications to our partner – the Better Health Channel team in the Department of Health and Human Services of the Victoria State Government. The team maintains one of the most popular consumer
health websites in Australia. There will be more information about the team and the website in Section 3.1.

1.6.4. General Design Considerations for Health Websites

The last part of this research is to verify the effectiveness and the performance of supporting health information seeking through the proposed design, and to summarise general design considerations for consumer health websites and health information seeking applications. This includes studying how the actual health information seeking behaviours are supported by the new design, and how information seekers respond to the new design. An evaluation on the prototype will be conducted to collect this information. Designers and software developers are able to improve the effectiveness and usability in the design of consumer health websites using these research outcomes. From the academic perspective, the outcomes will inform directions of future research in the HCI and health informatics disciplines. Additionally, the methodologies of the evaluation contribute to the study design of evaluations for health information seeking behaviour and exploratory search.

1.7. Thesis Outline

Chapter 2 presents a detailed literature review on the topics of this dissertation, which include the general perspective of online health information, current research about information needs, information seeking behaviour, and health information seeking. Moreover, the chapter introduces exploratory search, which is another search approach for finding online information. Finally, the literature review assesses and compares a number of innovative user interfaces for information seeking. Based on these reviews, the research opportunities of this PhD research are explained at the end of the chapter.
Chapter 3 reports on a preliminary study on Better Health Channel, which is known as one of the largest consumer health websites. This preliminary study has examined the statistics of visits to the site, in order to strengthen the research questions by using real user data in the Australian context. The results suggest a few focuses for the qualitative research in the latter part of the project.

Chapter 4 describes a qualitative lab observation study for conceptualising health information seekers (Research Phase 1). Participants were invited to the laboratory for search health information. Computer screens and activity logs were captured to identify behavioural patterns in the process of health information seeking. Semi-structured interviews were also conducted to gather participants’ past experience on health information seeking. The findings of this study consist of observations about focused and exploratory search in the health domain, and a deeper understanding of exploratory search in health information seeking.

Chapter 5 further develops the theoretical framework of health information seeking behaviour to generate design principles for building consumer health websites (Research Phase 2). This chapter will also discuss the behaviours observed in the health information seeking process, and how design improvements can address these behaviours. A proof-of-concept website Better Health Explorer implemented the design and were used as a probe for the next stage of research. This chapter will briefly describe the features included in Better Health Explorer.

Chapter 6 presents an evaluation on the proposed design principles using Better Health Explorer (Research Phase 3). This study is a lab-based study using mixed research method approach. Participants were asked to find online health information using both Better Health Explorer and a general health website. Qualitative and quantitative data were both collected to compare two websites, and obtain the advantages and the disadvantages emerged in the study.¹

¹ Parts of the publications published in this PhD candidature has been integrated into Chapter 4-6 and Appendix B.
Chapter 7 synthesises the findings of this PhD research. This chapter discusses the problems of health information seeking, the theoretical framework for solving the problems, the design principles for health website designers, and the lessons learnt in this research. Then, we will summarise the contributions, the limitations and challenges of this research. Finally, this chapter will discuss future work and other potential applications that have arisen from this research.
Chapter 2.

Literature Review

2.1. Introduction

This chapter reviews the relevant literature for this research. Section 2.1 and 2.2 present a brief overview of concepts regarding online health information and health information behaviour on the Internet. Section 2.3 reports on the information seeking theories for aiding the investigations of human information seeking process. After that, exploratory search, which is a common used search approach for health information seeking, is explained in Section 2.4. After reviewing the fundamental research, Section 2.5 explores how to design for exploratory search with the inspirations from other design work and design elements of serendipity. Finally, this literature review and the research opportunities that arise from the current literature are summarised in the last section of this chapter.
2.2. Online Health Information

2.2.1. Overview

Consumers increasingly choose to obtain information on their own (Boyer 2013; Fox & Duggan 2013; European Commission 2015). With the growing availability and speed of the Internet, it has become more convenient to access a number of online health resources, ranging from healthy lifestyle advice to medical details of diseases. Such information is readily available in various sources including official government health websites, private health service websites and online community forums. According to different studies (Donnelly et al. 2008; Horgan & Sweeney 2010; Jones et al. 2014), the Internet seems to be the fastest, most economic and most convenient way to obtain health information. Additionally, thanks to the principle of patient autonomy, i.e. “physicians make recommendations but patients make the final decisions” (Goldman & Schafer 2011) (p.3), people may prefer to retrieve health information by themselves to assist their decision making processes (Davison et al. 2002; Hersh 2009). All these factors motivate lay-people to access health information from the Internet. However, people are observed to be less engaged and persistent with health websites due to various design and usability problems (Hardiker & Grant 2011; David Johnson 2014; Palotti et al. 2016).

The Internet has become an important source for people looking for health information. A study showed 72% of U.S. Internet users at some point have tried to access health information online, and 77% of these people used search engines to start looking for health information (Fox & Duggan 2013). From another perspective, Spink et al. discovered that 7.5% of queries submitted to search engines were related to medical or health information (Spink et al. 2004). In an observation study conducted by Hansen et al. for clarifying how people find health information, in 60 out of 68 cases, people looked into the results provided by search engines (Hansen et al. 2003). It is clear that a large portion of Internet users utilise online health
information, and searching is a critical strategy for obtaining online health information, in addition to browsing health websites.

In summary, research has found that the Internet has become an importance source of health information, and people use search engines to look for online health information most of the time. Mobile websites and apps have begun to gain momentum in health information seeking, however, this research focuses only on health information seeking behaviours with search engines on desktop computers. This is because we want to avoid the constraints and limitations imposed by mobile devices. Additionally, health information seeking in desktop environments is still widely adopted by information seekers in different demographic groups.

### 2.2.2. The Use of Search Engines

While the utilisation of search engines is the primary method for accessing online health information, it has been shown that keyword-based search engines are unsatisfactory for health information seeking scenarios. Lay people generally have insufficient medical knowledge to describe health problems accurately (Keselman et al. 2008; Zhang 2011), and thus search results are often unsatisfactory due to the poor quality input to search engines (Chapman et al. 2003; Keselman et al. 2008; Luo et al. 2008). To minimise this problem, others have suggested that search engines should be specifically optimised for health search queries (Berland et al. 2001; Benigeri & Pluye 2003). With such unsolved issues in the tools for obtaining online health information, Toms and Latter even describe searching of health information as a “trial-and-error” process (Toms & Latter 2007). In additional to problems involved in locating and retrieving the information, consumer health websites are found to contain information that does not match the health literacy of readers (Cline & Haynes 2001; Birru et al. 2004; Lam & Lam 2012), but search engines are yet to return results filtered by levels of health literacy.

A number of studies have discovered that the Internet has been used as the source of a range of health information types, which can be summarised as follows:
• Conditions, symptoms and diseases information (Johnson & Meischke 1991; McMullan 2006; Andreassen et al. 2007; Fox & Jones 2009; Fox & Duggan 2013)
• Treatment and drug information (Bessell et al. 2002; Nicholas et al. 2003; Paul et al. 2016)
• Information for keeping a healthy lifestyle and maintaining a balanced diet (Andreassen et al. 2007; Gavgani 2010)
• Social networking, such as finding patients with similar symptoms and locating online community support groups (Nicholas et al. 2003; Andreassen et al. 2007)
• Getting information about medical providers (Fox & Jones 2009; Andreassen et al. 2007)
• Obtaining caregiving information, for instance, information for parents who care for their illness child (Shiffman et al. 2001; Wainstein et al. 2006; Khoo et al. 2008; Epstein et al. 2010)
• Looking for information on behalf of other people (Abrahamson et al. 2008; Cutrona et al. 2015)

While the above studies were focused on the usage of online health information in developed countries, recent research reveals similar trends in developing countries (Gavgani 2010; Kitikannakorn & Sitthiworanan 2011; Inthiran et al. 2013; Saad et al. 2013). The categories of information that people in developing countries seek for are comparable to the ones in developed countries, for example diagnosis and treatment information, drug information and information for fitness. However, due to language barriers and low health literacy, health information seekers in developing countries face more challenges in accessing Internet health information (Ciampa et al. 2012; Ajuwon 2015).

Many of the above studies have analysed the behaviour of searching for health information using logs of search queries (Graham et al. 2006; Herskovic et al. 2007; Toms & Latter 2007; Cartright et al. 2011; White & Horvitz 2009; Paul et al. 2016). This method has a main drawback which is that it is unable to capture seekers’ mind changes and activities before and after the actual search. Hence, our research takes
another angle, that is to focus on the entire process of health information seeking behaviour, beyond the search queries.

It is apparent that obtaining health information from the Internet is popular and useful in many scenarios. As we have described, while plenty of Internet users rely on search engines for health information, a number of limitations have been pointed out with this approach. It is crucial to understand how people search for health information and what their needs are, in order to identify and rectify the existing problems. For this reason, research about health information seeking, which will be discussed next, is the entry point of this research.

2.3. Concepts of Health Information Seeking

2.3.1. Health Information Seeking Behaviour

*Health information seeking* is a series of interactions to “reduce uncertainty regarding health status, but also to construct a social and personal (cognitive) sense of health.” (Tardy & Hale 1998) (p.338). Lambert and Loiselle use the term “*health information-seeking behaviour*” (HISB) for obtaining information about their health, health promotion activities, risks to one’s health, and illness (Lambert & Loiselle 2007).

Some have described the health information seeking process as a sense-making one (Wilson 1999; Case 2002; Wilson 1997). Finding health information is an attempt to bridge a knowledge gap, whichever appears whenever people perceive there is not enough information in their minds to handle the situations currently faced. As such, health information seeking is deemed to be a measure to fill the blank and make sense of the information.

Several outcomes associate with health information seeking behaviour. After seeking, people usually gain more knowledge (Andreassen et al. 2005), make more informed decisions (Davison et al. 2002; Hersh 2009), and perceive increased control
about the health scenario (Echlin & Rees 2002). Also, it brings better discussions with health professionals (Andreassen et al. 2005) and better self-caring abilities (Gray et al. 2005). But, sometimes people have an escalation in their medical concerns after searching on the Internet (White & Horvitz 2009). Generally speaking, health information seeking behaviour is desired in many situations (Lambert & Loiselle 2007).

Health information seeking behaviour is different from general search in many ways. Firstly, health information seeking behaviour introduces uncertainty in the process which influences the seeking behaviour (Johnson & Case 2012; Wilson 1997). Secondly, health information needs are hard to express with search queries (Keselman et al. 2008; Luo et al. 2008; Chapman et al. 2003). Thirdly, the health literacy of seekers affects the outcomes of health information seeking (Lam & Lam 2012), whereas general searches do not typically require special literacy skills. Moreover, people have expectations of quality and reliability when using health information, and thus guidelines for consumer health websites have long been proposed (Commission of the European Communities 2002; Boyer et al. 1998; Boyer 2013). Hence, the study of health information seeking behaviour has to consider the above characteristics, and is more complex than the research of general information seeking behaviour.

The research discussed above gives an overview of seeking for health information, and how health information seeking differs from other seeking. Scholars have also found that multiple motivations drive health information seeking. Next, this dissertation will present a deeper understanding about health information needs, that is argued to have impact on the actual information seeking behaviour.

2.3.2. Health Information Needs

Scholars have suggested that health information needs arise when someone realises their existing knowledge is inadequate to satisfy their goals about health and this may trigger health information seeking as an outcome (Williamson 1997; Case 2002;
Hersh 2009). For example: someone is diagnosed with a health problem and they have no knowledge of the problem at all; this creates an information need and leads to information seeking behaviour.

Stressful feelings and anxiety from health status motivate health information seeking as well. Consider this example: at the beginning of a sickness, people may feel anxious due to symptoms that have appeared, as well as feeling worried about their current health status, and then begin to look for related information. This example can be explained by Wilson's stress/coping theory (Wilson 1997; Wilson 1981), which proposed that people feel stressed and uncertain while facing threats (e.g. a health problem) and consequently look for information to reduce the stress and uncertainty.

Information needs is not solely used in the health context, but also in other areas. Information needs in the generic context can help us to further understand health information needs. Gorman classified information needs into four types: recognised, pursued, satisfied and unrecognised (Gorman 1995; Gorman 1999). This classification implies only some of the needs will be perceived and recognised by human. Further, Sharpe and Ross used an iceberg metaphor (Figure 2-1) to illustrate health information needs (Sharpe & Ross 1990). The part of iceberg above the sea surface, which represents recognised needs, is most studied by information researchers. This type of information need and behaviour can be observed and captured when an individual realises the search target and chooses to demand the information. However, there is a large portion of unexplored area in the lower part of the iceberg underneath the surface. These areas include information needs that are satisfied (i.e. the needed information has been obtained), recognised needs that are not demanded, and needs that are not even recognised by people.
Based on these frameworks, Alzougool et al. further derived an abstract model for describing health information needs (Alzougool et al. 2008; Alzougool et al. 2013), as displayed in Figure 2-2. The framework formulates health information needs in two dimensions, which will be reviewed accordingly.

Recognised needs are often observed in health information seeking. A person looking for detailed information about certain health conditions falls into the "recognised demanded" category. Conversely, people may choose to refuse or avoid information that relates to them (O’Brien 2004; Clark 2005; Lambert & Loiselle 2007),
which can be seen as undemanded needs. For example, patients with a severe disease such as cancer may choose to deny information, possibly to avoid the negative psychological effect on coping with the disease.

Another main category of health information needs is unrecognised needs. Unrecognised needs are information needs that seekers have not clearly identified, but they somehow feel that some vague information is important for the health scenario (such as caring for a patient). For instance, patients often think that information related to raising children is needed, but they cannot identify actual topics to read on. Seekers with unrecognised needs may also choose not to demand the information immediately, as time constraints may forbid them to do so (Gage & Panagakis 2012; Kostagiolas et al. 2013). In other cases, people may be alerted to some alarming health concern, such as hearing of the death of a celebrity on the radio (Dean 2015). The information needs arisen from these scenarios are unrecognised needs too.

Information needs are abstract motivation in seekers’ minds, but how do these needs transform into actual behaviour? How can different types of needs change the behavioural outcomes, in particular leading to exploratory information seeking? As Sherer suggests, “we need additional research to better understand the needs of these individuals and ways to support them” (Sherer 2014) (p.361). Through the understanding of these needs, health information providers can design better websites to support seekers’ needs, as a result the provision of health information and the user satisfaction can be improved. The next sub-sections will examine the theoretical work about information seeking behaviour and exploratory search, which can help to investigate these questions.

2.4. Information Seeking Theories

Theories of information seeking behaviour describe how people search for information in the seeking process. This work helps to understand the process of
seeking for health information, and guides the design of technologies that support such information seeking behaviour. When a seeker decides to demand a piece of information, abstract information needs will be transformed into the actual information seeking behaviours. In this process, a series of cognitive changes and physical actions are involved, rather than simply querying the search engines as can be observed. These theories describe the mental state changes and the physical actions in the information seeking process.

Wilson conceptualises information seeking behaviour with four modes, and introduces the concepts of active and passive searching (Wilson 1997). In addition to describe different modes of searching activities, the concept of acquisition is introduced to represent situations with the passive reception of information, even if people did not realise their own information needs. The four modes are listed in Table 2-1.

**Table 2-1: Wilson’s four modes of information seeking behaviour**

<table>
<thead>
<tr>
<th>Mode</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Passive Attention</td>
<td>Information acquisition may take place without intentional seeking, for example listening to the radio or watching TV ads.</td>
</tr>
<tr>
<td>Passive Search</td>
<td>Signifies those occasions when one type of search (or other behaviour) results in the acquisition of information that happens to be relevant to the individual.</td>
</tr>
<tr>
<td>Active Search</td>
<td>The individual actively seeks information.</td>
</tr>
<tr>
<td>Ongoing Search</td>
<td>Where the active search has already established the basic framework of knowledge, ideas, beliefs, or values, but the individual continues to search for expansion or updating of that framework.</td>
</tr>
</tbody>
</table>

Wilson has also summarised both Kuhlthau’s information search process (ISP) model and the work from Ellis et al., as displayed in Figure 2-3 (Wilson 1997). Kuhlthau’s ISP model uses six stages to describe the behaviour of seekers,
emphasising the changes of their thoughts and feelings during the search process (Kuhlthau 1991). The model from Ellis et al., on the other hand, shows a sequence of activities that people perform to satisfy their information needs (Ellis et al. 1993; Ellis & Haugan 1997; Ellis 1989). Wilson argues that these two models are complementary to each other in understanding people’s information seeking behaviour.

**Figure 2-3: Wilson’s summary on Kuhlthau and Ellis models** (Wilson 1999)

The focus of our research, i.e. exploratory search, falls into the *selection/exploration* stages shown in Figure 2-3. Kuhlthau has demonstrated that seekers dive into the information selection and exploration process before they can construct (shown as *identify/formulate* in the figure) the knowledge for addressing information needs (Kuhlthau 1991). Meanwhile, seekers may feel confused and anxious due to emotional changes in these stages. The Ellis framework also shows that the corresponding activities involve *browsing, chaining, monitoring* and *differentiating* (Ellis et al. 1993), respectively. This gives some clues about what kind of behaviour we should capture in order to investigate health information seeking behaviour.

Moreover, the different activities in Ellis’ model are allowed to alternate from one to other, as illustrated by multiple paths in the figure, implying that seekers choose appropriate search activities as necessary to handle the current situation.

*Information foraging theory* is another theory to model human information seeking behaviour, particularly for the information search (Pirolli & Card 1999; Fu & Pirolli 2007; Fu 2012). The theory describes how seekers use information cues to navigate in an information environment (e.g. the World Wide Web) for discovering information.
It originates from one of the food foraging theories named optimal foraging theory, which helps biologists understand the factors determining an animal's food preference and feeding strategies (Trepess 2015). The theory suggests that seekers will follow a path that maximises the information “intake”, and omit the tools/sources providing no useful information. Similarly, Case’s Principle of Least Effort indicates that seekers will try to minimise the effort of getting the information (Case 2005). Cost and benefit are also involved in the selection of health information sources (Zhang 2014). These research outcomes imply that it is important for information systems to meet the expectations of seekers and satisfy their information needs by providing easy-to-use and effective tools.

The Berrypicking model (Bates 1989), as shown in Figure 2-4, views information seeking behaviour as a journey of picking up berries. In this model, seekers formulate a query from an information need, and then move iteratively through an information system along potentially complex paths. In the process, they pick up bits of useful information (“berries”) along the way. In the meantime, they may change their queries as they learn more about what they need and what information is available from the system (Morville & Rosenfeld 2006). This is similar to exploratory search in terms of query reformulations and changes of information needs.

Figure 2-4: Berrypicking model (Morville & Rosenfeld 2006)
Most of the information behaviour models, including the ones discussed above, have been formulated before the widespread application of the Internet. The models mainly focused on how people used non-electronic ways to access information (looking up a library catalogue is an example). This leaves a blank in understanding information seeking behaviour with the Internet. To bridge this blank, Choo et al. tried to map the anticipated operations on the web to the activities in Ellis’ model (Choo et al. 2000). Table 2-2 lists the common activities of web users interpreted with Ellis’ model.

Table 2-2: Information seeking behaviours and web moves (Choo et al. 2000)

<table>
<thead>
<tr>
<th>Literature Search Moves (Ellis et al.)</th>
<th>Anticipated Web Moves</th>
</tr>
</thead>
<tbody>
<tr>
<td>Starting</td>
<td>Identifying source of interest</td>
</tr>
<tr>
<td></td>
<td>Identifying web sites/pages containing or pointing to information of interest</td>
</tr>
<tr>
<td>Chaining</td>
<td>Following up references found in given material</td>
</tr>
<tr>
<td></td>
<td>Following up links on starting pages to other content-related sites</td>
</tr>
<tr>
<td>Browsing</td>
<td>Scanning table of contents or headings</td>
</tr>
<tr>
<td></td>
<td>Scanning top-level pages: list, heading, sitemaps</td>
</tr>
<tr>
<td>Differentiating</td>
<td>Assessing or restricting information according to their usefulness</td>
</tr>
<tr>
<td></td>
<td>Selecting useful pages and sites by bookmarking, printing, copying and pasting, etc.</td>
</tr>
<tr>
<td></td>
<td>Choosing differentiated, pre-selected website</td>
</tr>
<tr>
<td>Monitoring</td>
<td>Receiving regular reports or summaries from selected sources</td>
</tr>
<tr>
<td></td>
<td>Receiving site updates using e.g. push, agents, or profiles</td>
</tr>
<tr>
<td></td>
<td>Revisiting favourite sites</td>
</tr>
<tr>
<td>Extracting</td>
<td>Systematically working a source to identify material of interest</td>
</tr>
<tr>
<td></td>
<td>Systematically searches a local site to extract information of interest at that site</td>
</tr>
</tbody>
</table>
The work of Choo et al. provides directions on how to capture and measure web-based information seeking behaviour. As shown in the table, identifying websites (using search engines or known sources), following up links and bookmarking web pages are some examples of enabling quantitative measurements. On the other hand, by observing the user activities, researchers can map the activities to corresponding information seeking models, which helps to explain information seeking behaviour.

Three major research gaps are summarised to conclude the literature review of information seeking theories. Firstly, while the existing literature covers different aspects of the information seeking process, little work (e.g. stress/cop ing and sense-making concepts) specifically examines its application in the health context. Since health information seeking is different from other types of information seeking as discussed above, it is not surprising that some of this work does not fit in the health context. Therefore, it is the focus of this research to study the differences between generic and health information seeking, and investigate the applications of the current models in the health context.

Secondly, most of the above theories describe the information seeking process as linear. However, this is not necessarily the case for health information seeking nowadays. The technologies for information seeking have advanced substantially since these models were built. Taking web pages as an example, users can go back/forward and jump to different locations easily. These technological factors may change the linear process. Also, health information needs are complicated and may show different patterns of steps when seeking information. Therefore, another area to be researched in this project is to identify the transition of various stages in the health information seeking process.

Moreover, the existing information seeking theories lack actionable design implications. The models reviewed merely describe the stages in the information seeking process, and the transitions between these stages. This is useful in explaining and predicting seekers’ behaviour, but not enough for designers and developers to build system requirements (Van Velsen et al. 2013). In this regard, this
work aims to address this research gap by synthesising the research findings into design strategies for supporting seekers.

2.5. Exploratory Search

*Exploratory search* refers to a search approach which involves *learning* and *investigation* behaviour in addition to *looking up* information simply, where the seeker interacts with information systems to retrieve a wider range of information (Marchionini 2006). Exploratory search can be found when an individual tries to address unfamiliar or unknown problems (Pearce et al. 2012), or only has a rough idea about the search target (Fu 2012). White and Roth suggest that people who are unfamiliar with the domain of their goals, or unsure about the ways to achieve their goals, or even unsure about what their goals are will engage in exploratory search (White & Roth 2009). Facing increasingly complicated scenarios and complex information systems, everyday search behaviour becomes a mix of both simple lookups and exploratory search tasks (Ruotsalo et al. 2014).

Based on these definitions, it is clear that exploratory search is highly relevant to health information seeking in many scenarios. Health information seekers are often found lacking the knowledge or unable to express their health conditions using medical terminologies (Chapman et al. 2003; Keselman et al. 2008). A typical example of this case is a person with a cough. A lay-person usually does not have the expertise to diagnose, and thus explores for all potential causes of the symptom. Moreover, due to lack of trust of online health information, seekers prefer to explore more information sources to verify the information (Eysenbach & Köhler 2002; Zhang 2013). All these examples imply that exploratory search and health information seeking behaviour are closely connected.

Exploratory search is different from the traditional *iterative search* (or *focused search*) in the way that queries are refined and the breadth of the targeted information space (White & Roth 2009). Figure 2-3 illustrates the comparison between iterative search
and exploratory search. Iterative search shows fewer query reformulations around the search target, more overlaps on the search target in each iteration and the range of the information space to be studied is relatively narrower. Whereas exploratory search displays a larger number of queries in different aspects, and as a result the seeker covers more information in the space which helps to deal with open-ended and uncertain situations.

![Figure 2-5: Iterative vs. exploratory search](White & Roth 2009)

Marchionini has pointed out three important elements of exploratory search: **lookup, learn and investigate** (Marchionini 2006). Exploratory search does not only mean how to locate the needed information but also emphasises investigation and the learning of new knowledge. Seekers need to process on search results and construct knowledge on-the-fly from the information acquired. Investigating refers to the effort to maximize the number of relevant results that can be accessed (broaden the scope), rather than minimizing the number of irrelevant content to be shown (filtering). This implies that dominant information retrieval tools (e.g. search engines) are not supporting exploratory search well, as these tools are designed to enhance accuracy instead of giving more choices for discovering.
Research about exploratory search has not exclusively been conducted in the information science discipline. Scholars of marketing and consumer research have investigated the exploratory behaviour of online customers. Hodkinson et al. have suggested consumers perform intra-site and inter-site searches depending on the nature of product (Hodkinson et al. 2000). They have introduced the concept of depth vs. breadth of search along with their study. A seeker demonstrates a strong interest to look up detailed information in certain scopes with deeper searches. In contrast, a higher degree of search breadth indicates that the seeker tries to combine information from more than one source. This narrative is similar to the fact that seekers may adopt exploratory search approaches depending on the nature of the scenario (White & Roth 2009).

Huang et al. have studied different strategies when customers looked for goods with different qualities. They identify search goods and experience goods (Huang et al. 2009). Search goods are products with clear and objective attributes which lead to a deeper search. Experience goods usually are service products for which the quality is very subjective. Customers prefer to spend more time and look broadly to justify their decisions with experience goods. This study identifies another trigger of exploratory search: as attributes of experience goods are often more difficult to specify than the ones of search goods, customers tend to explore to gather more information and hence moving them towards exploratory search. Kim has suggested comparable concepts called factual and exploratory search tasks (Kim 2009). These could be applied to health search because health information seekers sometimes aim at experience-based health information.

While exploratory search is defined as an independent concept in the literature, a number of information theories and models are similar or relevant to it. White and Roth posit exploratory search among other relevant research disciplines, as shown in Figure 2-4 (White & Roth 2009). Noted in the figure, exploratory search is closely related to three main study areas:

- Information seeking behaviour, i.e. berrypicking (Bates 1989), sense-making (Wilson 1997; Wilson 1999; Case 2002) and information foraging (Pirolli &
Card 1999; Fu 2012; Fu & Pirolli 2007): investigate and describe how users seek for information, how they interact with the information source to obtain the needed information (Wilson 1981).

- Information retrieval (IR): research about understanding users’ queries, transforming them into queries that computers can use, and returning matching documents that are relevant to the queries in the dataset (Van Rijsbergen 1979). Cognitive IR proposes that the information retrieval process should make use of the research outcomes from theories and studies of information seeking behaviour, so that IR systems can respond to the cognitive changes of seekers and provide better results (Ingwersen 1996).

- User interactions (such as information visualisation and interactive IR): present information in a way that can be better utilised, and enhance information systems to react on the evolving information needs due to the exploratory nature of the search.

![Figure 2-6: Venn diagram positioning exploratory search relative to other related research disciplines. Circle size signifies approximate size of each discipline. Colour is used to differentiate interior circles](White & Roth 2009)
Besides, exploratory search is often compared with informational queries in the taxonomy of web search (Broder 2002; Rose & Levinson 2004). In the taxonomy, web search queries can be classified into three categories: navigational, informational and transactional queries. The intent of informational queries is “to acquire some information assumed to be present on one or more web pages” (Broder 2002) (p.5). The exploratory search approach is used to describe the entire course of search, whereas information queries characterise the nature of a particular group of search queries. Despite the difference, exploratory search and informational queries share the same goal of acquiring additional information, and informational queries are issued during the process of exploratory search by seekers.

While the theories and models of exploratory search can properly describe parts of the health information seeking process, there is little scholarly work which specifically focuses on exploratory search in the health and medical context. The role of exploratory search in the health information seeking process remains unclear in the current literature, though aspects of exploratory search can be identified in different information seeking models. The information seeking models depict only the possible stages where exploratory health search may occur, for example, the Browsing-Chaining-Monitor phases in Ellis’s model (Figure 2-3). There is not enough information to describe how exploratory search happens, and how exploration search should be facilitated during the information seeking process. Therefore, our research will study how exploratory search is triggered in the health information seeking process, and how it makes the outcomes of HISB different.

The upcoming section will introduce projects and technologies about designing and implementing for exploratory search.

2.6. Designing for Exploratory Search

Exploratory search needs novel designs to support the different behavioural patterns and activities shown in the seeking process. There have been a few previous efforts
to design a user interface to support exploratory search, and to identify strategies for supporting exploratory search. Therefore, we will start by reviewing the general design for search user interfaces, then the literature about design for exploratory search, as well as using serendipity in user interactions.

2.6.1. Search User Interfaces

A number of studies have suggested several design principles for search user interfaces. Wilson recommends that search user interfaces should help seekers to create useful queries, present important information in the first page of results, use animations to convey a message of the system, and allow users to go back/start over (Wilson 2011). Some have reported that using handcrafted metadata can best assist searching; computer-generated metadata are not as good as the handcrafted ones but still useful for searching (Capra et al. 2007; Wilson 2011). Other work uses different approaches to let seekers understand the composition of the search results, by visualising the relationships between search queries and the documents in the database (Hearst 1995; Hoeber & Yang 2009). In addition, another research points out that interactivity in search user interfaces can enhance the engagement of seekers (Golovchinsky, Diriye, et al. 2012). The above research gives valuable insights in design health information seeking user interfaces.

2.6.2. Design Work for Exploratory Search

SeCo is a system using web application mashup to provide exploration in multiple dimensions such as spatial and temporal data (Bozzon et al. 2013). Given that effective exploratory search instances may require different information across dimensions. This system provides multiple user interfaces, from data table (for examine a list of items), selection (for filtering search scopes), to map (for exploring spatial data). The authors also propose a framework and a query language (SeCoQL) for processing exploratory search queries.
Querium is an experimental design for supporting exploratory search (Golovchinsky, Dunnigan, et al. 2012; Golovchinsky, Diriye, et al. 2012). It allows multi-session search as exploratory search often lasts for a lengthy time. The design also encourages seekers to follow up hyperlinks continuously. Also, the system uses a colourful background and animations to engage with users.

The web-based exploration engine iFISH provides an engaging environment for playful exploration of restaurants (Pearce et al. 2012) and library books (Pearce & Chang 2014), in which the usage of search keywords is eliminated. The system takes an unusual approach to understand the information needs of seekers. Instead of requiring explicit input about search keywords, the system enquires seekers about their preferences of items being looked for, for example, “casual” or “formal” restaurants and “fantasy” or “reality” novels. This approach works best when seekers do not know exactly what to look for, but have a rough idea in mind. Also, it eliminates the need of using exact keywords to conduct the search, in where this strategy can be used to assist health information seekers, as they often do not know the keywords for searching. Figure 2-5 illustrates the exploration of library books using iFISH.

![Figure 2-7: Exploration screen of iFISH for library books](image.png)
Exploration Wall is a touch-based software for incremental exploration and sense-making in a large information space (Klouche et al. 2015). The authors have identified a range of design challenges of supporting exploratory search on touch-based devices, such as the difficulty of formulating queries in unknown information spaces, manipulating queries using virtual keyboards, etc. A novel touch-based user interface was created to address these issues and improved the user experience of performing exploratory search on touch-based devices (Figure 2-6). The software was tested for exploratory search of scientific papers. Though the main focus of this system is on touch-based user interfaces, some of the design principles would be applicable in other contexts and devices.

Figure 2-8: Exploration Wall (Klouche et al. 2015)

Thudt et al. have presented the Bohemian Bookshelf as displayed in Figure 2-7 (Thudt et al. 2012), which is a public information display to support book discoveries in a library by serendipity (serendipity will be discussed in more depth in the next sub-section). In addition, they have pointed out a number of elements that are enticing information exploration. One of these elements is providing multiple visual access points to allow people to explore via different visual perspectives. Also, highlighting the adjacencies of books process seems effective for exploration, and the similar concept can be used for other contexts. Their research suggests that a playful
environment in information systems is good for encouraging information exploration as well.

Figure 2-9: One of the views in the Bohemian Bookshelf, allowing browsing through book covers and selecting adjacent books (Thudt et al. 2012)

Faceted search interface is one of the most used search user interfaces, and it is often associated with exploratory search tasks (Ferré & Hermann 2011). Faceted search interfaces (Figure 2-8) provide mechanisms to filter search results using hierarchical metadata, at the same time allowing users to browse through the search result list (Hearst et al. 2002). This aids exploratory search through query formulation and refinements (Kules et al. 2009). Nevertheless, faceted search only supports bi-directional manipulation (i.e. narrowing and broadening) of search results with the current query. The characteristics of exploratory search, such as multiple and dynamic search topics across the information space, cannot be handled by faceted search interfaces. Thus, faceted search interfaces cannot be seen as complete solutions to exploratory search, though they address certain problems in the course of exploratory search.
White et al. have summarised certain design strategies for supporting exploratory search (White et al. 2006; White & Roth 2009). For instance, supporting querying and rapid query reformulation, offering result filtering, leveraging search context, using visualisations, facilitating learning, understanding and collaboration, offering history and task management, etc. This research will investigate the applicability of these directions in health, and design appropriate user interfaces for implementing these directions for health information seekers.

In the consumer health context, current research of exploratory search and health information seeking has not moved much beyond theoretical studies and conceptual frameworks, to the best of my knowledge. Cartright et al. propose that exploratory health search can be categorised into evidence-based and hypothesis-based queries, and that different search interfaces and algorithms are needed for each type of queries (Cartright et al. 2011). Zarro suggests that exploratory health search can be analysed from a social psychology perspective (Zarro 2012). Lee et al. reviewed the current literature of health information seeking and argue that future research about
health information seeking behaviour should focus on the navigational needs of seekers (Lee et al. 2014; Lee et al. 2015).

Health information seeking is a complete user experience that exploratory search is embedded within. In this sense, this research project not only aims to support exploratory search with user-centred design, but also to provide other feasible features and support for health information seekers. In this regard, merely theoretical work of exploratory health search is not enough, the analysis has to consider seekers’ health information needs as a whole. At the time of this writing, the literature review cannot identify any theoretical design principles integrating health information seeking and exploratory search. Thus, one of the goals of this research is to generate such design principles.

2.6.3. Serendipity

*Serendipity* can play a role in the information seeking process. Oxford English Dictionary defines serendipity as “the faculty of making happy and unexpected discoveries by accident” (Oxford English Dictionary 2015). In terms of browsing information, a special case of browsing which leads to accidental discovery is serendipity (Apted & Choo 1971). In this context, people may encounter information without premeditated action, i.e. browse an explicit topic (Case 2002). People may find “valuable information on subject B when searching for subject A” and this “allows a user to recognise information of value in other contexts than that in mind when the search was started.” (Boyce et al. 1994) (p.177). From the perspective of information retrieval, serendipity suggests the scenario of discovering useful information with randomness and pleasure (Thudt et al. 2012).

The concept of serendipity is reported by multi-discipline research as an additional factor to aid information seeking (Foster & Ford 2003) and exploratory search (White et al. 2006). Others have proposed that health information seeking involves a certain degree of serendipity (Case 2002; Johnson & Case 2012). In contrast to traditional information retrieval methods, supporting serendipity requires a fuzzy approach to
responding to search queries, instead of returning exact matches (Toms 2000). With a suitable environment and approach, designing for serendipity can even enhance user experience (Leong et al. 2012).

2.7. Summary

By reviewing the existing work, a number of research gaps have been identified in the context of health information seeking. Table 2-3 outlines the major research gaps in the literature, and the associated research questions addressed in this thesis to narrow these gaps.

Table 2-3: Major research gaps and associated research questions

<table>
<thead>
<tr>
<th>Research Gap</th>
<th>Research Questions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Information seeking theories are not specifically designed for the health.</td>
<td><em>RQ1-1</em>: What factors have impact on the behaviour of health information seekers?</td>
</tr>
<tr>
<td>Example: (Kuhlthau 1991; Ellis &amp; Haugan 1997; Pirolli &amp; Card 1999; Bates 1989; Fu 2012)</td>
<td></td>
</tr>
<tr>
<td>Many information seeking theories are created before the widespread usage of electronic resources (e.g. the Internet).</td>
<td><em>RQ1-2</em>: How do health information seekers demonstrate their information seeking behaviours in terms of their usage patterns?</td>
</tr>
<tr>
<td>Example: (Kuhlthau 1991; Ellis &amp; Haugan 1997; Bates 1989)</td>
<td></td>
</tr>
<tr>
<td>Much understanding of health information seeking is generated from query log analysis, which does not capture the factors other than the interactions with search engines.</td>
<td></td>
</tr>
<tr>
<td>Example: (Spink et al. 2004; Graham et al. 2006; Cartright et al. 2011)</td>
<td></td>
</tr>
</tbody>
</table>
### Chapter 2. Literature Review

<table>
<thead>
<tr>
<th>Research Gap</th>
<th>Research Questions</th>
</tr>
</thead>
<tbody>
<tr>
<td>The role of exploratory search in health information seeking is unclear</td>
<td>(Same as RQ1-2)</td>
</tr>
<tr>
<td>(Cartright et al. 2011; Zarro 2012).</td>
<td></td>
</tr>
<tr>
<td>Information seeking theories provide no design implications, particularly in</td>
<td></td>
</tr>
<tr>
<td>the consumer health context.</td>
<td>RQ2-1: What is the model of health information seeking</td>
</tr>
<tr>
<td>Example: (Kuhlthau 1991; Ellis &amp; Haugan 1997; Pirolli &amp; Card 1999; Bates 1989)</td>
<td>behaviour with the focus of designing interactive</td>
</tr>
<tr>
<td>Strategies for designing for health information seeking is unclear, especially</td>
<td>technologies?</td>
</tr>
<tr>
<td>for dealing with heterogeneous behaviours. Some work (Zarro 2012; Lee et</td>
<td>RQ2-2: What design requirements can be used to build a</td>
</tr>
<tr>
<td>al. 2014) has discussed the research directions but not much detail has been</td>
<td>consumer health website for better supporting health</td>
</tr>
<tr>
<td>proposed.</td>
<td>information seeking behaviours?</td>
</tr>
<tr>
<td>The design elements for assisting and supporting the complex behaviour of</td>
<td>RQ3-1: How can the design of consumer health websites</td>
</tr>
<tr>
<td>health information seekers are unclear, which need additional research to</td>
<td>support the full range of health information seeking</td>
</tr>
<tr>
<td>understand the needs and support them (Sherer 2014).</td>
<td>behaviours?</td>
</tr>
</tbody>
</table>
Chapter 3.

Exploratory Study: Better Health Channel

3.1. Introduction

In the literature review, the existing work about health information seeking and the challenges faced by health information seekers have been introduced. Are these findings applicable to Australia which has its own lifestyle, healthcare system and Internet connectivity? Moreover, with the development of web technologies, do health information seekers behave today as they did five to ten years ago? In this PhD research, we explore these questions by collaborating with Australia’s largest consumer health website Better Health Channel. We obtain and analyse their visitor statistics to provide an overview of health information seeking as it happens currently in the Australian context. This study suggests directions for the other in-depth studies in this PhD research.
The Better Health Channel\(^2\) (BHC) is a consumer health website in Australia, established by the Department of Health and Human Services of the Victoria State Government in 1999. The website contains different categories of health information that is freely available to everyone. Being one of the largest and most popular health website in Australia, BHC attracts over one million unique visitors and millions page views in every month. With its targeted audience and magnitude of users, BHC is an ideal platform for exploratory studies about health information seeking using real data of real users.

The BHC team was supportive of the initiative of this research project. They provided the access to their Google Analytics account. Google Analytics\(^3\) is a free service for tracking and reporting on website traffic. A Google Analytics account records many aspects of the interactions between the site and users, including basic statistics (such as visitor counts and session length), search keywords, navigation flow, etc. This tool can provide an aggregated view of user behaviour and search activities in a large scale.

This preliminary study mainly investigated three aspects of health information seeking. Firstly, the work was to gain an overview of health information seeking using the basic information provided from Google Analytics. Secondly, the statistics and queries of search activities were used to understand how and what seekers looked for in the BHC website. Finally, the keywords used in search instances were processed and categorised using a computational algorithm, described below, so that the different patterns demonstrated in different intentions of search could be compared and analysed. The results of these analyses give hints about what kinds of information health information seekers look for, and how their behaviours differ for different types of searches.

\(^2\) http://www.betterhealth.vic.gov.au/

\(^3\) http://www.google.com/analytics
3.2. Data Summary

The data obtained for this study were captured in a 3-month period, from 1st Mar. 2013 to 31st May 2013. Table 3-1 shows the basic visitor statistics analysed in this preliminary study. In the 3-month of time, BHC recorded 12,496,000 page views in 9,188,743 sessions by 6,443,213 users. The data about sessions showed that BHC users were not engaged much with the website. On average a user stayed in the website for a minute and only read 1.4 web pages within a session. The high bounce rate meant that 84.2% of users left BHC without reading the second page, hinting that certain shortcomings of the site led to the low engagement and inactive interactions.

Table 3-1: Overview of visitors of Better Health Channel (Mar. – May 2013)

<table>
<thead>
<tr>
<th>Metric</th>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sessions</td>
<td>9,188,743</td>
<td>Total number of sessions within the date range. A session is the period time a user is actively engaged with the website.</td>
</tr>
<tr>
<td>Users</td>
<td>6,443,213</td>
<td>Users that have had at least one session within the selected date range, which includes both new and returning users.</td>
</tr>
<tr>
<td>Pageviews</td>
<td>12,496,000</td>
<td>Pageviews is the total number of pages viewed. Repeated views of a single page are counted.</td>
</tr>
<tr>
<td>Pages/Session</td>
<td>1.4</td>
<td>The average number of pages viewed during a session.</td>
</tr>
<tr>
<td>Average Session</td>
<td>59 sec.</td>
<td>The average length of a session.</td>
</tr>
</tbody>
</table>

4 The descriptions of the measured metrics were obtained from Google Analytics documentation and edited for clarity.
Chapter 3. Exploratory Study: Better Health Channel

<table>
<thead>
<tr>
<th>Metric</th>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bounce Rate</td>
<td>84.2%</td>
<td>The percentage of single-page visits, i.e. visits in which the person left your site from the entrance page without interacting with other web pages.</td>
</tr>
</tbody>
</table>

The data from Google Analytics also contained metrics about search activities. In all 9.19 million sessions captured in the data, 160,378 sessions (1.8%) used the BHC search feature. The ratio was low because these data included only the searches performed with the internal site search feature in BHC, and the system could not capture the usage of other external search engines (such as Google). However, this information still can provide a few insights about the search activities in the health information seeking process.

Table 3-2 lists the statistics for the BHC site search in the research period. Approximately 90 thousand different search keywords were used in 241,292 search queries, indicating some search keywords were more popular than others and repeatedly used by seekers. In average, seekers of BHC examined 1.4 pages of search results, consistent with the findings of prior research which suggested that seekers only look at limited number of links and read only the first few search result pages (Hodkinson et al. 2000; Eysenbach & Köhler 2002). The average time staying in BHC after performing a search (103 seconds) was higher than the average session length (59 seconds), indicating that search activities engaged visitors as they spent time to read the content that fits their information needs. However, the overall data showed that the search feature of BHC was not satisfactory: 66.2% of seekers left shortly and only 0.013 pages were read after search – meaning that only one seeker would open a web page to continue reading after viewing the search results. These reflected that the search results could not bring meaningful information to the seekers, i.e. unable to meet seekers’ information needs.
Table 3-2: Basic statistics of the BHC site search (Mar. – May 2013).

<table>
<thead>
<tr>
<th>Item</th>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Unique Searches</td>
<td>241,292</td>
<td>The number of times people searched the website. Duplicate searches within a single visit are excluded.</td>
</tr>
<tr>
<td>Number of Search Terms</td>
<td>90,738</td>
<td>The number of different search terms used in all search instances.</td>
</tr>
<tr>
<td>Time after Search</td>
<td>103 sec.</td>
<td>The average amount of time visitors spent on the website after getting results for the search term.</td>
</tr>
<tr>
<td>Results Pageviews</td>
<td>1.4</td>
<td>The average number of times visitors viewed a search results page after performing a search.</td>
</tr>
<tr>
<td>Average Search Depth</td>
<td>0.013</td>
<td>The number of pages visitors viewed after getting results for the search term.</td>
</tr>
<tr>
<td>Search Exits</td>
<td>66.2%</td>
<td>The number of exits from the website that occurred following a result from a search.</td>
</tr>
<tr>
<td>Average Search Refinement</td>
<td>0.369</td>
<td>The total number of times a refinement occurs between internal search keywords within a session. For example if the sequence of keywords is: “shoes”, “pants”, this value will be 1 because the refinement of “shoes” to “pants” occurs once.</td>
</tr>
</tbody>
</table>

Table 3-3 displays the geographic composition of BHC visitors. In the 3-month period, most visitors originated in Australia (58.6%), followed by the United States (14.7%) and the United Kingdom (8.1%). Considering the users originated in Australia (as shown in Table 3-4), most of the web traffic came from the major cities in the states. The majority of users sourced from Melbourne (VIC), Sydney (NSW) and Brisbane (QLD), while people from other places in Australia also had used BHC.

5 The descriptions of the measured metrics were obtained from Google Analytics documentation and edited for clarity.
These figures demonstrate a good diversity of the composition of BHC users, making BHC is an ideal platform for exploratory studies about health information seeking across different types of users.

**Table 3-3: The origin countries of BHC visitors (Mar. – May 2013).**

<table>
<thead>
<tr>
<th>Rank</th>
<th>Country</th>
<th>No. of Sessions</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Australia</td>
<td>5,387,147</td>
<td>58.6%</td>
</tr>
<tr>
<td>2</td>
<td>United States</td>
<td>1,348,349</td>
<td>14.7%</td>
</tr>
<tr>
<td>3</td>
<td>United Kingdom</td>
<td>743,232</td>
<td>8.1%</td>
</tr>
<tr>
<td>4</td>
<td>Canada</td>
<td>275,017</td>
<td>3.0%</td>
</tr>
<tr>
<td>5</td>
<td>India</td>
<td>233,717</td>
<td>2.9%</td>
</tr>
</tbody>
</table>

**Table 3-4: The origin cities of BHC visitors in Australia (Mar. – May 2013).**

<table>
<thead>
<tr>
<th>Rank</th>
<th>Country</th>
<th>No. of Sessions</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Melbourne</td>
<td>1,775,441</td>
<td>32.7%</td>
</tr>
<tr>
<td>2</td>
<td>Sydney</td>
<td>1,596,710</td>
<td>29.6%</td>
</tr>
<tr>
<td>3</td>
<td>Brisbane</td>
<td>760,185</td>
<td>14.1%</td>
</tr>
<tr>
<td>4</td>
<td>Perth</td>
<td>467,568</td>
<td>8.7%</td>
</tr>
<tr>
<td>5</td>
<td>Adelaide</td>
<td>369,044</td>
<td>6.9%</td>
</tr>
<tr>
<td>6</td>
<td>Canberra</td>
<td>97,831</td>
<td>1.8%</td>
</tr>
<tr>
<td>7</td>
<td>Hobart</td>
<td>55,991</td>
<td>1.0%</td>
</tr>
<tr>
<td>8</td>
<td>Gold Coast</td>
<td>36,573</td>
<td>0.7%</td>
</tr>
<tr>
<td>9</td>
<td>Newcastle</td>
<td>22,561</td>
<td>0.4%</td>
</tr>
<tr>
<td>10</td>
<td>Geelong</td>
<td>16,327</td>
<td>0.3%</td>
</tr>
</tbody>
</table>
In sum, the basic statistics of BHC display highlight the problems of findability and usability commonly found in consumer health websites (Eysenbach 2005; Johnson & Case 2012), and result in setting a few directions for the future research. First of all, while there is plenty of health information in the website, users are unable to find what they need and the bounce rate is high as a result. This implies additional effort needs to be put into improving the information discovery of health websites in the design phase. Also, seekers try to access the needed information using the search feature but the result is not satisfactory. This repeats the difficulties of using search engines for health issues as illustrated in existing research. The next phase of research needs to identify the causes and investigate methods to rectify the issues.

3.3. Search Keywords

Next, the search keywords in the Google Analytics dataset were analysed as part of this preliminary study. This series of data can help to understand what kinds of data seekers searched, and how seekers searched in the BHC website. The data came in an aggregated format, that is, search instances with the same queries were grouped together and averaged.

The first metric considered was the popularity of different search queries, which provides implications of the types of information people looked for in BHC. As seen in Table 3-5, 8 of the top 10 search keywords were related to some kinds of disease or health conditions. This is similar to a previous study which suggests a large ratio of intentions of health search queries are relevant to symptoms and specific diseases (Cartright et al. 2011; Fox & Jones 2009).
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Table 3-5: Top 10 search queries issued to BHC (Mar. – May 2013)

<table>
<thead>
<tr>
<th>Rank</th>
<th>Search Keywords</th>
<th>No. of Searches</th>
<th>Rank</th>
<th>Search Keywords</th>
<th>No. of Searches</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>diabetes</td>
<td>1,138</td>
<td>6</td>
<td>smoking</td>
<td>546</td>
</tr>
<tr>
<td>2</td>
<td>cholesterol</td>
<td>1,131</td>
<td>7</td>
<td>gout</td>
<td>545</td>
</tr>
<tr>
<td>3</td>
<td>obesity</td>
<td>854</td>
<td>8</td>
<td>bmi</td>
<td>543</td>
</tr>
<tr>
<td>4</td>
<td>depression</td>
<td>602</td>
<td>9</td>
<td>asthma</td>
<td>540</td>
</tr>
<tr>
<td>5</td>
<td>osteoporosis</td>
<td>562</td>
<td>10</td>
<td>shingles</td>
<td>533</td>
</tr>
</tbody>
</table>

In general, exploratory search demonstrates a different information seeking behaviour, by performing more learning, reading, investigating activities and expanding the search scope (White & Roth 2009; Marchionini 2006). In terms of search metrics, the number of search result pages viewed, time spent after search and pages read after search (i.e. search depth) are some of the measurements to identify the categories and the intentions of web search (Singer et al. 2011; Alhenshiri et al. 2013).

Table 3-6 lists the top search keywords sorted by the number of search results pages viewed. While the bigger values of this metric not only imply the search function in BHC cannot find the information queried by users, but also denote that the seekers who entered these queries are more determined to get the information about the inputted topic, even the information was hard to discover. In other words, this might be easier to initiate exploratory search behaviour for this category of health issues.

As seen in the table, different categories of search queries were identified. In addition to diseases and conditions, queries about service providers (e.g. pharmacist) and information leaflets appear in the list, meaning that seekers who search for these types of information may potentially perform exploratory search.
Chapter 3. Exploratory Study: Better Health Channel

Table 3-6: Search queries with most search result pages being viewed (Mar. – May 2013)

<table>
<thead>
<tr>
<th>Rank</th>
<th>Search Keywords</th>
<th>Page Viewed</th>
<th>Rank</th>
<th>Search Keywords</th>
<th>Page Viewed</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>pharmacist</td>
<td>8.3</td>
<td>6</td>
<td>pregnancy</td>
<td>4.88</td>
</tr>
<tr>
<td>2</td>
<td>blood cancer</td>
<td>7.33</td>
<td>7</td>
<td>causes of childhood obesity</td>
<td>4.70</td>
</tr>
<tr>
<td>3</td>
<td>joint pain</td>
<td>5.58</td>
<td>8</td>
<td>Inflammation</td>
<td>4.58</td>
</tr>
<tr>
<td>4</td>
<td>publications</td>
<td>5.18</td>
<td>9</td>
<td>pdf</td>
<td>4.50</td>
</tr>
<tr>
<td>5</td>
<td>child development fact sheets</td>
<td>4.92</td>
<td>10</td>
<td>Exercise</td>
<td>4.18</td>
</tr>
</tbody>
</table>

Following the same analytical approach, the list of search queries with highest search depth shows the similar pattern. Search depth is the average number of web pages read after performing a search. A higher value indicates stronger engagement with the website and higher desire of acquiring information. As shown in Table 3-7, the searches with most pages read included services providers and symptoms.

Table 3-7: Search queries with highest search depth (Mar. – May 2013)

<table>
<thead>
<tr>
<th>Rank</th>
<th>Search Keywords</th>
<th>Search Depth</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>dentist</td>
<td>1.83</td>
</tr>
<tr>
<td>2</td>
<td>say when</td>
<td>1.73</td>
</tr>
<tr>
<td>3</td>
<td>resources</td>
<td>1.00</td>
</tr>
<tr>
<td>4</td>
<td>blue lips</td>
<td>1.00</td>
</tr>
<tr>
<td>5</td>
<td>sjogrens</td>
<td>1.00</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Rank</th>
<th>Search Keywords</th>
<th>Search Depth</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>Bronchiectasis</td>
<td>0.67</td>
</tr>
<tr>
<td>7</td>
<td>dental care</td>
<td>0.50</td>
</tr>
<tr>
<td>8</td>
<td>doctors</td>
<td>0.50</td>
</tr>
<tr>
<td>9</td>
<td>irregular heartbeat</td>
<td>0.43</td>
</tr>
<tr>
<td>10</td>
<td>Acupuncture</td>
<td>0.42</td>
</tr>
</tbody>
</table>
Lastly, I looked at the time spent after search. This is one of the elements to measure the reading activities in the exploratory search process. With this data (Table 3-8), I observed that more abstract and queries with a broader scope of results appeared to display a longer time spent after search. Information for care giving and parenting seemed to fall into this category too.

**Table 3-8: Search queries with longest time spent after search (Mar. – May 2013)**

<table>
<thead>
<tr>
<th>Rank</th>
<th>Search Keywords</th>
<th>Time</th>
<th>Rank</th>
<th>Search Keywords</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>endocrine system quiz</td>
<td>0:45:01</td>
<td>6</td>
<td>the endocrine system</td>
<td>0:11:50</td>
</tr>
<tr>
<td>2</td>
<td>Psoriasis</td>
<td>0:23:55</td>
<td>7</td>
<td>Exercise safety quiz</td>
<td>0:10:53</td>
</tr>
<tr>
<td>3</td>
<td>child development fact sheets</td>
<td>0:21:00</td>
<td>8</td>
<td>obesity risk factors</td>
<td>0:10:43</td>
</tr>
<tr>
<td>4</td>
<td>Male reproductive system</td>
<td>0:18:32</td>
<td>9</td>
<td>modified milk</td>
<td>0:10:07</td>
</tr>
<tr>
<td>5</td>
<td>aged people</td>
<td>0:14:17</td>
<td>10</td>
<td>Food fact sheets</td>
<td>0:09:41</td>
</tr>
</tbody>
</table>

In conclusion, the analysis of search keywords reveals some insights into health information seeking behaviour. Generally, the types of information sought by seekers in BHC were mainly about diseases, symptoms and health conditions. This observation is comparable to the findings in existing literature. However, another set of searches hidden in the statistics showed a different behaviour. By looking at other metrics, scenarios such as looking for services providers, or finding care giving and parenting information, seemed relevant to exploratory search. Seekers of these queries demonstrated higher engagement and longer time used in the website. This finding shows that the focus of investigating exploratory search should be put on these search queries and information needs.
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3.4. Computational Analysis

The previous section reports on the analysis of top search keywords ranked by various metrics. Given the large amount of search queries (over 90,000 queries), merely reviewing a small amount of queries cannot obtain a representative result. Thus, we apply computational techniques to all the search keywords and cluster them into groups, in order to gain an aggregated view of certain aspects in the query dataset. The findings obtained with this approach are discussed in this section.

3.4.1. UMLS and MetaMap

This analysis utilised two popular resources for processing medical text information: the Unified Medical Language System (UMLS)\(^6\) and MetaMap\(^7\), respectively. UMLS is a compendium designed and maintained by the U.S. National Library of Medicine to enable computer to understand the language of biomedicine and health (Lindberg et al. 1993). The system contains the Metathesaurus which is a vocabulary database including biomedical and health concepts. These concepts “link alternative names and views of the same concepts together” (U.S. National Library of Medicine 2010), in order to solve the ambiguous problem of human language used in the medical and health domain.

In addition to the vocabulary, an additional software is needed to map text into the concepts defined in UMLS. MetaMap is a program developed by the U.S. National Library of Medicine to accomplish this task. It applies natural-language processing (NLP) and computational-linguistic techniques to connect individual terms in text to UMLS concepts in the Metathesaurus (Aronson 2001). These MetaMap functions can be accessed via a web-based API without an installation on the local machine.

\(^6\) https://www.nlm.nih.gov/research/umls/

\(^7\) https://metamap.nlm.nih.gov/
3.4.2. Methodology

The list of search keywords was firstly processed by removing useless characters (such as punctuations), and then converted to the appropriate data format (XML) and character encoding (from UTF-8 to ASCII) required by MetaMap. After these steps, the processed keywords were submitted to the MetaMap server. The server returned the mapping of concepts that was corresponding to the original text. An example of the server output is given in Figure 3-1. Queries that cannot be converted to appropriate input format, or cannot be mapped into any concepts were discarded.

<table>
<thead>
<tr>
<th>Search Term:</th>
<th>sleep hygiene</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mapping 1:</td>
<td>Sleep [Organism Function]</td>
</tr>
<tr>
<td></td>
<td>Hygiene [Biomedical Occupation or Discipline]</td>
</tr>
<tr>
<td>Mapping 2:</td>
<td>Sleep [Organism Function]</td>
</tr>
<tr>
<td></td>
<td>hygiene (Self care hygiene) [Finding]</td>
</tr>
</tbody>
</table>

Figure 3-1: An example of the output from MetaMap

In this example, “sleep hygiene” is the input. As human language may represent multiple meanings at the same time, MetaMap often returns groups of mappings to reflect this ambiguous nature. Thus two mappings are returned in this example. In fact, these mappings are in descending order sorted by the “accuracy” calculated by MetaMap. In such cases, the first mapping was always picked to simplify processing.

The names in the square brackets (e.g. [Organism Function]) are semantic types, which describe the nature of each word. These names can be used to further leverage the hierarchy of semantic groups (McCray et al. 2001) to derive the category of these search keywords (e.g. [Physiology] in this example). This approach allows researchers to look at the aggregated statistics of search keywords at both concept level (Sleep) and category level (Physiology). A similar methodology for processing search queries is also used in the work of Palotti et al. (Palotti et al. 2016).

3.4.3. Findings of Category Level Analysis

Table 3-9 summaries these semantic groups along with the examples of individual semantic groups (Bodenreider & McCray 2003). While there are no formal definitions to describe the meanings of each category, the examples can be used to infer the contents included in these categories. This table is provided for better interpreting the results of the subsequent computational analyses.

<table>
<thead>
<tr>
<th>Semantic Group</th>
<th>Examples of Semantic Types</th>
</tr>
</thead>
<tbody>
<tr>
<td>Activities &amp; Behaviours</td>
<td>• Activity • Individual Behaviour • Social Behaviour</td>
</tr>
<tr>
<td>Anatomy</td>
<td>• Anatomical Structure • Body Part, Organ, or Organ Component</td>
</tr>
<tr>
<td></td>
<td>• Cell • Tissue</td>
</tr>
<tr>
<td>Chemical &amp; Drugs</td>
<td>• Antibiotic • Chemical • Clinical Drug • Vitamin</td>
</tr>
<tr>
<td>Concepts &amp; Ideas</td>
<td>• Functional Concept • Language • Spatial Concept</td>
</tr>
<tr>
<td>Devices</td>
<td>• Medical Device • Research Device</td>
</tr>
<tr>
<td>Disorders</td>
<td>• Disease or Syndrome • Injury or Poisoning</td>
</tr>
<tr>
<td></td>
<td>• Mental or Behavioural Dysfunction • Sign or Symptom</td>
</tr>
<tr>
<td>Genes &amp; Molecular Sequences</td>
<td>• Amino Acid Sequence • Gene or Genome</td>
</tr>
<tr>
<td></td>
<td>• Molecular Sequence</td>
</tr>
<tr>
<td>Geographic Areas</td>
<td>• Geographic Area</td>
</tr>
<tr>
<td>Living Beings</td>
<td>• Animal • Bacterium • Human • Plant • Virus</td>
</tr>
<tr>
<td>Objects</td>
<td>• Entity • Food • Physical Object • Substance</td>
</tr>
<tr>
<td>Occupations</td>
<td>• Biomedical Occupation or Discipline</td>
</tr>
<tr>
<td></td>
<td>• Occupation or Discipline</td>
</tr>
<tr>
<td>Organizations</td>
<td>• Health Care Related Organization • Professional Society</td>
</tr>
</tbody>
</table>

Table 3-9: List of semantic groups returned by MetaMap (Bodenreider & McCray 2003)
<table>
<thead>
<tr>
<th>Semantic Group</th>
<th>Examples of Semantic Types</th>
</tr>
</thead>
</table>
| Phenomena     | • Human-caused Phenomenon or Process  
• Laboratory or Test Result  
• Phenomenon or Process |
| Physiology    | • Cell Function  
• Genetic Function  
• Organ or Tissue Function |
| Procedures    | • Diagnostic Procedure  
• Health Care Activity  
• Laboratory Procedure  
• Research Activity |

After eliminating queries which were unable to processed, in total 64,526 (71.1%) search queries were analysed and mapped into 15 different semantic groups (i.e. categories). First of all, the average numbers of search result pages viewed after search were analysed across different categories of search keywords. As displayed in Figure 3-2, the X-axis outlines the number of search result pages viewed in each category. All 15 categories of search queries do not show a substantial difference. This meant that seekers reviewed 1.3-1.5 pages of search results regardless to the types of search queries. As search queries are textual representation of information needs, this reflects that seekers expose a universal pattern that they will not explore many search results across different information needs. This needs to be considered in the later stage of research, in which design implications are formulated for better supporting the needs of health information seekers.
In contrast, the analysis of time spent in BHC after issuing a search query show a different pattern. Figure 3-3 displays the time (in seconds) spent in BHC after seekers performed searching (X-axis), broken down by the categorisation of MetaMap. As observed in the figure, some categories demonstrated longer time spent after search. These categories included Disorders (such as diseases and symptoms), Concepts & Ideas, and Activities & Behaviours, etc. While the meaning of some categories could not be clearly understood from their brief names, the analysis suggests that the information seeking behaviour is affected by the type of information sought. Assuming seekers were reading and browsing the information after initiating the search, what caused them to behave differently in terms of the types of information searched, and what led them to engage with longer reading and browsing activities? These questions provide directions for further investigation in the qualitative research of this PhD project, which will be discussed in Chapter 4.
3.4.4. Findings of Concept Level Analysis

Another analysis with MetaMap was to study the search queries grouped in a single concept, in order to observe what seekers looked for around a health topic. For instance, some seekers who searched for a common cold related information might use different search queries (e.g. common cold, flu, inflection...). These keywords were stored as different records in Google Analytics, and this created difficulties in analysing the data. Using MetaMap to handle these query logs has two advantages. Firstly, MetaMap can process each individual word in a query properly using NLP techniques. Furthermore, it uses UMLS Metathesaurus to handle the synonyms in the medical domain. Terms referring to the same concept are recognised by MetaMap and grouped together. In this way, we may understand how seekers generate divergent search queries for one health topic, and what kinds of information are often sought around a topic.

Figure 3-3: Average time (seconds) spent after search of different categories of queries
Tables 3-10 and 3-11 summarise the search queries of the concepts of diabetes and cholesterol, which have both similar results. These two health concepts were chosen because of their popularity (the top two concepts listed in Table 3-5). A glance at the terms shows that seekers mixed lowercase and uppercase letters, as well as misspellings in the queries, which suggest that search engines have to handle these varieties of the keywords. Also, people were trying to seek different aspects of information in addition to the name of the disease. These included symptoms, diet, treatments, remedies, etc. The diverse aspects of information sought matched the findings of previous literature (Andreassen et al. 2007; Gavgani 2010). Aboriginal and indigenous specialities were identified in the search queries, which was unique to health information seeking in the Australian context.

**Table 3-10: Search queries classified into the diabetes concept (top 20, total 377)**

<table>
<thead>
<tr>
<th>Terms</th>
<th>No. of Searches</th>
</tr>
</thead>
<tbody>
<tr>
<td>diabetes</td>
<td>1138</td>
</tr>
<tr>
<td>Diabetes</td>
<td>205</td>
</tr>
<tr>
<td>DIABETES</td>
<td>18</td>
</tr>
<tr>
<td>aboriginal diabetes</td>
<td>15</td>
</tr>
<tr>
<td>diabetes 2</td>
<td>11</td>
</tr>
<tr>
<td>indigenous diabetes</td>
<td>11</td>
</tr>
<tr>
<td>aboriginal health issues diabetes</td>
<td>10</td>
</tr>
<tr>
<td>diabetes and healthy</td>
<td>9</td>
</tr>
<tr>
<td>diabetes quiz</td>
<td>9</td>
</tr>
<tr>
<td>diabetes symptoms</td>
<td>7</td>
</tr>
<tr>
<td>diabetes 1</td>
<td>6</td>
</tr>
<tr>
<td>diabetes and diet</td>
<td>6</td>
</tr>
<tr>
<td>diabetes and exercise</td>
<td>6</td>
</tr>
<tr>
<td>diet diabetes</td>
<td>6</td>
</tr>
</tbody>
</table>
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<table>
<thead>
<tr>
<th>Terms</th>
<th>No. of Searches</th>
</tr>
</thead>
<tbody>
<tr>
<td>aboriginal health issues-diabetes</td>
<td>5</td>
</tr>
<tr>
<td>Diabetes symptoms</td>
<td>5</td>
</tr>
<tr>
<td>diabetes treatment</td>
<td>5</td>
</tr>
<tr>
<td>what is diabetes</td>
<td>5</td>
</tr>
<tr>
<td>aboriginal health diabetes</td>
<td>4</td>
</tr>
<tr>
<td>diabetes and healthy eating</td>
<td>4</td>
</tr>
</tbody>
</table>

**Table 3-11: Search queries classified into the cholesterol concept (top 20, total 90)**

<table>
<thead>
<tr>
<th>Terms</th>
<th>No. of Searches</th>
</tr>
</thead>
<tbody>
<tr>
<td>cholesterol</td>
<td>1131</td>
</tr>
<tr>
<td>Cholesterol</td>
<td>86</td>
</tr>
<tr>
<td>CHOLESTEROL</td>
<td>24</td>
</tr>
<tr>
<td>what is cholesterol</td>
<td>20</td>
</tr>
<tr>
<td>cholesterol diet</td>
<td>17</td>
</tr>
<tr>
<td>cholesterol and diet</td>
<td>11</td>
</tr>
<tr>
<td>cholesterol and healthy eating</td>
<td>7</td>
</tr>
<tr>
<td>lower cholesterol</td>
<td>5</td>
</tr>
<tr>
<td>cholesterol explained</td>
<td>4</td>
</tr>
<tr>
<td>what is cholesterol?</td>
<td>4</td>
</tr>
<tr>
<td>cholesterol lowering</td>
<td>3</td>
</tr>
<tr>
<td>lowering cholesterol</td>
<td>3</td>
</tr>
<tr>
<td>cholesterol food</td>
<td>2</td>
</tr>
<tr>
<td>cholesterol healthy eating tips</td>
<td>2</td>
</tr>
<tr>
<td>cholesterol medication</td>
<td>2</td>
</tr>
</tbody>
</table>
### Terms and No. of Searches

<table>
<thead>
<tr>
<th>Terms</th>
<th>No. of Searches</th>
</tr>
</thead>
<tbody>
<tr>
<td>reducing cholesterol</td>
<td>2</td>
</tr>
<tr>
<td>What is cholesterol</td>
<td>2</td>
</tr>
<tr>
<td>alcohol cholesterol</td>
<td>1</td>
</tr>
<tr>
<td>bad cholesterol</td>
<td>1</td>
</tr>
<tr>
<td>blood cholesterol</td>
<td>1</td>
</tr>
</tbody>
</table>

As revealed by these findings, the health information needs of seekers cover a variety of information (e.g. basic information, treatments, symptoms, etc.). Additional keywords were used to find these subsets of information. The additional keywords appended to the health concept (e.g. diabetes) implies that seekers are not satisfied with a single type of information. Rather, they need to access information of multiple aspects of the health topic. Future research can focus on the behavioural patterns of these different perspectives of searches, so that design implications can be generalised for designing and building health websites for these patterns.

### 3.5. Limitations

This preliminary study has several limitations. Firstly, the study works on the search keywords of Better Health Channel, which captures only the search activities of the intra-site search function. Although there are a substantial number of queries recorded, it is still not comparable with mainstream search engines (such as Bing, Google, etc.). The analysis would be more comprehensive if the access to the data of these search engines can be obtained.

Another limitation is related to the computational analyses. The MetaMap program categorised the search terms into different semantic groups. These high level semantic groups maybe suitable for medical purposes, but are not necessarily the best for interpreting the intentions underlying health information seeking.
Nevertheless, the approach of using MetaMap is the only feasible way to handle a large amount of data in this study. Other natural language processing techniques could be used to perform a fine-grained analysis on the search queries, but this is out of the scope of this research.

### 3.6. Summary

The visitor statistics and the search activities in BHC were examined in this preliminary study. These analyses give an opportunity to compare the users of an active consumer health website with the understandings from the existing literature. Also, the findings raise a few questions that need to be clarified in the subsequent stages of research.

These quantitative data reflect the behaviours of visitors using BHC for accessing health information. The overall high bounce rate and short usage of time suggest that visitors did not engage with the website, as consistent with the literature (David Johnson 2014; Hardiker & Grant 2011; Palotti et al. 2016). Search logs show that users leave quickly and spend little time after search. By looking at the search keywords used by BHC users, it was observed that they demonstrated different behaviour when they searched with different categories of queries. Meanwhile, they sought a broad range of information using various keywords.

While the findings reveal the behavioural patterns of health information seekers, they cannot explain the reasons for these behaviours, nor provide in-depth insights about the health information seeking process. Qualitative research is more appropriate to investigate these aspects. For example, what kinds of search approaches are used in the health information seeking process, why seekers choose these options, and how to support these approaches in the process. Such investigations will be reported and discussed in the remaining chapters of this dissertation.
Chapter 4.

In-depth Understanding of Health Information Seeking Behaviour

The relevant content of the following publications has been integrated into this chapter:


4.1. Introduction

From the study reported in Chapter 3, we have gained a preliminary understanding of health information seeking behaviours. Lay-users are observed to be disengaging from health websites and to spend little time with them. In addition, people show different information seeking behaviours with different search queries. While the preliminary study has revealed some aspects of health information seeking, it does not capture users’ interactions with search engines, the activity flows, and their thoughts in the seeking process. On the other hand, the current literature has not studied the detailed process of health information seeking. In order to have a more complete understanding about information seeking and search approaches taken in the consumer health context, a qualitative study was conducted to obtain an in-depth understanding of health information seeking, which helps to establish the design of consumer health websites in the later stages.

This chapter will discuss the design and results of this qualitative study. Twenty participants completed this lab-based study. The results suggest that in many cases people adopt the exploratory search approach to find relevant information, and the exploratory search in the health context demonstrates different unique characteristics. Additionally, four types of navigational patterns were summarised based on the activity logs captured when the participants searched for health information. These findings can be used to inform a theoretical model for the design phase of this research.

4.2. Research Purpose

The current research has a few major gaps in the understanding of health information seeking behaviours, as summarised in Chapter 2.7. Most of the information seeking theories are formulated for general information seeking behaviours (Kuhlthau 1991; Ellis & Haugan 1997; Pirolli & Card 1999; Bates 1989),
which may not be applicable to health information seeking behaviours. Furthermore, these models were not created for electronic environments. People may demonstrate different health information seeking behaviours when using Internet resources.

While the analysis of the BHC visitors in the preliminary study can fill in some of these blanks, the preliminary study does not provide an in-depth viewpoint for the health information seeking process. Particularly, it does not provide information about users’ interactions with search engines, the activity flows, and how seekers’ thoughts affect the information seeking process. Moreover, from the literature review we have learnt that exploratory search is related to health information seeking (Cartright et al. 2011; Zarro 2012), but no exploratory search behaviours were captured in the preliminary study.

Exploratory search approaches are used when seekers deal with unfamiliar or unknown problems in general topics (Pearce et al. 2012), or feel unsure about the ways to achieve their goals (White & Roth 2009). While health information seekers often fall into these tough situations, there is little literature about exploratory search in the health context, other than conceptualising medical search queries (Cartright et al. 2011). Although our preliminary study gives hints about exploratory search in health information seeking, the study could not identify the scenarios that trigger the searches, and the factors that change the search approaches. For these reasons, a study is needed to further seek answers for these problems.

This chapter presents a qualitative study for obtaining an in-depth understanding of health information seeking, which helps to establish the design of consumer health websites in the later stages. The study mainly focuses on the factors that change the search approaches in different health information seeking behaviours, and the actual behavioural patterns arisen from different types of searches. These research outcomes are useful in designing appropriate technologies for supporting health information seeking.

There are two research sub-questions for this phase of research. The first research sub-question:
**RQ1-1: What factors have impact on the behaviour of health information seekers?**

looks into the different search approaches and the factors causing the changes between different search approaches. In the health information seeking process, seekers use different search approaches to find information. In some circumstances, they take the exploratory search approach in the seeking process. By knowing these factors, we can design technologies to support this behavioural change at a proper time.

The second research sub-question:

**RQ1-2: How do health information seekers demonstrate their information seeking behaviours in terms of their usage patterns?**

investigates the behavioural patterns in different health information seeking behaviours. These patterns display the user interactions and duration with the web during the information seeking process. This information can reflect how people use current technologies to find health information, for identifying the issues and designing better solutions. Moreover, the patterns of exploratory health search are expected to be captured. These patterns can contribute to the understanding of exploratory search, and derive support for exploratory HISB.

### 4.3. Methodology

A qualitative research approach was adopted in this study. As mentioned earlier, the literature does not describe the health information seeking process in detail, and the preliminary study only illustrates a limited range of activities performed by health website visitors. In this case, a qualitative study is more appropriate to investigate in-depth understandings and reasons behind health information seeking (Creswell 2014), which can shed light on the research directions for the latter part of this research. The capability of qualitative studies allows researchers to collect a rich
dataset and to generate new insights from the collected data (Leedy et al. 1997). The main component of this qualitative study is a laboratory observation. Laboratory-based observation studies have been used in a range of research to investigate human behaviours in regard to health information seeking (Hansen et al. 2003; Eysenbach & Köhler 2002; Birru et al. 2004; Buhi et al. 2009).

The entire lab session was structured as three parts:

1. Pre-task semi-structured interview
2. An observational study
3. Post-task session (including surveying and a semi-structured interview)

These three parts were carried out in a one-hour session. The first section was a semi-structured interview conducted with the participants, inquiring about their past experiences of finding health information on the Internet. In the second section, participants were given access to a computer to find online health information for two pre-defined search scenarios, with screen activities and web browsing histories recorded. The last section was a debriefing session, which is a semi-structured interview for understanding how the participants performed the tasks in detail. The design of three components were used in another study to investigate consumer information seeking behaviour (Kumar et al. 2005). The experiment was approved by the Human Research Ethics Committee (HREC Ref.: 1340097). Details of the designs of these parts will be explained below.

### 4.3.1. Pre-task Interview

The purposes of the pre-task interview were to learn the past experience of health information seeking, and in what scenarios the participants would go for seeking health information. There are a number of reasons to collect the past experience of health information seeking. First of all, participants’ experience could supplement the limitation of lab study. People may behave differently than what they usually do in the lab settings. The interview could partially reflect the real experience of health
information seeking. Additionally, the interview could highlight the challenges people were facing with the current health websites and search tools, even though they were not captured in our study. Lastly, the interview could provide richer information about the process of health information seeking, which helped to inform the latter parts of this research.

We composed a number of interview questions for guiding this interview. These questions involved different aspects: the circumstances that lead to health information seeking, experience in health information seeking, and the way of finding and accessing online health information. The implementation of the interview was inspired from relevant studies (Zhang 2013; Thudt et al. 2012; Stinson & Mueller 1980; Gavgani 2010; Lee et al. 2014; Leydon et al. 2000), and adjusted for the purposes of this study. Table 4-1 lists the questions used in this interview, with the keywords in each question bolded.

Table 4-1: The interview questions for the pre-task interview in research phase 1.

<table>
<thead>
<tr>
<th>Question Text</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Under <strong>what circumstances</strong> would you go to the Internet for health information?</td>
</tr>
<tr>
<td>2 <strong>How often</strong> do you search for health information on the Internet?</td>
</tr>
<tr>
<td>3 <strong>What device</strong> (e.g. mobile, iPad, laptop, desktop computer...) do you use to search for health information?</td>
</tr>
<tr>
<td>4 <strong>What</strong> sort of <strong>information</strong> were you seeking?</td>
</tr>
<tr>
<td>5 <strong>At which sites</strong> did you search that information?</td>
</tr>
<tr>
<td>6 <strong>How long</strong> did the search last?</td>
</tr>
<tr>
<td>7 Can you <strong>describe</strong> briefly about that <strong>experience</strong>?</td>
</tr>
<tr>
<td>8 Why did you think search on the Internet was <strong>useful or not useful</strong> at that time?</td>
</tr>
<tr>
<td>9 What were the <strong>difficulties or problems</strong> you found during your search?</td>
</tr>
</tbody>
</table>
4.3.2. The Observational Study

The construct of a task-based observational study has been adopted in many prior work (Eysenbach & Köhler 2002; Hansen et al. 2003; Birru et al. 2004; Buhi et al. 2009; Haak & Hooijdonk 2010). In this type of study, participants are given one or more tasks to perform, while researchers observe how participants work on the tasks. While some research uses a think-aloud approach to collect participants’ thinking during the experiment, this study used a debrief session after the search tasks instead. The main reason was to avoid disruption of the task introduced by the conversations, and to avoid slowing down of the entire flow of the study (Leedy et al. 1997).

The search tasks used in this study imitate two styles of health scenarios. The goal was to identify the behavioural differences between focused and exploratory search with a contrastive setup of tasks by leveraging the clarity and abstraction of the tasks. Similar design was used in the work of Kules et al. (Kules et al. 2009). Table 4-2 presents the task instructions used in this study.

Table 4-2: The tasks used in the observational study in research phase 1.

<table>
<thead>
<tr>
<th>Task 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Please take the scenarios as situations you might need to realistically address. Try to remember key messages you find rather than a “copy and paste” approach to answer the questions for the scenario.</td>
</tr>
<tr>
<td><strong>Scenario:</strong> One of your family members has recently been diagnosed <em>Type 2 Diabetes</em>. You decided to try your best to take care of him/her and avoid anything which could worsen the health condition. Therefore, you go to the Internet and look for information of taking care of him/her. As you’re living together, your daily life needs to be changed in different ways as well. What special attention should be paid in your daily life? What kinds of changes are needed in your everyday life? Please write <em>up to 5</em> key changes in your own words.</td>
</tr>
</tbody>
</table>
Task 2

Urination can become a health problem when it becomes too excessive at night. As the person needs to wake up to go to the bathroom, the sleep is interrupted and the sleep quality is heavily affected. This seems quite common in many people’s lives, however, there is only little covered in Wikipedia, possibly due to lack of volunteers interested in this topic. Your task is to suggest key aspects of this phenomenon to be added into its Wikipedia page.

Please write up to 5 key aspects you suggest to be added in your own words.

In the first task, participants were asked to find information about how to care for a diabetic family member. This particular task intended to investigate two aspects. Firstly, this task simulated the information need that arises from getting a straightforward diagnosis from a medical professional, which falls into the category of focused and recognised information needs. In this case, seekers often have a clear goal about what to search. The observation could investigate how participants conduct the search in the scenarios with a clear search goal. Secondly, this task described a situation of looking for information on behalf of other people. This design could highlight the differences with the health information seeking behaviour for other people.

In the second task, participants were required to find information for appending to Wikipedia pages about a urination problem and relevant symptoms. Participants needed to find out the relevant information from other sources in the web with only limited information and vague symptoms provided. This is very similar to the scenarios of feeling unwell, when the actual sickness has not clearly known yet. According to the theories, exploratory search is likely to occur under these conditions. Such study design could help researchers to observe how exploratory search emerged and was conducted in the health information seeking process.

Additional measures were taken to avoid the bias in this observational study. In order to prevent the tendency of using a search engine due to the browser’s default configuration, the home page settings (i.e. the web page displayed when the browser
launches) of the browser were cleared. Participants started with a blank screen at the beginning of each task. Also, browsing histories and search input suggestions from the previous tasks might affect the outcome. Therefore, all browsing histories and auto-suggestions were removed before each session to ensure the behaviour of the current participant was not affected.

In order to keep track of user activities efficiently and accurately, a web browser plugin was developed to record different data generated during the lab session. Participants were asked to use a Mozilla Firefox browser with this plugin installed. The plugin can produce a log file with the web addresses of visited pages, time of visits, duration of each visit, and identifiers of sessions. Opening a new tab or a new browser window will also be recorded. Besides these logs, the computer screen was captured and saved in the duration of study as a part of the full record of the experiment.

4.3.3. Post-task Session

The post-task session consisted of two parts: a survey and a retrospective semi-structured interview. The survey was used to collect demographic data and to let participants express the prevalence of different subjective feelings and emotions during the information seeking process. The quantitative values collected were not used for quantitative analysis due to the small number of participants, but for inspiring conversations in the semi-structured interview about their abstract feelings of health information seeking. Table 4-3 (next page) lists the questions of the survey.

Survey question 4-11 were used as a probe into exploratory search in the health information seeking process. The questions first measured the succeed of the tasks, as well as the emotions and difficulties associated with the tasks. Then, the questions inquired about the attributes of exploratory search, such as knowledge acquisition and the perceived level of exploration (Marchionini 2006; White & Roth 2009). The answers to these questions informed the discussion about exploratory search in the retrospective interview.
### Table 4-3. The post-task survey used in Research Phase 1.

<table>
<thead>
<tr>
<th>Demographic Questions (Choose one option for the following questions)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Gender: Male / Female</td>
</tr>
<tr>
<td>2 Age: 20 or under / 21-30 / 31-40 / 41-50 / over 50</td>
</tr>
<tr>
<td>3 Are you a:</td>
</tr>
<tr>
<td>• Student of the University of Melbourne</td>
</tr>
<tr>
<td>• Staff of the University of Melbourne</td>
</tr>
<tr>
<td>• None of Above</td>
</tr>
</tbody>
</table>

### Questions about Health Information Seeking

Choose from a 5-Likert Scale (Strongly Disagree ... Strongly Agree)

| 4 I learnt new health information about the scenario after these tasks. |
| 5 I am successful in finding the needed information.                   |
| 6 I have no difficulties in finding the needed information.           |
| 7 I have a pleasant experience in finding the needed information.     |
| 8 I felt engaged with the tasks just now.                             |
| 9 I feel that there are differences between searching for and exploring information online. |
| 10 I was searching most of the time in the tasks.                     |
| 11 I was exploring most of the time in the tasks.                     |

The retrospective semi-structured interview allowed participants to reflect on the experience and emotions of health information seeking. The interview questions covered the differences between two styles of search tasks, the process of finding health information, the experience and emotions, as well as the ways of finding information. These are common aspects of health information seeking behaviours (Zhang 2013; Lee et al. 2014; Case 2002). Furthermore, the interview responded to
the survey responses discussed above. This could help to pinpoint the differences of exploratory health search, the way of carrying out exploratory health search, and the difficulties of performing exploratory search with the current web technologies.

Table 4-4 shows the questions used in this interview, with the keywords in each question bolded.

**Table 4-4: The interview questions for the post-task interview in Research Phase 1.**

<table>
<thead>
<tr>
<th>Question Text</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>What were the <strong>differences</strong> in the way you approached the 2 tasks? Why?</td>
</tr>
<tr>
<td>2</td>
<td>What <em>emotions</em> (i.e. happy, sad, frustrated, engaged, annoying...) did you experience?</td>
</tr>
<tr>
<td>3</td>
<td><strong>What</strong> would you suggest are the <strong>differences</strong> between searching for and exploring information?</td>
</tr>
<tr>
<td>4</td>
<td>Why do you suggest you’re <strong>searching/exploring</strong> most of the time?</td>
</tr>
<tr>
<td>5</td>
<td>What were the <strong>difficulties</strong> in finding information?</td>
</tr>
<tr>
<td>6</td>
<td>How <em>well</em> did you <strong>know</strong> the information for the task at the beginning?</td>
</tr>
<tr>
<td>7</td>
<td>How did you <strong>develop</strong> your <strong>understanding</strong> of the scenarios throughout the task?</td>
</tr>
<tr>
<td>8</td>
<td>Why did you decide to make or not to make a <strong>new search query</strong>? How did you <strong>decide</strong> on the <strong>keywords</strong> for the new search query?</td>
</tr>
<tr>
<td>9</td>
<td>What made you <strong>investigate/study</strong> information about certain topics while you’re doing something?</td>
</tr>
<tr>
<td>10</td>
<td>What features in the websites you visited were particularly <strong>helpful or not helpful</strong> for the task? For example: menus, sitemaps, search recommendations...</td>
</tr>
</tbody>
</table>
4.3.4. Data Analysis

Two types of data, namely interviews and web browsing logs, were analysed in this study. Both datasets were used together to interpret the observations. The use of multiple data types in qualitative research is common for making sense the phenomenon being investigated (Creswell 2014).

First of all, pre-task and post-task interviews were transcribed in full, which then were reduced to a number of codes iteratively (Creswell 2002). Codes relating to the focuses of this study (e.g. search approaches, search motivations and information seeking behaviours) were organised into themes (Creswell 2014). Themes were further derived with the thematic analysis methodology (Braun & Clarke 2006; Greg et al. 2012). The methodology involved reading transcripts multiple times, categorising codes into themes and refining the theme list iteratively along the analysis (Braun & Clarke 2006). The numbers of participants who connect to these themes were recorded for verifying the generality of themes.

For browsing logs, a navigation graph was created manually for each participant. A navigation graph indicates the flow of web page views along the search progress, as well as the duration of each step. This can provide researchers insights about how the search process and the behaviours evolve while the participant engaged with the information seeking process. Navigation graphs were originally used in algorithms of recommendation systems for suggesting relevant information to users (Wang et al. 2008). In this study, navigation graphs were used in a qualitative manner to illustrate the human behaviours. Navigation graphs with similar patterns were merged into themes (Perez et al. 2015), in order to further derive generalised representations of different health information seeking behaviours.

4.3.5. Participants

For this experiment, we used multiple methods to recruit participants. We posted promotional materials at different locations across the university campus. E-mail
invitations were also sent out to staff and students to encourage participation. At the same time, we encouraged participants to invite potential participants to our study through their connections. This recruitment method is known as snowball sampling (Goodman 1961). Recruitment continued until data saturation was achieved. Data saturation is a common method in qualitative studies to control the sample size when the collection of new data does not shed any further light on the issue under investigation (Mason 2010; Glaser & Strauss 1967). This experiment was voluntary and no incentive was given to participants for the study. Informed consent was obtained before the study by requiring participants to sign a consent form.

The actual study was conducted from October to December in 2013. Twenty participants successfully completed the lab experiment, including 11 males and 9 females. Among them there were 8 university students, 9 university staff and 3 external participants. All reported that they were capable of reading and searching information on the Internet. All participants claimed they had experience in searching online health information previously. For privacy considerations, age group rather than the exact age was recorded. The distribution of the demographic attributes of the participants is listed in Table 4-5.

<table>
<thead>
<tr>
<th>Gender</th>
<th>Number of Participants</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>11</td>
<td>55%</td>
</tr>
<tr>
<td>Female</td>
<td>9</td>
<td>45%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Age Group</th>
<th>Number of Participants</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>21-30</td>
<td>8</td>
<td>40%</td>
</tr>
<tr>
<td>31-40</td>
<td>6</td>
<td>30%</td>
</tr>
<tr>
<td>41-50</td>
<td>4</td>
<td>20%</td>
</tr>
<tr>
<td>Over 50</td>
<td>2</td>
<td>10%</td>
</tr>
</tbody>
</table>

Table 4-5: The distribution of the demographic attributes of the participants (N=20).
In the data analysis process, the collected data was segmented into different age groups and genders. The analysis of the partitioned data shows no significant differences in the themes and the patterns across different groups of participants. Therefore, the results apply to all health information seekers as a whole group, regardless of their ages and genders.

### 4.4. Results

This section consists of the four aspects of results from this study. Firstly, we will summarise the search strategies for finding health information used by the participants based on the in situ observation of the researcher. Then, we will show the factors that lead to exploratory search approach, based on the qualitative feedback obtained in the interviews. In addition, we will categorise how exploratory search differ from other types of search from the perceptions of the participants. Finally, we will use the browsing logs captured in the study sessions to illustrate the patterns of health information seeking. The section will be structured as follows:

1. The search strategies of health information seeking
2. The factors causing exploratory search
3. The characteristics of exploratory search
4. The behavioural patterns of health information seeking
4.4.1. Search Strategies

This sub-section gives an overview about how participants performed health information seeking behaviours in our lab sessions with current technologies, as well as the problems they encountered with these technologies.

In this study, 19 out of 20 participants used Google to look for health information, while the remaining one directly entered the web address of his preferred health website and started browsing. For search engine users, in addition to performing keyword searches, they were found to use Google as a web directory. In some observations, participants clearly knew the name but not the address of the website they wished to access. Consequently, they used Google to directly jump to the website. These are known as “navigational” queries (Broder 2002; Rose & Levinson 2004). At the same time, Google acted as a “connector” to link different parts of a website together. There were occasions that the participants could not find, or simply missed, a hyperlink internal to a website and instead queried the information from Google and landed back in the same website (for example accessing another article in Wikipedia). However, hyperlinks were still preferable as they are more convenient and easier to use. To use hyperlinks, they only needed to discover them, and simply click on them.

The observations suggested that search engines were not satisfactory in handling the search queries about health. There were difficulties in knowing and using accurate keywords for health search, for example, as Participant #1 said:

I do not know sometimes what are the right keyword to use in order to get the right information. (Participant #1)

Also, some of the participants mentioned the difficulty of filtering and narrowing down the search results, due to the lack of medical knowledge and analytical skills.

If you search for health, then there is so much information coming up. You are not the doctor, so you pick and choose whatever you want and that could be
very wrong at the end, because you think you’re sicker. It all depends on what kind of symptoms you searched for. (Participant #13)

Besides, the participants used multiple websites for each health topic in their lab sessions. The reason was mainly due to concerns about the trustworthiness of the online health information. They used multiple data sources to reassure the quality of the information, as one of the participants reported:

But sometimes you don’t know whether it’s genuine so I keep searching other sites for that. (Participant #1)

### 4.4.2. The Factors Causing Exploratory Search

Not every attempt to find health information is exploratory, but several potential factors that lead to the exploratory search approach were observed in this study. This sub-section presents five factors that are associated with the use of the exploratory search approach. Table 4-6 outlines these factors and displays the number of participants who mentioned the factor in their sessions.

**Table 4-6: The factors causing exploratory search (N=20).**

<table>
<thead>
<tr>
<th>Factors</th>
<th>Number of Participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Encountering Health Issues</td>
<td>18</td>
</tr>
<tr>
<td>Receiving Conflicting Information</td>
<td>12</td>
</tr>
<tr>
<td>Searching for Other People (e.g. Family Members)</td>
<td>12</td>
</tr>
<tr>
<td>Curiosity</td>
<td>9</td>
</tr>
<tr>
<td>Task Clarity</td>
<td>7</td>
</tr>
</tbody>
</table>
**Encountering Health Issues**

A number of participants suggested that they adopted the exploratory search approach in finding health information because of suffering from health issues or seeing physical signs of health issues. In this case, the participants did not simply perform a simple search, but tried with different queries to learn more about the issue.

> I would usually search if I think there is a health problem... If I go search for something, I don’t stop at the first page comes up at Google. I explore, I read further, try different search terms, looking at the other results... And then occasionally I will think of new words, I go back to the search bar and type that different words. (Participant #2)

**Receiving Conflicting Information**

Participants reported that they were more exploratory when they encountered conflicting information. In these cases, they investigated different data sources, used hyperlinks to navigate to different web pages, and tried to verify the validity of the information.

> [When] I receive advice that seemed to be conflicting from different sources I often look for an answer... I cross [check] references, check another source... One thing leads to other things. They have links within the article, and I end up finding about more information than needed, still interesting and related. (Participant #20)

**Searching for Other People**

When the health issues were related to the people that are important to the participants (e.g. family members or close friends), the searches were deemed to be more exploratory.
But I guess if it was my mum like that, I would go back to look into, to compare information on sites... I would definitely look for more websites... I think I will continue to search afterwards as well. (Participant #13)

Curiosity

Curiosity also caused participants to become more exploratory. This type of search was relatively lengthy and they tended to look deeper about the health topic.

Usually I end up finding information on the government websites and specific to the health information I am curious about... It lasts probably a few days. Because sometimes I started with one bit of information and I keep searching other websites as well and looking deeper to the topic. Just to get more information and a bigger picture – to see if there [are] any other related issues. (Participant #4)

Task Clarity

The relationship between different search approaches and task clarity was identified in the study, due to our setup of two comparable tasks. The participants described that Task 1 (focused search task with straightforward diagnosis) led to the focused search approach; whereas in Task 2 (the open-end task) the exploratory approach appeared to be used more, because the participants had less of ideas about what to look for. They explored more to build up an initial understanding for the task. Based on this contrastive setup, we observed that the level of task clarity was another factor to initiate exploratory search.

In my mind searching is when you know exactly what information you need to find out. Just basically looking for, like a concrete direct answer [in the first task]... For the second task I have to do more exploratory because I didn’t know what I was looking for. So I need to find out more general information about the answer, including searching as part of that, but exploratory doing more. (Participant #16)
4.4.3. The Characteristics of Exploratory Search

This sub-section presents the characteristics of exploratory search in the health context, after realising that exploratory search appeared due to a number of different factors. These characteristics made exploratory search different from general health information seeking behaviours. Table 4-7 summarises the characteristics of exploratory search and the number of participants reported these.

Table 4-7: The characteristics of exploratory search (N=20).

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Number of Participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-specific Search Target</td>
<td>8</td>
</tr>
<tr>
<td>Learning New Information</td>
<td>16</td>
</tr>
<tr>
<td>Co-existence and Switching of Focused and Exploratory Search</td>
<td>7</td>
</tr>
</tbody>
</table>

**Non-specific Search Target**

In contrast to the focused search approach which had a specific search target, the search target in the exploratory search approach was non-specific and unclear. The participants did not have an idea about what keywords to be used for searching. In this case, they opened up their mind for incoming information as hints for the search.

> Searching tends to be focused. I feel like when I am searching, I have my keywords in my head, I have a reasonable idea of what I am looking for or find. So a lot of time I already go with some sort of information in keywords...
> Exploration is not so focused. Exploration suggests that you have more time. You are not going in so many keywords perhaps. You are much open to the information that’s coming to you. (Participant #6)
Learning New Information

Participants learnt new information in the exploratory search approach. Throughout the information seeking process, the participants felt “a bit lost” in the health information seeking process. Therefore, participants tried to use the exploratory search approach for reading the information and learning new search keywords. As a result, they obtained necessary knowledge for the search. The learning experience was emphasised in the health information seeking behaviour. In contrast, general search was merely about finding the information.

For me searching is like Google and find the website; and exploring is taking time to read the information and check the information a website has, and learning. My perception of exploring would be more on the learning experience. Searching is just getting where to find the information. (Participant #7)

Because as I Google, I can find other words and connections that I can use to search. (Participant #7)

Co-existence and Switching of Focused and Exploratory Search

A few participants suggested both search approaches were not completely unrelated, though the behaviours of the focused and the exploratory search approaches are distinct from each other. They reported that the two types of search approaches existed at the same time and alternated in the search process.

At the beginning I was searching, and then I started exploring things more and more, and opened various links. I think when I open multiple links that’s kind of exploring. Then I did another search, which is more specific and then I continue exploring. (Participant #17)
4.4.4. Behavioural Patterns

A navigation graph was generated from web browsing activity and history logs for each successful task. In total 36 navigation graphs were created, and four tasks were not completed by participants due to the time constraint in these lab sessions. These graphs were further analysed and categorised according to the behavioural patterns. These patterns are reflecting different health information seeking behaviours and choices of the navigation in the information seeking process, which will be further discussed in Chapter 5. Here we present the four categories of behavioural patterns categorised from the data, as illustrated in Figure 4-1.

Figure 4-1: Behavioural patterns of different health information seeking behaviours.

Type A showed the simplest pattern of all health information seeking behaviours. The participant simply submitted a query to a search engine. They quickly spotted a web page to read from the list of search results. The web page was then skimmed to identify the most relevant information. The seeking process stopped soon once the information was found. The participant did not engage in deeply reading the web page in this type of behaviour.
Type B appeared very similar to Type A in terms of the small number of searches incurred in the information seeking process. However, the participant engaged with longer and deeper reading activities. Identically to Type A, the participant picked the most appropriate web page to start with. Then, they behaved differently in follow-up of hyperlinks and the readings of subsequent web pages. The duration of reading is longer as the seeker digests and absorbs the information. The series of reading continues until no more valuable information is found.

Type C demonstrated not much reading but more query reformulations, which showed intentions to explore more additional information. In this type of information seeking behaviour, the participant tried to skim through the search results and picked up only the relevant web pages. While the search continued, they would adjust the search queries (i.e. search keywords), using the information newly read. This query reconstruction would happen when the search result was not satisfactory. Sometimes the participant followed hyperlinks to seek for more information. However, the depth of hyperlink follow-up was limited since restructuring search queries were more preferred in this type of information seeking behaviour.

Type D presented a mixed approach to find information. These participants began with a keyword search and chose a small number of good websites for reading. These websites were usually reputable and contained a vast amount of content. Whenever necessary, they would use hyperlinks to discover new information page-by-page. The participant was observed immersing themselves into the reading of every page. At the same time, they also utilised search engines to find additional information. In such case, a new reformed query was executed and the new search result would be examined again. This type of information seeking behaviour displayed searching and reading activities in multiple iterations until the information needs were satisfied.

In summary, this sub-section outlines four categories of behavioural patterns, which show different health information seeking behaviours. While some of these patterns have little reading activities, the other ones show a pattern of studying the health
Chapter 4. In-depth Understanding of Health Information Seeking Behaviour

topic extensively. These patterns provide hints for creating a model to describe health information seeking behaviours, which will be further discussed in Chapter 5.

4.5. Discussion

4.5.1. Current Search Strategies of Health Information Seeking

In the everyday use of the Internet people heavily rely on search engines. Most modern search engines are designed to work with keyword queries and have no special adaptation for health-related searches (Berland et al. 2001; Benigeri & Pluye 2003). According to studies, lay-peoples usually have only limited knowledge of the medical domain (Zhang 2011), and face difficulties in searching due to insufficient knowledge of technical and medical language (Keselman et al. 2008; Chapman et al. 2003). We have identified similar problems in this study. The participants did not know the keywords in some tasks, due to the lack of medical terminologies (such as not knowing the name of a disease, or misspelling certain medical terms). Some participants even reported that they do not know which keywords should be used for the first query in their searches. Moreover, they were not able to use search queries precisely, and unable to narrow down the search results. For example, for a given set of symptoms, search engines returned multiple possibilities and the participants could not determine the correct one for further reading.

Regardless of the scenarios, nearly all participants searched with Google, while few users directly used their own preferred health websites. For search engine users, they explicitly entered the web address of Google, or intentionally used the search toolbar provided by the web browser, even though we had removed the default home page settings. This reflects the high tendency to use search engines in health information seeking. Some participants reported that they used to save bookmarks of health websites, but these bookmarks were no longer used after the growth of Google. These findings adds to the work of Choo et al. (Choo et al. 2000), which
describes that seekers prefer to start their information seeking behaviour (i.e. the “starting” stage) with a search engine. However, search engines may become a barrier for obtaining the most suitable health information, since the algorithms controlling the ranking of search engine results are designed for general purposes. Without special handling of health information, the algorithms may not know the best way to sort the search results in terms of the expectations of health information seekers. As a result, seekers may not be able to access the best health website if it is displayed in a lower rank; or the worst case is that search engines may even unintentionally hide a website though it contains credible and useful information.

There were some cases in which the participants clearly knew which websites to look for, but did not know the web addresses. Google was used to navigate to the particular website, which is described as a “teleport” process by Teevan et al. (Teevan et al. 2004), or “navigational” queries (Broder 2002; Rose & Levinson 2004). Also, Google was “linking” different web pages by indexing the pages from a single website, so that the user could navigate from one to another within a website, which is a smaller scale of teleporting inside a website. Some participants felt frustrated in navigating in a website because of unsatisfactory designs (such as misplaced hyperlinks and ill-designed menu categories), therefore they used Google to discover and access the information even in the context of the same website. This study clearly shows that teleporting is common in health information seeking, and should be supported by the design of health websites.

4.5.2. The Factors Causing Exploratory Health Search

Health information seeking behaviour is different from the searching for other types of information in many ways. For instance, health information seeking behaviour is used for dealing with health-threatening situations, making medical decisions, and assisting in disease prevention (Lambert & Loiselle 2007). Because of these different motivations, the search approaches are expected to be different in health information seeking. Based on the observations in the study, a number of factors that lead to the
use of the exploratory search approach have been identified when people look for health information.

**Dealing with Health Issues**

People with health issues or recently diagnosed with a sickness are observed to be more exploratory in their searches. They have concrete and explicit information needs on certain issues relevant to their health, such as treatments and remedies. In such scenarios, the exploratory search approach is mainly the approach of understanding the complete picture of the health-threatening situation, and obtaining more options for dealing with the health issues.

These findings can be discussed together with existing literature. First of all, the exploratory search approach is a consequence of a stressful situation derived from health issues. This has been described in Wilson’s stress/coping theory (Wilson 1997; Wilson 1981), which suggests that people will look for further information under stressful scenarios, in order to cope with the problem. This study confirms that similar behaviour occurs in the health context. Secondly, dealing with known health issues is categorised as having recognised health information needs (Alzougoool et al. 2008; Alzougoool et al. 2013). While it is known that people with recognised needs will demand health information, this study adds that these seekers will engage with the exploratory information seeking behaviour as well.

**Encountering Conflicting Health Information**

Seekers are observed to be more exploratory if they encounter conflicting health information. Having contradictory information on the Internet is common because anyone can publish online without any necessary verification of the information. While much effort is invested to improve the quality and reliability of health websites (Commission of the European Communities 2002; Boyer et al. 1998; Boyer 2013), health information seekers have their own strategies to verify the information by adopting exploratory search.

For resolving conflicts, seekers will investigate different information sources, follow hyperlinks to different articles, read carefully the contents, and try to verify the
reliability of the information. In this process, seekers try to look for additional information for verification purposes, and they become more open minded to the information encountered. At the same time, they will be cautious to the new information to avoid wrong information. While the Internet consists of a large amount of false information, health information seekers can obtain useful information by exploring the web instead of simply performing narrow searches for health information.

**High Level of Situational Relevance**

People search for health information on behalf of other people (Khoo et al. 2008; Macken et al. 2014), particularly for people that are important or highly relevant to the seeker (e.g. family members or close friends). Though the health situations are not directly faced by the health information seeker, the level of situational relevance is high if the situations are related to people who are important to the seeker. The seeker would behave as if they are facing the health issues themselves. This observational study further identifies that the searching will become more exploratory in the cases of high situational relevance.

Exploratory search has a different usage in this case. It is used to identify preventative measures to protect the important people from health threats, and to address the anxieties caused by diagnosed health problems. For both scenarios, the concerns of the seeker are high, and the seeker would use a wide array of approaches to understand the problems, looking for remedies and learning to provide support. It is observed that the seeker will not only search for the information, but also look into every detail in the web page. The nature of exploratory search is to retrieve as much information as possible to deal with the threat.

**Being Curious**

Curiosity is another type of information need that motivates exploratory search. Health information seeking is often triggered passively, such as hearing of information about health on TV, news about the health of a celebrity, or becoming
interested in a medical topic during an everyday conversation. Although seekers may have a clearer search target initially in the scenario of curiosity, they will then adopt the exploratory search approach when encountering other interesting material during the search process. This is an instance of interchanging behaviours between focused and exploratory search approaches, which will be discussed in more detail in the next sub-section.

**Low Task Clarity**

The clarity of the search task is related to the search approaches used in the health information seeking process. Although in the context of this study the search tasks are pre-defined and the level of task clarity is fixed, in real life people are actually performing different kinds of search tasks, with different levels of clarity. For real world health scenarios, some are concrete and precise, while some do not have information provided.

Concrete search tasks with enough information provided are more likely to show a more focused search. On the other hand, exploratory search is observed in many ill-formed tasks. For example, unclear and fuzzy tasks, or the information about the task is not enough. In this regard, seekers have to explore around the knowledge domain to figure out what exact information is needed, i.e. determining a search target.

In this sub-section, five factors that motivate exploratory search have been identified and discussed. These help to classify different modes of health information seeking by information needs. Next, we will introduce the characteristics of exploratory search, for which HCI practitioners and researchers can support through appropriate design.

**4.5.3. Characteristics of Exploratory Health Search**

Exploratory search in health information seeking is observed to be different from other types of searching. In this sub-section, we will discuss four unique
characteristics found in exploratory search in the health context, which were observed in this study.

**Non-specific Search Target**

The search target of exploratory search is not as specific as for focused search. We are able to identify this difference with the setup of the two comparable search tasks in this study. As observed in the study, seekers with the focused search approach have a clearer awareness of the health scenario and a reasonable plan to search in mind. In contrast, exploratory seekers need to look up in a wider range of information in the knowledge domain to satisfy unclear and unfamiliar information needs. This finding is in agreement with the recent research on exploratory search (Marchionini 2006; White & Roth 2009).

In order to retrieve a broad range of information, seekers use multiple information sources to explore. There are reasons behind this. For example, seekers use exploratory search to reassure the validity of the information, or to form a broad understanding of a topic. For accessing multiple resources, hyperlinks play an important role in exploring additional information. It is reported in our study that hyperlinks are more convenient to use, compared to issuing search queries. In contrast, keyword-based searching requires a cognitive process to form a query and to analyse the search result. Users are more likely to visit relevant web pages by following hyperlinks when conducting exploratory search.

**The Intention of Learning New Knowledge**

Another characteristic of exploratory search is the desire to understand and to study the encountered information, beyond simply locating the information. According to Marchionini, exploratory search involves learning and investigation about the information (Marchionini 2006). We have noticed the similar results in the health information seeking context. From the perspective of information seeking theories, knowledge gaps exist at the beginning of the information seeking process (Case 2002). Exploratory search is the actual behavioural outcome for gathering knowledge to “bridge” the knowledge gaps.
Co-existence of Focused and Exploratory Search

While we have identified a few differences between the characteristics of exploratory and focused search approaches, the two approaches are not totally distinct in the course of health information seeking. Within the entire information seeking process, the two types of search approaches can co-exist with each other. A user might switch between them several times.

As illustrated in Figure 4-2, White and Roth have suggested that exploratory search in general will change towards focused search as the searching evolves (White & Roth 2009). This is because the uncertainty reduces when the seeker finds and learns information in the search process. An example of buying a used car can demonstrate this transition. The seeker has no idea about cars at the beginning, therefore they would explore all car models which fall in the price range. This stage is an instance of exploratory search. After examining the result and gaining a basic understanding of the market, the seeker then looks for details of a particular car model, which is a focused search activity. As the search goes on, the range of the search becomes narrower and narrower.

![Figure 4-2: Exploratory search changes towards focused search (White & Roth 2009).](image-url)
We have observed a different behaviour for health information seeking. In the health information seeking process, new and unknown information may appear at any point while exploration is underway. When encountering such new and unknown information, the level of uncertainty will climb again, and thus the search will become more exploratory. Rather than a one-way transition from exploratory to focused search, we argue that these two search approaches are switchable along the health information seeking process until the search stops.

Figure 4-3 depicts the switching between exploratory and focused search. A seeker starts health information seeking with Topic 1. While not having a full understanding of Topic 1, exploratory search is adapted and the search area is wide initially. As the search goes on, the seeker gains more knowledge about Topic 1. The search goal becomes clearer and the search area becomes narrower and focused gradually, as indicated by the spiral curves in the figure. Meanwhile, the seeker may have new doubts at any point of time. As a result, this leads to a search on a new topic (Topic 2). As the new topic is unfamiliar to the seeker, the search becomes exploratory again. This process continues until the search stops.

**Figure 4-3: Illustrating switching between exploratory and focused search.**

An example from our study can further demonstrate the switching of both search approaches. A participant started to search for “diabetes management information”. This search instance was exploratory at the beginning, because the participant did
not know much about this topic. After learning that diabetes is controllable with healthy eating (i.e. starting to get an understanding about the topic), the participant transformed the search to a focused one. After a while, the seeker read some information about cooking and felt confused about which types of food were beneficial to diabetic patents. At this moment the uncertainty increased again and the search turned back to an exploratory one, and the seeker began to study different topics such as diet suggestions and nutrition facts.

4.6. Limitations

This study has limitations, as with other qualitative studies. In this study, the participants were invited to a lab environment and performed artificial search tasks. As such, the study may not truly reflect the real health information seeking behaviours in daily lives. Also, the time constraint of the study may force the participants to end their search more quickly than usual. Moreover, health information seeking behaviours may vary depending on other factors that we have not directly tested, e.g. the type of diseases (i.e., acute vs. chronic), the stages of the illness, education levels, ages, etc. While this research presents the findings that apply to a general group of health information seekers, future research can address these limitations by extending the investigations to more specific groups of health information seekers, or even patients.

4.7. Summary

This chapter reports on a qualitative study for gaining an in-depth understanding about health information seeking behaviours. This study has found some characteristics of the health information seeking process which may be helpful for designing consumer health websites and other health information seeking applications. We have observed people use general search engines for exploratory
search in the process of finding health information but they have also faced several challenges, such as the generation of new search queries and the ordering of search results that is not optimised for health queries. Exploratory search in health information seeking possesses some unique characteristics, which are distinct from focused search. In addition, we have argued that both exploratory and focused search approaches are adopted by seekers within the same session of searching, and the two approaches may be used alternatively as the search progresses.

Besides these findings, this study responds to the research questions defined in this research phase. For the first research question:

**RQ1-1: What factors have impact on the behaviour of health information seekers?**

We have highlighted five factors that cause seekers to adopt exploratory search approaches. These factors include: (1) dealing with health issues; (2) encountering conflicting information; (3) high level of situational relevance; (4) being curious; and (5) low task clarity. The outcomes can inform the design for supporting exploratory search. Designers can expect the emergence of exploratory search if the product contains the above factors, and hence may use the appropriate ways to support the above factors.

For another research sub-question:

**RQ1-2: How do health information seekers demonstrate their information seeking behaviours in terms of their usage patterns?**

Four different behavioural patterns are generalised from the data collected in this study. People show different levels of interactions with search engines and websites. Some people read briefly and quit the search, while others engage with a long reading. With this information, users can be categorised into different user groups, and the website can present different information and navigation paths to different groups. Also, this finding can contribute to the understanding of online health information seeking behaviour, by adding the actual activities seekers perform into the literature.
Based on these findings, we are able to start the actual design of a system to better support for health information seeking behaviours. In the next chapter, a model of health information seekers will be derived from the results of this study. This model will then lead to the design implications and the prototyping of a consumer health website in the subsequent research phase.
Chapter 5.
Designing for Health Information Seeking Behaviours

The relevant content of the following publications has been integrated into this chapter:


5.1. Introduction

In the previous chapter, we introduced the focused and the exploratory search approaches, which are adopted by health information seekers for different scenarios. We have also learnt that seekers implicitly demonstrate different patterns of their search activities because of the different search approaches. To the best of our knowledge, there is not much existing research about practical design of health websites. Therefore, this chapter will continue to investigate the design of a better consumer health website based on the findings described in the last chapter.

This chapter covers mainly three aspects. We will introduce a model of health information seeking behaviours based on the results of the previous study. This model describes health information seeking behaviours that can be observed through the interactions between the user and the system. Secondly, drawn upon this model, we further formulate a number of design requirements for building a consumer health website, which supports the series of these health information seeking behaviours. Finally, a prototype website called Better Health Explorer (BHX) is created to implement these design requirements. This chapter will also outline the details of developing this prototype, as well as how the features in BHX respond to the design requirements.

5.2. Research Purpose

The literature review and the previous studies provide insights of health information seeking behaviours. We have learnt that people take either focused or exploratory search approach in different scenarios. While the focused search approach is well supported by modern search engines, the support for the exploratory counterpart is still insufficient. Fortunately, the prior studies provide insights about how seekers conduct their searches. We can further develop on these findings to derive strategies for the design. For this purpose, this research attempts to develop a model for
informing design in the latter research phases based on the previous results. Below is the research sub-question:

RQ2-1: What is a model of health information seeking behaviour that will support the design of interactive technologies?

In the consumer health context, current research of exploratory search and health information seeking has not moved much beyond theoretical studies and conceptual frameworks, and therefore these are insufficient for empirical designs. Some existing work in this area is listed below:

- White et al. have suggested several design directions for supporting exploratory search in the general context (White et al. 2006; White & Roth 2009), including supporting query reformulations, facilitating learning and understanding, providing history and task management, etc.
- Cartright et al. have proposed that exploratory health search can be categorised into evidence-based and hypothesis-based queries (Cartright et al. 2011).
- Zarro has suggested that exploratory health search can be analysed from a social psychology perspective (Zarro 2012).
- Lee et al. have reviewed the current literature of health information seeking and argued that future research about health information seeking behaviour should focus on the navigational needs of seekers (Lee et al. 2014; Lee et al. 2015).

The above research can be the foundation that we can build upon, for informing design requirements and appropriate user interfaces for health information seeking behaviours. The research sub-question for this goal is:

RQ2-2: What are the design requirements for a consumer health website for better supporting health information seeking behaviours?

When constructing the appropriate design for health information websites, some existing work provides clues, directions and implementations for considerations. In
terms of the data perspective, Bozzon et al. have suggested that multiple
dimensional data are often used in exploratory search (Bozzon et al. 2013). The
similar approach of using multiple perspectives to explore information is used in the
Bohemian Bookshelf (Thudt et al. 2012). On the other hand, exploratory search
engine iFISH uses an interactive and engaging environment to facilitate a playful
information exploration (Pearce et al. 2012; Pearce & Chang 2014). While these tools
focus on exploratory search of different topics, their concepts of user interactions can
be studied to extend to exploratory health information seeking behaviours.

The design requirements formulated in this research will be used to build a
prototype website for supporting various health information seeking behaviours.
This purposes of creating a usable prototype website are two-fold. First, it can show
the feasibility of applying the design using modern web technologies. Additionally,
the website can serve as a technology probe for carrying out evaluations against the
design in the next stage of research.

5.3. Methodology

We use the grounded theory approach to generate the model of health information
seeking behaviours in our research. Grounded theory is a systematic methodology to
construct theories through data analyses (Martin & Turner 1986; Strauss & Corbin
1998; Glaser & Strauss 1967). Originally grounded theory is created for social
sciences studies (Faggionlani 2011), but it is now commonly used in HCI research
(Kjeldskov & Graham 2003; Cairns & Cox 2008). Grounded theory is not used for
finding the truth, but for conceptualising what is going on by using empirical
research (Glaser & Strauss 1967). The traditional research approach suggests that the
researcher chooses an existing theoretical framework and shows how a theory
applies. Unlike the traditional research approach, grounded theory advocates that
the researcher generates insights as a new theory from the data, and should not rely
on the existing work. Grounded theory is suitable for this research, as there is not
much literature about health information seeking behaviours.
Data analyses using grounded theory include several iterative steps of generating codes, concepts, categories, and finally a theory. Codes are small units of information which are the key points in the data. Similar codes are collected into a concept, and similar concepts are grouped into a category. Finally, a collection of categories is used to generate a theory to describe the details about the subjects in the research (Creswell 2014). The data analyses discussed in the previous chapter followed the same coding approaches, which led to several themes (concepts) about different health information seeking behaviours. In this chapter, we will show how to further categorise these findings into a model (theory) to describe behaviours.

After obtaining the model, we will use these theoretical work to build a website using a user-centred design approach. A user-centred design is a design approach for developing applications that incorporates user-centred activities throughout the entire development process (Ghaoui 2005). A user-centred design allows end-users to influence the design for increasing the usability, to optimise the product for a better use, instead of forcing the users to change their behaviour to adapt the product (Lee 1999; Wikipedia 2016). A user-centred design is used in designing interactive health technologies and increases the likelihood of promoting the intended health outcomes (De Vito Dabbs et al. 2009). In this study, a user-centred design is based on the conceptualisation of search approaches and the classifications of health information seeking behaviours, which originate in the feedback of users. This can ensure the website satisfies the needs that arise from different health information seeking behaviours.

5.4. Modelling Health Information Seeking Behaviours

In previous chapters, we have learnt that different search approaches are observable in the health information seeking process, and seekers demonstrate different behavioural patterns. The next step is to summarise these findings into a robust
model to describe health information seeking behaviours. Taking on the perspective of designing health websites and health information seeking applications, this work puts the focus on the search depth and the reading effort in the seeking process.

Both aspects (search depth and reading effort) correspond to the behavioural patterns observed in the previous study. Both aspects are also key elements to distinguish focused and exploratory search. *Search depth* is measured by the numbers of hyperlinks followed up and the numbers of page opened during a search session. Exploratory search is different from focused search in terms of the search scope and the sparse of search targets (White & Roth 2009), which can be captured with search depth. On the other hand, *reading efforts* connect to learning and investigating aspects in exploratory search (Marchionini 2006). This is another perspective to identify different search approaches. The duration of reading is a metric to measure reading efforts.

Figure 5-1 illustrates the model for conceptualising health information seeking behaviours with the above two aspects. Drawn from the behavioural patterns collected in the prior qualitative study (Section 4.4.4), the model presents a combination of *Research Tactics* and *Reading Engagement* in a two-by-two matrix.

**Figure 5-1: Model of health information seeking behaviours.**

Research Tactics (Extensive vs. Basic) represent the level of eagerness and intention for investigating a topic and finding in-depth information. We use search depth to measure the level of Research Tactics. For example, a seeker who follows many hyperlinks and submits many search engine queries in order to retrieve more
information is demonstrating the Extensive Research Tactics; whereas a seeker who stays in the same web page falls in the Basic one. On the other hand, Reading Engagement (High vs. Low) illustrates the duration of reading and the effort of learning the information. For instance, skimming and reading the summary of an article is considered the Low Reading Engagement; while pursuing and digesting the information is an instance of the High Reading Engagement.

With two Research Tactics and two Reading Engagement, the model describes totally four different health information seeking behaviours in four quadrants. The quadrants and the corresponding health information seeking behaviours will be discussed below.

### 5.4.1. Quick Fact Seeking

Research Tactics: Basic  
Reading Engagement: Low

Quick Fact Seeking indicates that the seeker has a clear understanding of the topic. They know which parts of the information are missing in their mind or exactly what information is needed. This type of seeker has concrete information needs, so that they will quickly go through the material to locate the relevant information. The information seeking process will terminate once the knowledge is found. This type of searches is similar to factual search (Li & Belkin 2008) and known item search (Jiang et al. 2014) in the current literature of general information seeking behaviour.

### 5.4.2. All-around Skimming

Research Tactics: Extensive  
Reading Engagement: Low

All-around Skimming is similar to Quick Fact Seeking in the way of skimming and quickly going through information. In general, seekers who demonstrate this type of behaviour have a fair understanding of the problem and want to investigate an issue
more deeply. With a vast amount of content and various quality of online health information, these seekers prefer to use a time-efficient approach to find information. Since the information may not fit seeker's information needs at the first scene, they perform a quick reading before investing time and effort to read in detail. Based on our observation, people with higher search skills (e.g. researchers or people with professional background) are more likely to demonstrate this information seeking behaviour.

### 5.4.3. Focused Reading

Research Tactics: Basic  
Reading Engagement: High

Seekers who have the Focused Reading behaviour devote significant effort to read, but focusing in a small number of materials, e.g. the reading is limited in only one or two web pages. We have found that different scenarios lead to this behaviour. In many cases, people will display Focused Reading when they discover a lengthy document which contains the needed information (such as a journal paper or a fact sheet in PDF format). Also, the lack of skills of using a search engine makes seekers unable to find other web pages that match the topic, and causes them to read a limited number of pages. Similarly, some websites contain a bad design of hyperlinks and menu structures, and therefore some people cannot navigate smoothly (Samuel et al. 2012). These examples demonstrate the Focused Reading behaviour. Moreover, some seekers perform Focused Reading because they want to improve their intellectual understandings (Li & Belkin 2008).

### 5.4.4. Knowledge Digging

Research Tactics: Extensive  
Reading Engagement: High

Knowledge Digging behaviour shows the intention of devoting time and effort to investigate the health problem. The seekers who display the Knowledge Digging
behaviour usually possess relatively better skills at discovering, researching and exploring for more possibilities to enhance their understanding of the issues. An example to trigger this kinds of information seeking is the search motivated by emotional investment and situational relevance, i.e. searching for people who are important or highly relevant to the seeker (Khoo et al. 2008; Macken et al. 2014). When the health issues are related to these related persons, this type of extensive searches is more likely to occur. Seekers aim to acquire as much information as possible, so that they can help another person and provide support with a more complete understanding about the issue.

To conclude, health information seekers do not adhere to a single search approach or behaviour in their search processes. Instead, they choose the most appropriate approach and health information seeking behaviours to them, and switch among these behaviours as the seeking progresses. Therefore, it is not feasible to design for just a single or a limited number of seeker types. Conversely, we should focus on the properties and requirements of each health information seeking behaviour, and support such properties through the appropriate design. In this way, the design covers most of the actions executed by each type of health information seeking behaviour. In the next sub-section, we will incorporate the different activities of these behaviours into a few design requirements for building consumer health websites.

5.5. Design Requirements

In this sub-section, we derive six design requirements for designing a prototype consumer health website with support for different health information seeking behaviours. These requirements are synthesised from the behavioural patterns observed in prior studies (Section 4.4.4) and the model of health information seeking behaviours (Section 5.4). The design requirements attempt to address different characteristics of the heterogeneous behaviours identified in health information seeking. The six design requirements are outlined in Table 5-1 and described in
detail in the following sections.

Table 5-1: Design requirements for our prototype health website.

<table>
<thead>
<tr>
<th>Design Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Provide a Wide Spectrum of Information</td>
</tr>
<tr>
<td>2. Support Information Exploration</td>
</tr>
<tr>
<td>3. Minimise Keyword Search</td>
</tr>
<tr>
<td>4. Design for Reading Activity</td>
</tr>
<tr>
<td>5. Offer Preview and Summary</td>
</tr>
<tr>
<td>6. Leave Clues for the Journey</td>
</tr>
</tbody>
</table>

5.5.1. Provide a Wide Spectrum of Information

We have learnt that both focused and exploratory search approaches exist at the same time, and alternate with each other during the process of finding health information. This means that multiple focused and/or exploratory search may occur in a search session. In order to support both approaches, the design has to cater for both categories of search scopes at the same time. Therefore, the spectrum of information needed for this case is broad. For the exploratory search approach, comprehensive and wide-ranging information is required to enable information discovery; whereas highly relevant and specific information is needed for performing focused search. In this regard, the website should be able to provide both broad and targeted information to users in the same user interface, so that the two flavours of search approaches can be supported. The presence of both types of information also enables ease of transition between the two search approaches.
5.5.2. Support Information Exploration

In terms of health information seeking behaviours described in Section 5.4, Extensive Research Tactics behaviours (i.e. All-around Skimming and Knowledge Digging) involves a number of lookup activities to locate information in various areas within the possible information space. This needs some mechanisms for travelling to other parts of the information space, in order to support efficient information exploration.

To implement the transportation between different parts of information space in a web-based interface, the design needs to highlight the visual connections among different information, for example, by providing hyperlinks to other possible destinations. Different information visualisations can also illustrate connections using a graphical manner.

Serendipity is also another desirable factor that encourages discovery of unexpected information. Seekers may find some information useful if the information is presented to them by the system. In this case, the system needs to recommend information without user interventions, as seekers generally do not know or cannot think of what information is useful for this current scenario. In practical, the user interface could include loosely connected information for encouraging potential exploration.

As demonstrated in existing exploratory search systems (Pearce & Chang 2014; Bozzon et al. 2013; Thudt et al. 2012; Pearce et al. 2012), information exploration is often performed across multiple dimensions. Examples include: relevance of content in the information space, geographical data, personal preferences, temporal information, etc. An effective design should allow users to select and traverse freely among these different dimensions.
5.5.3. Minimise Keyword Search

Keyword search is a fast and intuitive way to find information for general topics, however, it is one of the main challenges in finding health information (Eysenbach 2005; Samuel et al. 2012; Lee et al. 2014). In many health scenarios, seekers do not know the correct keywords for searching (Chapman et al. 2003; Keselman et al. 2008; Zhang 2010), and actions are taken to learn the potential keywords and reformulate search queries (Bickmore et al. 2016). Hence, it is crucial to provide alternatives for accessing health information with minimal use of search keywords.

Health information seekers with different research skills and Internet search capabilities will benefit from the reduction of keyword search. For seekers with higher skill levels, they can carry out the exploration of different areas within the information space easier without having to enter keywords, and the process will become easier and more convenient. Moreover, keyword search requires cognitive workload to consider appropriate terms for searching. People with limited research skills will find a lower barrier to find information with less keyword searches, as the cost of learning and thinking up new keywords is eliminated.

Despite the above discussion, we do not advocate to completely remove keyword search in health websites. Keyword search has its advantages in some scenarios, such as Quick Fact Seeking. We argue that minimising keyword search is an effective strategy for supporting exploratory information seeking behaviours.

5.5.4. Design for Reading Activity

Reading is the main activity associated with browsing, learning and exploring information, which are the primary components of searching. For this reason, the website should provide a friendly environment for reading. Particularly, this is important for Higher Reading Engagement and Extensive Research Tactics behaviours, as these behaviours engage with reading heavily during the information seeking process.
The design for reading activities can be elaborated in two aspects. Firstly, modern web design practice is a good starting point for a comfortable reading environment. The design should ensure the content easy to read. Some techniques include building an uncluttered interface, selecting appropriate fonts and font size for reading, clearly distinguishing headings and content, etc. If the content is long, consider showing long text in sections or tabs.

Secondly, health information seeking should take account of the health literacy levels of the seekers (Johnson & Case 2012). Health information seekers often encounter information that they feel hard to read and understand (Birru et al. 2004; Lam & Lam 2012). The website should avoid this mismatch by understanding the range of health literacy levels of the audience, and providing the information with suitable readability. A desirable design needs to allow users to select their perceived reading levels, or uses mechanisms to estimate and to provide matching information to users.

5.5.5. Offer Preview and Summary

Quick Fact Seeking and All-around Skimming behaviours show only Basic Research Tactics, i.e. these searches provide a shallow understanding about the topic, and therefore seekers who demonstrate these behaviours need to check and evaluate the relevance and usefulness of information quickly in the seeking process. As such, the design needs to facilitate the needs of “peeking” at the information, by providing a short descriptive preview or a summary of the information, so that the reader can rapidly gain an overview of the contents and evaluate whether the information suits before committing a serious reading. Similar concepts have been long used in general search engines, i.e. the snippets of web pages in the search results. However, search engines are mainly for general and focused search. The same concept should extend to health information seeking and other kinds of information exploration.
5.5.6. Leave Clues for the Journey

Health information seeking can be a relatively lengthy process, especially with Extensive Research Tactics which stimulates many readings of different topics. As a result, it leads to frequent navigations between web pages, and users are easily to lose track in the middle of this process. It is important to leave enough clues for the them, so that they can easily perceive where they are currently located within the information space, and the path of reaching the current information. Additionally, users travel back and forth multiple times in their web browsing history, thus the design should include mechanisms which can take the users backward (and forward) along the information journey path, for resuming exploration from earlier stages when necessary. Some examples of providing clues for the journey are history lists, breadcrumb menu bars, etc.

5.5.7. Summary

In the previous six sub-sections, we have introduced the six design requirements that guide the design of consumer health websites. Since health information seekers may shift from one behaviour to another in the search process, it is impractical to design for a specific type of health information seeker. Hence, we need to create design requirements so that different behaviours will be better supported in all scenarios. Next, we will introduce the prototype website Better Health Explorer, and how we build this website using the design requirements discussed above.

5.6. Prototype Website: Better Health Explorer

The goal of building a prototype website is not replacing the sophisticated search engine technologies, but demonstrating an alternative for finding and exploring health information. Particularly, we wish to allow efficient information exploration
with this prototype, since this is not widely supported in existing health websites. For this purpose, we have designed and built a prototype website called Better Health Explorer (BHX), which addresses different requirements of health information seeking behaviours as studied previously, and delivers an interactive and engaging experience in the health information seeking process. This sub-section will firstly introduce the content used in BHX, followed by the explanation of the overall design of the user interface of BHX. Finally, we will discuss how the features arisen from the above-mentioned design requirements can assist in health information seeking.

5.6.1. Data Source

We collaborated with the Better Health Channel (BHC) team in this research, and they supplied the database of BHC to us for building our prototype website. BHC is a consumer health information website established by the State Government of Victoria, Australia since 1999. According to the Google Analytics report of April 2015, there are 4.3 million visits recorded (among them 3.4 million unique users) in this month. In fact, BHC is one of the most popular health information websites in Australia. These figures show that BHC is a satisfactory platform for studying about consumer health websites. The content is suitable for building our prototype, as the content is extracted from a live health information website.

The health information database obtained from BHC is a subset of their articles, which cover more than 250 health and medical topics for the lay audience. These articles are grouped into five categories: Conditions and Treatments, Health Living, Relationships and Family, Services and Support and Video. In addition to text-based materials, pictures and figures in their site, as well as video clips published in their YouTube channel are included in this prototype website. This gives us a variety of topics and information types for trialling with information exploration.
5.6.2. Overall Design

The overall design of BHX is to support the activities observed in different health information seeking behaviours, especially for the use of the exploratory search approach, which is not well supported in existing health information websites. Figure 5-2 displays a screen capture of the Better Health Explorer.

Figure 5-2: A screenshot of Better Health Explorer.

As shown in the figure, although the user interface of Better Health Explorer is similar to a general health information website, the exploration panel (the right portion of the screen) offers a different experience of finding and exploring health information. The two main interaction features of the site are provided by a set of articles represented by clickable tiles (top right of screen) that allow the user to select various topics, and four sliders (bottom right of screen) to let him or her refine the display of tiles based on various personal criteria.

Each tile represents an article in the database and these tiles are arranged in a hierarchy from the best matches to the current slider settings, down to least well matched. The sizes of the tiles also strengthen the impression of the degree of
matching between the input and the results, by enlarging the better matches and shrinking the less ones. The colours of the clickable tiles denote the category that the information belongs to. Therefore, the colour pattern also offers an overview of the composition of the results.

Besides sliders and tiles, the website also has a summary and a table of contents for previewing the content and the structure of the current page (top left), checkboxes filters for narrowing down information by categories (centre right), and a “breadcrumb” history bar for memory aid and navigations among visited web pages (top right).

An example of the woman with a cough and runny nose can be used to illustrate different experience brought by Better Health Explorer. The beginning of the story is similar to the current approach of finding online information. At the beginning, the woman wants to find some information about a common cold, and she arrives at a web page in BHX with a search engine. After some initial reading about colds, she finds the content is a bit difficult for her, therefore she adjusts the slider of reading levels to find something more suitable. This starts the exploration process.

As she moves the sliders, the tiles on the screen spring into action. Some move up; some down; some appear to jostle their positions. Her attention is grabbed by a large tile labelled “Influenza (flu)” so she mouses over it and reads a summary description. She explores in this manner for a while but then, intrigued by the interaction between her slider movements and the animated tiles, she notices a particularly interesting tile about flu prevention. After clicking on it, the main screen changes to reflect this new topic, a new set of tiles appears and she continues to explore without having to exit the website. Her reading history is recorded and displayed as “breadcrumb” menu links so that she can easily go back to her previously viewed information.

The woman continues to move the sliders, explores the possible useful articles by “peeking” at them using mouse hovering, and clicks on the tiles to view the contents, until she satisfies her exploration. It is likely that the playful and engaging experience brings her a more informative search session, and engages her longer in
the search than entering a sequence of search terms into a conventional search engine.

5.6.3. Features

This sub-section will demonstrate the five features in Better Health Explorer that are designated for health information seeking behaviours. We will also discuss how these features correspond to the design requirements proposed in Section 5.5. Table 5-2 lists these BHX features.

Table 5-2: Features of Better Health Explorer and related design requirements.

<table>
<thead>
<tr>
<th>Feature</th>
<th>Relevant Design Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Structured Content</td>
<td>→ 2. Support Information Exploration</td>
</tr>
<tr>
<td></td>
<td>→ 5. Offer Preview and Summary</td>
</tr>
<tr>
<td>B. Tiles</td>
<td>→ 1. Provide a Wide Spectrum Information</td>
</tr>
<tr>
<td></td>
<td>→ 2. Support Information Exploration</td>
</tr>
<tr>
<td></td>
<td>→ 5. Offer Preview and Summary</td>
</tr>
<tr>
<td>C. Sliders</td>
<td>→ 1. Provide a Wide Spectrum Information</td>
</tr>
<tr>
<td></td>
<td>→ 3. Minimise Keyword Search</td>
</tr>
<tr>
<td></td>
<td>→ 4. Design for Reading Activity</td>
</tr>
<tr>
<td>D. Animated Transitions</td>
<td>→ 2. Support Information Exploration</td>
</tr>
<tr>
<td>E. Breadcrumb</td>
<td>→ 6. Leave Clues for the Journey</td>
</tr>
</tbody>
</table>

A. Structured Content

The content in the original BHC database consists of mainly unstructured plain text, which is not a useful file format for both data processing and a user-friendly presentation. Therefore, we generated structured metadata (such as summaries, lists
of paragraphs, lists of sections, etc.) by pre-processing the plain text. These metadata were used to implement extra user interface elements of the website. With the metadata, we created user interface features such as displaying the summary and the table of contents, which presents an overview of an article on the screen.

The structured text and relevant user interface features comply with the design requirements. The article structure listed in the table of contents can be used to explore the content and jump within a long article, without the need of scrolling back and forth to look for the needed information (→ 2. Support Information Exploration). On the other hand, seekers and users can review the content quickly with the summary and the table of contents (→ 5. Offer Preview and Summary). This is convenient for Low Reading Engagement behaviours (i.e. Quick Fact Seeking and All-around Skimming).

**B. Tiles**

The tile display serves the purpose of displaying the results of slider manipulations for further exploration. The tiles are arranged in an order that shows the degree of matching between the metadata of articles and the criteria of information exploration (i.e. the slider input and the checkbox filters). Meanwhile, the sizes of tiles also serve as a visual cue for how strongly each is recommended based on the degree of matching. In such a design, articles with stronger recommendation are displayed at the top as bigger tiles and in larger font size, indicating their significance. Less recommended articles are smaller and are placed at the end. The contrast of this presentation can assist health information seekers to explore articles of interest from this set of tiles with visual perceptions (→ 2. Support Information Exploration).

Additionally, the tile list shows information from different categories. Tiles are coloured with different colours according to the categories of the article. The colour pattern of tiles acts as an information visualisation for the result list. At a glance, the colour pattern illustrates the composition of articles that match with the slider input in terms of the type and the nature of the information. The design helps users to
identify the needed information among a wide spectrum of information easier and quicker (→ 1. Provide a Wide Spectrum Information).

Each tile corresponds to an article in the database. A popup window is shown when the mouse pointer is moved over a tile, as illustrated in Figure 5-3. Consequently, the summary information of the article is displayed. Seekers can then click on these tiles to navigate to other content. This is a design decision supporting users by offering preview before showing the substantial content (→ 5. Offer Preview and Summary).

![Figure 5-3: Displaying a popup summary when hovering a tile.](image)

C. Sliders

Slider controls facilitate the multi-dimensional exploration in the information space without requiring keyword input. Figure 5-4 shows the design of the sliders in the Better Health Explorer. Every single slider represents a dimension to explore the information space. Seekers can adjust the dimensions to reflect their personal preferences at any point in the information exploration process, without the needs of using search keywords (→ 3. Minimise Keyword Search). The similar use of sliders have also been used in the iFISH exploratory engine (Pearce et al. 2012; Pearce & Chang 2014).
Figure 5-4: Sliders in Better Health Explorer.

As seen in the figure, there are four dimensions provided with these sliders for exploring health information. According to Capra et al., it is challenging to identify the correct dimensions for searching, and to ensure that the dimensions are consistent across all data (Capra et al. 2007). For the cases of health information seeking, we chose attributes that are hard to express with search keywords as well as subjective feelings as the dimensions. In addition, these dimensions were suggested from the findings and feedback of the participants in the previous studies described in Chapter 4. Details of these dimensions are discussed as follows.

“Less Related” – “More Related”: This dimension enables exploration within the information scope in terms of the relevance to the current reading article. When users move the slider towards “More Related”, the website shows the information with higher relevance to the current article, and vice versa. The slider allows users to set the focus of the exploration, either be closer or further to the current context. This also facilitates the changes of the search scope between focused and exploratory search approaches, because focused search often needs closely linked information while exploratory search requires a broader scope of information. (→ 1. Provide a Wide Spectrum Information). Additionally, throughout the movements of the sliders, some information that is new to the seeker may show up and capture his/her attention. This serendipitous interaction may lead to useful findings that the seeker has never anticipated.
“Care Giving/Support” – “Condition/Facts”: The BHC database is similar to other health websites in the diversity of information. The database contains health information from five different categories. Some articles present fact-based information about diseases or health conditions, which are more scientific and precise; whereas other information address caring for a patient or handling a health problem, which is more experience-based and social. As observed and discussed before, in some scenarios people looks for enhancing their knowledge on the health problem and needs fact-based information, whereas caring and supporting information is suitable for seekers who search on behalf of others. This slider therefore caters to the information spectrum in both cases (→ 1. Provide a Wide Spectrum Information).

“More Text” – “Image/Video”: Some people are more comfortable reading text, whereas others prefer less text and more images. On the other hand, in certain cases, an article accompanied with images is better at explaining the knowledge. This slider provides a way to include this preference in the exploration process, as a result the website can deliver information that suits the preferences and reading requirements of users (→ 4. Design for Reading Activity).

“Easiest to Read” – “Easy to Read”: Health literacy plays an important role in the health information seeking process, and the interpretation of online health information. Users with poor literacy might have difficulties in understanding health information presented in a technical or professional manner (Lam & Lam 2012; Lee et al. 2015). This slider assists the website in providing information that suits their reading level by explicitly collecting their preferences (→ 4. Design for Reading Activity). We avoid to use the term “Hard to Read” in the label of the slider, as this would introduce bias and users would not use that. Hence, we experiment with the current label to describe the spectrum of different reading levels.

During the exploration process, the prototype website compares the slider input and article scores in the database, and return closest matches for reading recommendations. Sometimes users may wish to explore with fewer dimensions. They can then select or deselect the checkboxes for the sliders to consider or ignore the respective dimensions. The idea of sliders is presenting a list of results that is
closest to the slider settings, instead of showing exact matches. In this case, there are always information to be shown for users’ assessment and exploration, even the users select extreme slider combinations and the dataset lacks such information.

Each article in the database is associated with a score for each of these dimensions. The process of generating the score for each of the articles in the database is called tagging. Tagging can be done automatically or manually. There is a tension between the choice of automatic and manual tagging. Automatic tagging can process a large number of information but the accuracy may vary for different articles and the algorithm lacks control over the scores of particular articles. Manual tagging needs somebody with the expertise of the data (e.g. a librarian) to read and assign scores for the dimensions. The process is slow but the data owner has fine-grained control. In our prototype, we use the automatic tagging with simple heuristics such as word counts and common word detection. We believe other natural language processing and machine learning techniques can improve the results of the tagging algorithm, but this is out of the scope of this project. In fact, this is one of the limitations of our research.

The technical details of handling the slider-based queries and tagging documents for the sliders will be discussed in Appendix B.

**D. Animated Transitions**

Animated transitions are key elements to inform responses and provide hints of actions in interaction design (Chang & Ungar 1993; Baudisch et al. 2006). BHX incorporates animated transitions in the design to enhance the user experience of information exploration. For instance: tiles move in distinct response to slider changes; tiles newly included or removed from the exploration results are shown in slide-in/out effects; recommended articles are enlarged with transitions of tile sizes; changes in higher/lower rankings are displayed as swapping tiles on the screen.

The series of animations and transitions provides clues of how each article connects with the current slider settings. Meanwhile, the animated transitions illustrate the relationships among articles in the tile list and how they individually relate to slider
changes. Information seekers, for example, can realise the articles no longer match the current slider settings when they see tiles drop off from the screen. This provides a visual hint to an implicit overview of the entire information space that can be perceived by meticulous information seekers, which can aid the information exploration (→ 2. Support Information Exploration).

**E. Breadcrumbs**

A “breadcrumb” history bar (Figure 5-5) is created for recording and displaying the track of articles visited by the users. As pointed out in the literature review, health information seeking has been seen as a trial-and-error process (Toms & Latter 2007). Seekers often need to revert to previous web pages and make new decisions during the information exploration process. As such, the breadcrumb bar allows fast navigation back to previous web pages as well as earlier slider settings. Also, exploratory search can be a lengthy process (White & Roth 2009), and users may forget how they arrive at the current location and hence feel lost. Thus, this feature serves a purpose of reminding seekers of the path leading to the current context (→ 6. Leave Clues for the Journey).

![Figure 5-5: The “breadcrumb” history bar in Better Health Explorer.](image)

**5.7. Summary**

This chapter develops the work from Chapter 4 to conceptualise a model to describe different patterns of health information seeking behaviours, for the first research sub-question defined for this phase:

*RQ2-1: What is a model of health information seeking behaviour that will support the design of interactive technologies?*
In the model described at the beginning of this chapter, health information seeking behaviours are categorised using Research Tactics and Reading Engagement. During the health information seeking process, we argue that seekers may adapt either Basic or Extensive Research Tactics, reflecting their eagerness to investigate the problem. Besides, seekers may engage in reading the information or quickly skim through it, expressed as different Reading Engagement. Totally four behaviours are described using this model, including Quick Fact Seeking, Focused Reading, All-around Skimming, and Knowledge Digging respectively. Designers can make use of this model to create user interfaces that address different levels of research and reading requirements.

For the second research sub-question:

**RQ2-2: What are the design requirements for a consumer health website for better supporting health information seeking behaviours?**

We have introduced six design requirements for designing a testing environment for heterogeneous health information seeking behaviours in this chapter. These requirements are consistent with the model of health information seeking behaviours and the related behavioural patterns. Then, we have built a website called Better Health Explorer to implement these requirements. This prototype website equipped a number of features to provide an innovative experience on reading and exploring health information.

Figure 5-6 (next page) summarises the main contributions of this research phase. The centre column of the figure shows the design requirements for building health information websites, which support health information seeking along with the conceptual model of health information seeking behaviours, as illustrated on the left column. The right column depicts major features in BHX, which is the prototype of our research outcomes, and how these features are backed up by the design.

In the next chapter, we will discuss the evaluation of this prototype website and summarise the results into several strategies to support a full range of health information seeking behaviours identified in this thesis.
Chapter 5. Designing for Health Information Seeking Behaviours

Figure 5-6: Summary of the model of health information seeking behaviours, design requirements, and corresponding features in Better Health Explorer.
Chapter 6.
Design Considerations for Health Websites

The relevant content of the following publications has been integrated into this chapter:


6.1. Introduction

We have learnt that different search approaches and diverse health information seeking behaviours are adopted when searching for health information in Chapter 4. Then in Chapter 5, a website for supporting health information seeking behaviours was built with a number of design requirements based on our findings. However, the effectiveness and the performance of such a design still remain unclear. This chapter presents an evaluation of this work.

The prototype website introduced in Chapter 5 was used as a technological probe to evaluate the design. This study measures the effectiveness and the performance of supporting health information seeking behaviours using multiple metrics. In the study, we observed the usage of the prototype website, in order to identify the advantages and disadvantages brought by the new design. More importantly, the study collected feedback from the users about the design. This feedback reflects their perceptions about the design elements of supporting health information seeking behaviours, and the roles of these elements in the health information seeking process.

The findings of this research phase are two-fold. First, the study informs the effective design for consumer health websites, which brings a better experience to health information seekers. Secondly, the evaluation contributes to the research design of health information seeking behaviours and exploratory search, which are beneficial to the HCI and health informatics disciplines.

6.2. Research Purpose

While a few design requirements and website features are discussed in Chapter 5, these design considerations have not been used and verified in a practical environment. Also highlighted by Sherer, the design elements for assisting and supporting the complex behaviour of health information seekers are still unclear
Chapter 6. Evaluation and Design Considerations for Health Websites

(Sherer 2014). As such, there is a need to evaluate these design considerations and investigate the outcomes brought by the design. This is guided by this research sub-question:

*RQ3-1: How can the design of consumer health websites support the full range of health information seeking behaviours?*

This study uses a deductive approach to evaluate the support of health information seeking behaviours. Firstly, the evaluation consists of a human-based usability test against the prototype website Better Health Explorer. In our research, the aim is to rectify the challenges for health information seeking behaviours, meanwhile without introducing new problems. Usability is a basic requirement for web technologies (Nielsen 2012). If this baseline requirement of usability cannot be achieved, it is not possible to discuss further about supporting health information seeking behaviours.

In addition to the usability evaluation, the prototype website serves as a vehicle to assess the design proposed in Chapter 5. In the process of the usability evaluation, we captured a range of data (such as reading duration, numbers of web pages opened, etc.) to classify the search session into one of the four health information seeking behaviours. We also measured performance metrics so that we can observe the effectiveness and the performance associated with each of health information seeking behaviours.

Finally, the study collected user feedback from the evaluation of the website, for obtaining a broad scope of reflections for the proposed design. The feedback includes user perceptions about the new design, and reports the role of the different features of the website in the health information seeking process. Based on the data, we gain an empirical understanding about supporting health information seeking behaviours, as well as the design elements that are effective for this purpose.
6.3. Methodology

A lab-based observation study was conducted for this research phase. Lab-based observation studies have been used in prior research to study health information seeking behaviours (Hansen et al. 2003; Eysenbach & Köhler 2002; Birru et al. 2004; Buhi et al. 2009), and usability tests of websites (Rogers et al. 2011; Nielsen 2012). Participants were invited to the laboratory to perform different tasks of searching health information, and complete a questionnaire after each task. We used a mixed research approach for this study, capturing both qualitative and quantitative data. The experiment was approved by the Human Research Ethics Committee (HREC Ref.: 1544659).

In a lab study session, participants were asked to use two websites. One website was Better Health Explorer (BHX), whereas the other one was Better Health Channel (BHC). As mentioned in Chapter 5, BHC is a live consumer health website owned by the Victoria State Government. With the large extent of visitors and public usage, BHC is a representative health information website for comparison. Therefore, in this study, the data from BHC were used as baseline measurements, for comparing the differences between the current and our proposed design.

Both websites shared the same contents in this experiment. The physical differences of both websites were the web page layout and the way of accessing health information, for instance, participants can use menus to navigate in BHC but not in BHX. By eliminating the possible bias introduced by the content, we were able to observe the differences introduced by different designs, particularly the design proposed for supporting health information seeking behaviours. Figure 6-1 shows the user interfaces of both websites used in this study.

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9 The web layout of Better Health Channel has been changed since November 2015. In the entire period study we used the old version of layout as shown in the figure. The old version can be accessed in the Internet Archive (https://archive.org).
Flu (influenza)

Influenza, commonly known as the flu, is caused by a highly contagious virus that is spread by fluids produced during coughing and sneezing or by direct contact with those fluids on surfaces. There are three types of flu virus: influenza A, B and C.

Older people, pregnant women and those with an underlying medical condition are more likely to develop serious complications as a result of the flu. These complications include secondary bacterial pneumonia, primary influenza pneumonia and inflammation of the brain and heart.

The flu virus has a unique ability to change its surface structure. This means that people’s immune systems might not be able to effectively fight the new version of the flu that circulates each season (known as seasonal flu). This can cause widespread illness (epidemics and pandemics). For this reason, people who are at risk of complications should be immunised each year. Most cases of influenza occur within a six-to

Figure 6-1: The user interfaces of websites used in this study: Better Health Channel (top) and Better Health Explorer (bottom).
The setting of the lab is shown in Figure 6-2. The researcher and the participant were positioned side-by-side in the laboratory. Two monitors were configured for mirroring the computer screen to both monitors, which enabled the researcher to observe the activities performed by the participant without interference. During the lab study, the researcher jotted down notes about the interactions between the participant and the websites.

![Figure 6-2: The lab setting of the study in Research Phase 3.](image)

The remainder of this section will explain the procedure of the study, the design of search tasks performed by participants, the data collection details of qualitative and quantitative data, and the overview of the participation.

### 6.3.1. Procedure

Participants began with a brief introduction to the study and the two websites used, followed by a demographic questionnaire. The demographic questionnaire follows the design of the one in Chapter 4 (Table 4-3), which asked about the gender, age, and the relationship to the university. Then, informed consent was obtained through a signed consent form. After these steps, participants were asked to perform four
search tasks on a desktop computer. The details of the four tasks will be explained in Section 6.3.2.

Tasks were sequentially carried out on a desktop computer in a defined order, and each task was associated with an instruction to inform the participant the website used in the task. For counter-balancing learning and ordering effects, the order of the tasks was allocated by a 4x4 Latin Square as shown in Table 6-1 (Williams 1949). For instance, the first participant conducted the tasks in the order of ABDC according to the table, the second one would be allocated the order of BCAD, and so on. The allocation was reset back to the first row after every four participations.

**Table 6-1: Latin Square task allocation.**

<table>
<thead>
<tr>
<th></th>
<th>1st Task</th>
<th>2nd Task</th>
<th>3rd Task</th>
<th>4th Task</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>A</td>
<td>B</td>
<td>D</td>
<td>C</td>
</tr>
<tr>
<td>2</td>
<td>B</td>
<td>C</td>
<td>A</td>
<td>D</td>
</tr>
<tr>
<td>3</td>
<td>C</td>
<td>D</td>
<td>B</td>
<td>A</td>
</tr>
<tr>
<td>4</td>
<td>D</td>
<td>A</td>
<td>C</td>
<td>B</td>
</tr>
</tbody>
</table>

Participants were then given the task instructions and worked on the tasks on a desktop computer. Each task started with the home page of either BHC or BHX, depending on the website corresponding to the task. The home page contained a list of popular health topics and a search input box. Participants were allowed to search, navigate, browse the website freely. The only restriction was that they could not open and use websites other than the testing one. Different user interaction metrics, which will be discussed in Section 6.3.3, were recorded for analysis during the process. Meanwhile, the computer screen and activity logs were captured for later analyses.

After completion of a task, participants were asked to fill in a single-page questionnaire about their thoughts about the health information seeking process. All
responses were in the format of 5-point Likert scales, measuring from “strongly disagree” (1) to “strongly agree” (5). The survey content will be introduced in Section 6.3.4.

At the half-way point and at the completion of the study session, a short semi-structured interview was conducted, mainly for collecting verbal feedback about the tasks. Also, this gave the researcher a chance to collect feedback from the users about their experiences. The interview protocol will be explained in Section 6.3.5.

Table 6-2 summarise the workflow of an entire study session. The whole study session was expected to fit in a one-hour period.

**Table 6-2: The procedure of the study in Research Phase 3.**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Introduction to the study and the websites</td>
</tr>
<tr>
<td>2</td>
<td>Demographic questionnaire</td>
</tr>
<tr>
<td>3</td>
<td>1st Task</td>
</tr>
<tr>
<td>4</td>
<td>Post-task questionnaire</td>
</tr>
<tr>
<td>5</td>
<td>2nd Task</td>
</tr>
<tr>
<td>6</td>
<td>Post-task questionnaire</td>
</tr>
<tr>
<td>7</td>
<td>Semi-structured interview</td>
</tr>
<tr>
<td>8</td>
<td>3rd Task</td>
</tr>
<tr>
<td>9</td>
<td>Post-task questionnaire</td>
</tr>
<tr>
<td>10</td>
<td>4th Task</td>
</tr>
<tr>
<td>11</td>
<td>Post-task questionnaire</td>
</tr>
<tr>
<td>12</td>
<td>Semi-structured interview</td>
</tr>
</tbody>
</table>

### 6.3.2. Search Tasks

Participants were given four tasks in a study session, consisting of two focused and two exploratory search tasks. This setup corresponded to the previous discussions of
focused and exploratory search approaches in the seeking process. Such a design allowed us to observe the differences between the two search approaches. In each group of search tasks, the data obtained from the participants who used BHC were treated as baseline figures, which were compared with the data from the participants with BHX. As listed in Table 6-3, the tasks posed fictional health scenarios and questions about the scenarios. We asked the participants to obtain answers for these questions from the specific website.

Table 6-3. Task descriptions used in the study.

<table>
<thead>
<tr>
<th>Task</th>
<th>Website Used</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Better Health Channel (Baseline – Focused Search)</td>
<td>F</td>
<td>Imagine one of your family members has recently been diagnosed with <strong>Type 2 Diabetes/hypertension</strong>. As you’re living together, your daily life might need to be changed in different ways as well. Please identify three kinds of changes that might be needed in your everyday life.</td>
</tr>
<tr>
<td>B</td>
<td>Better Health Explorer</td>
<td>F</td>
<td>Imagine one of your close friends has recently been diagnosed <strong>osteoarthritis/asthma</strong>. As you’re living together, your daily life might need to be changed in different ways as well. Please identify three kinds of changes that might be needed in your everyday life.</td>
</tr>
<tr>
<td>C</td>
<td>Better Health Channel (Baseline – Exploratory Search)</td>
<td>E</td>
<td>Imagine you are going to a party and will discuss health information with your friends. Use the website provided by us to identify some interesting health topics. Continue reading until you think it is enough for the discussion.</td>
</tr>
</tbody>
</table>

10 F: Focused Search Task   E: Exploratory Search Task
Before the start of the study, we asked the participant about their pre-existing conditions. Then, we assigned tasks with the conditions they had not suffered before (the different conditions are underlined in the task description in Table 6-3). This particular setup was to avoid repeats when testing different websites, and to minimise the potential impact of prior knowledge affecting the outcomes, for example, when participants had suffered from that particular sickness before.

The design of these tasks was purposefully considered. The health issues used in the task descriptions were sourced from the most popular searched keywords of the BHC website, as these topics have substantial amount of information available in the database for seeking. The contrastive setup with two search approaches could facilitate the observation of their differences (Kules et al. 2009). The design of exploratory tasks followed the principles outlined in another research (Wildemuth & Freund 2012). In addition, we asked participants to find information for family members and close friends in the focused search tasks (A and B), because this could motivate seekers to engage with the search tasks as found in our previous work (Pang et al. 2014). The scenario involving social discussions with friends, as used in Task C and D, was found to be helpful for generating exploratory search (Hendahewa & Shah 2015).

<table>
<thead>
<tr>
<th>Task</th>
<th>Website Used</th>
<th>Type&lt;sup&gt;10&lt;/sup&gt;</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>D</td>
<td>Better Health Explorer</td>
<td>E</td>
<td>Imagine you are going to a party and will discuss health information with your friends. Use the website provided by us to identify some interesting health topics. Continue reading until you think it is enough for the discussion. (Same as Task C)</td>
</tr>
</tbody>
</table>
6.3.3. User Interaction Metrics

For the quantitative analysis and to compare the user interactions between two websites, we selected four metrics from previous research for measuring user interactions in the health information seeking process (White & Roth 2009; Hodkinson et al. 2000; Huang et al. 2009). The following metrics were included:

- Page reads (number of times)
- Task duration (seconds)
- Clicks on links (BHC) or tiles (BHX) (number of times)
- Query reformulation (number of times)

Page reads and task duration reflect the amount of information accessed and the user engagement with the website. Clicking on links (or tiles in BHX) indicates the effort of understanding in-depth about a topic and represents the depth of search. Query reformulation is an essential concept in exploratory search for measuring the degree of information exploration (Klouche et al. 2015; Zhang et al. 2012). In the context of this study, query reformulation means issuing a new search query in the BHC website, or adjusting the sliders in BHX.

6.3.4. Post-task Questionnaire

After completion of each search task, participants were asked to fill in a single-page questionnaire. All responses were in the format of 5-point Likert scales, labelled from “strongly disagree” (1) to “strongly agree” (5). The post-task questionnaire included 14 questions to capture different metrics in the health information seeking process, for example, knowledge acquisition for evaluating the efficiency of exploratory search (Marchionini 2006; Hendahewa & Shah 2015; White & Roth 2009), how to find information (Pu et al. 2011), and usability and user experience (Brooke 1996; Pu et al. 2011). The complete list of questions is shown in Table 6-4.
Table 6-4. The post-task survey used in Research Phase 3.

<table>
<thead>
<tr>
<th>Question Text</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. I was uncertain about what information to look for before starting the task.</td>
</tr>
<tr>
<td>2. The design of the website helped me to figure out what information I should look for.</td>
</tr>
<tr>
<td>3. I learnt new knowledge throughout the task.</td>
</tr>
<tr>
<td>4. I was successful in getting the information I needed.</td>
</tr>
<tr>
<td>5. I found it easy to tell the website what I needed.</td>
</tr>
<tr>
<td>6. I was presented with diverse information on the topic through the design of the website.</td>
</tr>
<tr>
<td>7. I was presented with topics that I hadn’t thought of before but was interesting to me.</td>
</tr>
<tr>
<td>8. I had enough time to look for the information I needed.</td>
</tr>
<tr>
<td>9. I found using the website enjoyable.</td>
</tr>
<tr>
<td>10. I felt engaged with the website.</td>
</tr>
<tr>
<td>11. I felt the website was easy for me to use.</td>
</tr>
<tr>
<td>12. I would use the website at home if it were made available.</td>
</tr>
<tr>
<td>13. Overall, the website was useful.</td>
</tr>
<tr>
<td>14. Overall, I was satisfied with the website.</td>
</tr>
</tbody>
</table>

6.3.5. Half-way and Completion Interview

Two short semi-structured interviews were collected in the middle and at the end of a study session, for collecting qualitative feedback about the search tasks. While the post-task questionnaire measured different aspects of health information seeking behaviours with the different websites, this interview followed up on these areas.
and allowed participants to reflect on the thoughts, experience and emotions of using the novel design. Semi-structured interviews are suitable for collecting rich data for analysing relatively new and unknown concepts (Creswell 2014).

The design of the interview was similar to the one explained in Section 4.3.3, as both interviews studied health information seeking behaviours. Based on the context of this study, we added a few questions regarding to supporting exploratory search and serendipity (White & Roth 2009; Toms 2000). These elements are identified in health information seeking behaviours but there is little support on them with current health information websites, therefore we added these to the interview for identifying their roles in health information seeking behaviours with our design. The list of interview questions is listed in Table 6-5.

Table 6-5. The questions for the interview in Research Phase 3.

<table>
<thead>
<tr>
<th>Question Text</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. How did these websites help you when you were uncertain what to look for?</td>
</tr>
<tr>
<td>2. How did you find new knowledge with these websites?</td>
</tr>
<tr>
<td>3. Do you think the diverse information presented to you was useful? Please explain.</td>
</tr>
<tr>
<td>4. Do you think the unexpected but interesting information presented to you was useful? Please explain.</td>
</tr>
<tr>
<td>5. Why did you feel engaged/not engaged with these websites?</td>
</tr>
<tr>
<td>6. Why did you feel enjoyable with the website?</td>
</tr>
<tr>
<td>7. Were there any differences in the way you approached these two tasks? Please explain.</td>
</tr>
<tr>
<td>8. How do you compare these two websites?</td>
</tr>
<tr>
<td>9. (For BHX Search Tasks Only) Do you think the design of this website (BHX), e.g. sliders, filters, animations..., was helpful or not helpful for the tasks? Why?</td>
</tr>
</tbody>
</table>
6.3.6. Data Analysis

Multiple methodologies were used to analyse the various formats of data obtained from this study. For semi-structured interviews, interview transcripts were analysed with thematic analysis (Braun & Clarke 2006), which is one of the collection of Content Analysis methods (Hsieh & Shannon 2005). Themes obtained from the thematic analysis were used to investigate the influence on the design. Screen recordings were reviewed and coded by the researcher (Creswell 2013; Creswell 2014). This information was used to categorise and compare the patterns of health information seeking behaviours in both websites.

In the data analysis, screen recordings and activity logs were reviewed by the researcher. We used this information to classify participants into one of the four health information seeking behaviours (i.e. Quick Fact Seeking, Focused Reading, All-around Skimming, and Knowledge Digging). This classification helps to investigate how to design for different health information seeking behaviours for different types of search tasks.

For quantitative analysis, statistical computations were applied on the quantitative figures using R version 3.2.3. We applied a Wilcoxon Signed-rank Test (Wilcoxon 1945) to verify the statistical significance and to compute the effect size between BHC and BHX in each category (i.e. focused and exploratory) of search tasks. The Wilcoxon test does not require the normality of data (McDonald 2014). In addition, we used Spearman’s correlations to find out correlated metrics of BHX responses in focused and exploratory search tasks accordingly. These results help us to understand potential relationships between the design and the actual outcomes of using the websites.

6.3.7. Participants

Participants were recruited using a number of channels from September to October 2015 (the university mailing list, electronic bulletin boards, physical flyers in student
lounges and the student union building). We also use social networking platforms such as Facebook and Twitter for recruitment. Adults with previous experience of searching on the Internet were targeted for this study. The target of the sample size was 30, which is a common minimum requirement for many quantitative analyses (Creswell 2002). No incentive was given for this experiment.

The actual number of participants who completed the study was 31. The participants include 15 males and 16 females. The mean age was 33.9 (SD=12.67) and the median was 29. Ages ranged from 20 to 72. Among the participants, 19 of them were university students, whereas 10 were university staff, and two had no relations to the university. All reported that they were capable of reading and searching information on the Internet and had experience in searching online health information previously. The distribution of the demographic attributes of the participants is listed in Table 6-6.

Table 6-6: The distribution of the demographic attributes of the participants (N=31).

<table>
<thead>
<tr>
<th>Gender</th>
<th>Number of Participants</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>15</td>
<td>48%</td>
</tr>
<tr>
<td>Female</td>
<td>16</td>
<td>52%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Age Group</th>
<th>Number of Participants</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>20-30</td>
<td>18</td>
<td>58%</td>
</tr>
<tr>
<td>31-40</td>
<td>6</td>
<td>19%</td>
</tr>
<tr>
<td>41-50</td>
<td>2</td>
<td>6%</td>
</tr>
<tr>
<td>Over 50</td>
<td>5</td>
<td>16%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Identity</th>
<th>Number of Participants</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Students</td>
<td>19</td>
<td>61%</td>
</tr>
<tr>
<td>Staff</td>
<td>10</td>
<td>32%</td>
</tr>
<tr>
<td>Others</td>
<td>2</td>
<td>7%</td>
</tr>
</tbody>
</table>
6.4. Results

This section reports on both the qualitative and quantitative results collected from this study. With a large amount of the results, we summarise the results into the following categories and they are explained accordingly in these sub-sections:

1. The classification of health information seeking behaviours
2. User interactions
3. Quantitative results from the post-task questionnaire
4. Qualitative results from the interviews

6.4.1. Classifying Health Information Seeking Behaviours

Based on the screen recordings and the activity logs, we reviewed participants’ health information seeking behaviours and classified them according to the theoretical model in Section 5.4. This classification gives us an overview about what kind of information seeking behaviours we should expect for certain types of searches, and thus helps to design consumer health websites based on user behaviours.

Table 6-7 lists the annotations of health information seeking behaviours, as discussed previously in Section 5.4, after reviewing the data. For focused search tasks (Task A and B), the majority of searches was consistent with the Quick Fact Seeking (42% and 52% respectively) behaviour. However, more than half of participants demonstrated All-around Skimming (58%) in both of the exploratory tasks (Task C and D). The results reinforce our previous results that seekers adopt different information seeking behaviours due to the different nature of search tasks.
Table 6-7: Seeking behaviours observed in our participants.

<table>
<thead>
<tr>
<th></th>
<th>Focused Search Tasks</th>
<th>Exploratory Search Tasks</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Task A (BHC)</td>
<td>Task B (BHX)</td>
</tr>
<tr>
<td>Quick Fact Seeking</td>
<td>13 (42%)</td>
<td>16 (52%)</td>
</tr>
<tr>
<td>Focused Reading</td>
<td>8 (26%)</td>
<td>5 (16%)</td>
</tr>
<tr>
<td>All-around Skimming</td>
<td>9 (29%)</td>
<td>9 (29%)</td>
</tr>
<tr>
<td>Knowledge Digging</td>
<td>1 (3%)</td>
<td>1 (3%)</td>
</tr>
<tr>
<td>Total</td>
<td>31 (100%)</td>
<td>31 (100%)</td>
</tr>
</tbody>
</table>

The results display a distinct pattern in terms of the dimension of Research Tactics in the model of health information seeking behaviours. Seekers demonstrated different behaviours across the task type, even with the same website. In focused search tasks, the majority of participants (68% in both Task A and B) adopted Basic Research Tactics (i.e. Quick Fact Seeking and Focused Reading) behaviours. However, in exploratory search tasks, large portions of participants (81% in Task C; 84% in Task D) showed Extensive Research Tactics (i.e. All-around Skimming and Knowledge Digging).

Nevertheless, all four types of information seeking behaviours were observed in the study. This reflects the diverse composition of health information seeking behaviours, and suggests that the design of consumer health websites needs to address all types of information seeking behaviours.

6.4.2. User Interactions

We partitioned the user interaction data in terms of search approaches and analysed them accordingly. Participants illustrated different levels of user interactions across
focused and exploratory tasks. As shown in Table 6-8, in focused search tasks (Task A and B), we did not observe significant differences between BHC and BHX. Participants read a similar number of pages, clicked on a similar number of links, and spent a similar amount of time in both websites. However, the number of query reformulations is substantially higher for BHX with a mean of 3.3 compared to 0.8 for BHC ($p<0.001$). Both the $p$-value and the effect size ($r$) show the significant and strong difference of this particular measurement.

**Table 6-8: User interaction figures in focused search tasks.**

<table>
<thead>
<tr>
<th></th>
<th>Task A (BHC)</th>
<th>Task B (BHX)</th>
<th>Wilcoxon Signed-rank Test</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
</tr>
<tr>
<td>Page Reads</td>
<td>2.7</td>
<td>1.5</td>
<td>2.7</td>
</tr>
<tr>
<td>Task Duration (Seconds)</td>
<td>285</td>
<td>115</td>
<td>271</td>
</tr>
<tr>
<td>Clicks on Links (BHC)/Tiles (BHX)</td>
<td>2.6</td>
<td>1.7</td>
<td>2.5</td>
</tr>
<tr>
<td>Query Reformulation</td>
<td>0.8</td>
<td>0.8</td>
<td>3.3</td>
</tr>
</tbody>
</table>

* $p<0.001$

On the other hand, the figures demonstrate a different pattern in exploratory search tasks, as displayed in Table 6-9. BHX users presented a higher number of pages read with a mean of 5.7 compared to 3.9 for BHC ($p<0.001$), and more query reformulations for BHX (4.2 times) than BHC (0.3 times) at $p<0.001$ level with a large effect size. In average, they also spent more time on exploring information with BHX (410 seconds) than BHC (364 seconds) at $p<0.05$ level. We also found that the number of tile clicks (4.8 times) in BHX is significantly higher than link clicks (2.7 times) in BHC ($p<0.001$).
Table 6-9: User interaction figures in exploratory search tasks.

<table>
<thead>
<tr>
<th></th>
<th>Task C (BHC)</th>
<th>Task D (BHX)</th>
<th>Wilcoxon Signed-rank Test</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
</tr>
<tr>
<td>Page Reads</td>
<td>3.9</td>
<td>1.7</td>
<td>5.7</td>
</tr>
<tr>
<td>Task Duration (Seconds)</td>
<td>364</td>
<td>153</td>
<td>410</td>
</tr>
<tr>
<td>Clicks on Links (BHC)/Tiles (BHX)</td>
<td>2.7</td>
<td>1.9</td>
<td>4.8</td>
</tr>
<tr>
<td>Query Reformulation</td>
<td>0.3</td>
<td>0.6</td>
<td>4.2</td>
</tr>
</tbody>
</table>

* p<0.001    # p<0.05

6.4.3. Post-task Questionnaire

This sub-section will present the results of the post-task questionnaire. We will first report on the results of the differences between both websites (BHC and BHX) in the focused search tasks, followed by the counterparts of the exploratory search tasks. Then, the overall differences between the focused and exploratory search approaches will be reported. A correlation analysis will illustrate the potential relationship between the outcomes and the design factors.

* Differences between Two Websites (Focused Search Tasks)*

Table 6-10 shows the responses of focused search tasks for comparing BHC and BHX. For the perceived level of uncertainty (#1) for both focused search tasks, i.e. Task A and B, the average scores were similarly low (less than 3.0). This means that the validity of the instructions for focused search tasks was verified with the participants’ responses, as they could understand the clearer and more specific
search goals in the tasks. More importantly, the data also suggested that, for focused search tasks, participants found that BHX outperformed BHC in the areas of:

- Helping to find the needed information (#2)
- Presenting more diverse information (#6)
- Showing serendipitous items (#7)
- Enjoyably using the website (#9)
- Ease of use (#11)

For the task outcome and the perception on the system, BHX was better than BHC in:

- Task success (#4)
- Learning new knowledge (#3)
- Engaging with the website (#10)
- Usefulness (#13)
- Satisfaction (#14)

The differences between these measurements were statistically significant. There was a particular strong difference on Satisfaction (#14) because of a large effect size ($r > 0.5$).

**Table 6-10: Responses to the post-task questionnaire in focused search tasks.**

<table>
<thead>
<tr>
<th>Question</th>
<th>Task A (BHC)</th>
<th>Task B (BHX)</th>
<th>Wilcoxon Test</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
</tr>
<tr>
<td>1. Uncertain about the task</td>
<td>2.2</td>
<td>1.3</td>
<td>2.4</td>
</tr>
<tr>
<td>2. The design helps to find information</td>
<td>3.2</td>
<td>1.0</td>
<td>3.8</td>
</tr>
<tr>
<td>3. Learnt new knowledge</td>
<td>3.7</td>
<td>1.1</td>
<td>4.3</td>
</tr>
<tr>
<td>4. Successfully get the information</td>
<td>3.8</td>
<td>1.1</td>
<td>4.4</td>
</tr>
</tbody>
</table>
**Table 6-11** displays the responses of exploratory search tasks. The level of task uncertainty (#1) was higher than the one in focused tasks, reflecting the vaguer nature of exploratory search tasks. Though the difference was not statistically significant, both exploratory search tasks could be completed successfully on average by the participants (#4). The results of exploratory tasks are similar to the
ones of the focused tasks. BHX was found superior than the BHC website in these items:

- Helping to find the needed information (#2)
- Easy to tell the website what was needed (#5)
- Presenting more diverse information (#6)
- Showing serendipitous items (#7)
- Enjoyably using the website (#9)
- Ease of use (#11)

For the task outcome and the perception on the system, BHX performed better than BHC in:

- Learning new knowledge (#3)
- Engaging with the website (#10)
- Usefulness (#13)
- Satisfaction (#14)

The reported differences between two websites were statistically significant. In terms of the effect size ($r$), the effect of serendipity (#7), engagement (#10) and user satisfaction (#14) were particularly strong.

**Table 6-11: Responses to the post-task questionnaire in exploratory search tasks.**

<table>
<thead>
<tr>
<th>Question</th>
<th>Task C (BHC)</th>
<th>Task D (BHX)</th>
<th>Wilcoxon Test</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
</tr>
<tr>
<td>1. Uncertain about the task</td>
<td>3.5</td>
<td>1.4</td>
<td>3.4</td>
</tr>
<tr>
<td>2. The design helps to find information</td>
<td>3.1</td>
<td>1.2</td>
<td>4.0</td>
</tr>
<tr>
<td>3. Learnt new knowledge</td>
<td>3.7</td>
<td>1.0</td>
<td>4.3</td>
</tr>
<tr>
<td>4. Successfully get the information</td>
<td>3.7</td>
<td>1.0</td>
<td>4.1</td>
</tr>
<tr>
<td>Question</td>
<td>Task C (BHC)</td>
<td>Task D (BHX)</td>
<td>Wilcoxon Test</td>
</tr>
<tr>
<td>-----------------------------------------------</td>
<td>--------------</td>
<td>--------------</td>
<td>---------------</td>
</tr>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
</tr>
<tr>
<td>5. Easy to tell what I needed</td>
<td>2.8</td>
<td>1.1</td>
<td>3.4</td>
</tr>
<tr>
<td>6. Presented diverse information</td>
<td>3.4</td>
<td>1.3</td>
<td>4.4</td>
</tr>
<tr>
<td>7. Presented serendipitous topics</td>
<td>3.3</td>
<td>1.2</td>
<td>4.4</td>
</tr>
<tr>
<td>8. Had enough time to find information</td>
<td>3.9</td>
<td>1.0</td>
<td>4.1</td>
</tr>
<tr>
<td>9. Using the site was enjoyable</td>
<td>3.2</td>
<td>0.9</td>
<td>4.1</td>
</tr>
<tr>
<td>10. Felt engaged with the site</td>
<td>3.3</td>
<td>1.0</td>
<td>4.1</td>
</tr>
<tr>
<td>11. Felt easy to use</td>
<td>3.5</td>
<td>0.9</td>
<td>4.1</td>
</tr>
<tr>
<td>12. Would use again if available</td>
<td>3.5</td>
<td>1.0</td>
<td>4.0</td>
</tr>
<tr>
<td>13. The site was useful</td>
<td>3.7</td>
<td>0.8</td>
<td>4.4</td>
</tr>
<tr>
<td>14. Satisfied with the site</td>
<td>3.5</td>
<td>0.9</td>
<td>4.3</td>
</tr>
</tbody>
</table>

* p<0.05   ^ p<0.01   ** p<0.001

**Differences between Focused and Exploratory Tasks**

In this experiment we would like to investigate how the design of BHX helped in different types of search tasks. For this purpose, we applied statistical tests to the BHX responses across focused (F) and exploratory (E) tasks. The results suggest that most of them were not significant. However, we identify the significant difference of presenting serendipitous findings (#8), $M_F=3.84 \text{ (SD}_F=0.97), M_E=4.42 \text{ (SD}_E=0.96),
$Z=2.685$, $p=0.008$, $r=0.341$. For this particular item, BHX is perceived better in exploratory search tasks.

**Correlation Analysis of Quantitative Responses**

We used Spearman’s Rank Order Correlation method to assess relationships in the metrics of the BHX responses in both of the focused and exploratory search tasks accordingly. These results help us to identify the potential relationships between the novel design and the actual outcomes in the search tasks.

For focused tasks, the following two pairs of items were significantly correlated at $p<0.05$ level:

- **C1.** Learnt new knowledge (#3) & Easy to tell what I needed (#5)
- **C2.** Felt engaged with the site (#10) & Using the site was enjoyable (#9)

For exploratory tasks, the following two pairs of items were significantly correlated at $p<0.05$ level:

- **C3.** Learnt new knowledge (#3) & Presented serendipitous topics (#7)
- **C4.** Successfully getting the information (#4) & Easy to tell what I needed (#5)

As illustrated above, we identified that different factors were linked to the positive outcomes, including learning new knowledge, greater user engagement, and getting the information successfully respectively. In both types of tasks, the ease of inputting what information is needed to the system played a role in the information seeking process. In addition, enjoyment had an effect on the positive outcomes in focused tasks, while serendipitous findings were effective in exploratory search tasks. The full list of the correlation figures is presented in Table 6-12.
Table 6-12: Correlations in focused and exploratory search tasks.

### Focused Search Tasks

<table>
<thead>
<tr>
<th>Correlated Metrics</th>
<th>r</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>3. Learnt new knowledge &amp; 5. Easy to tell what I needed</td>
<td>0.396</td>
<td>0.016*</td>
</tr>
<tr>
<td>4. Successfully getting the info. &amp; 5. Easy to tell what I needed</td>
<td>0.281</td>
<td>0.062</td>
</tr>
<tr>
<td>10. Felt engaged with the site &amp; 6. Presented diverse info.</td>
<td>0.346</td>
<td>0.084</td>
</tr>
<tr>
<td>10. Felt engaged with the site &amp; 9. Using the site was enjoyable</td>
<td>0.502</td>
<td>0.032*</td>
</tr>
</tbody>
</table>

* p<0.05

### Exploratory Search Tasks

<table>
<thead>
<tr>
<th>Correlated Metrics</th>
<th>r</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>3. Learnt new knowledge &amp; 7. Presented serendipitous topics</td>
<td>0.725</td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td>4. Successfully getting the info. &amp; 5. Easy to tell what I needed</td>
<td>0.470</td>
<td>0.006*</td>
</tr>
<tr>
<td>10. Felt engaged with the site &amp; 6. Presented diverse info.</td>
<td>0.074</td>
<td>0.097</td>
</tr>
<tr>
<td>12. Would use again if available &amp; 6. Presented diverse info.</td>
<td>0.423</td>
<td>0.062</td>
</tr>
<tr>
<td>13. The site was useful &amp; 6. Presented diverse info.</td>
<td>0.483</td>
<td>0.069</td>
</tr>
</tbody>
</table>

* p<0.05
6.4.4. Qualitative Feedback

This sub-section presents the qualitative feedback from the participants, interpreted together with the *in situ* observations of the researcher. Using thematic analysis, we have derived four themes about our proposed design for supporting health information seeking behaviours. Table 6-13 lists the four themes and the number of participants who provided feedback about these themes.

**Table 6-13: The qualitative themes emerged from the BHX evaluation (N=31).**

<table>
<thead>
<tr>
<th>Themes</th>
<th>Number of Participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dynamic Information Scope</td>
<td>18</td>
</tr>
<tr>
<td>Serendipity and Curiosity</td>
<td>25</td>
</tr>
<tr>
<td>Trust Issues</td>
<td>21</td>
</tr>
<tr>
<td>Delightful User Experience</td>
<td>19</td>
</tr>
</tbody>
</table>

**Dynamic Information Scope**

Participants reported that the BHX design helped them to find information within a dynamic information scope. Most of the time they looked for the directly relevant information, but they also needed to broaden to other topics at times. Participants reported that BHX was useful in such cases to discover topics, as they could adjust the sliders to explore, and diverse topics were presented to them. In contrast, traditional health websites and search engines require issuing new search queries to achieve the same result. Also mentioned by the participants, our approach required less effort to construct new search queries, and was perceived easier to use.

*It (BHX) did help me find topics, and I think here I found topics that were related to what I was reading... In another one (BHC) I need to look for topics. This one (BHX) showed me topics. So it's easier.* (Participant #26)
People like to see the context, (and) this one (BHX) shows me the context. (Participant #8)

This (BHX) is very good for discovering related information. (Participant #14)

I expect things that are somehow relevant. (Participant #6)

Additionally, participants appreciated that BHX showed diverse types of information around the topic, which provided opportunities for approaching the problem from different perspectives.

It (BHX) gives me more options about the topic. (Participant #15)

By giving you choices rather than just coming up with the top things, I think it makes (the system) more interesting to use. (Participant #3)

There are a range of things that are sort of related... and things are not much related. There are a range of different aspects. So I think that has a good diversity. (Participant #3)

**Serendipity and Curiosity**

In the context of this experiment, serendipity refers to identifying useful but unexpected information in the health information seeking process (Apted & Choo 1971). Serendipitous findings happened when seekers did not know much about the health topics, and in such a case BHX reminded them the existing information they did not consider.

Giving me different options that I didn't consider. (Participant #15)

It is useful if I can get other information connecting (a sickness) to other subjects that I haven't thought of before. (Participant #23)

I never thought about this and then (it showed up). Ah! This is good. (Participant #26)
Curiosity was another important factor for engaging users in the information exploration process. The design of BHX was observed to stimulate curiosity in the health information seeking process.

*It (BHX) is engaging because you can kinda play with it and see what you get. You have a reasonable expectation what sort of things you're going to get and what exactly you are getting out of it. It's sort of curious.* (Participant #13)

*I am curious to see what it is all about.* (Participant #18)

*Because when you started reading something, the another one (tile) gave me more options - something that captured my eyes and it's interesting.* (Participant #3)

**Trust Issues**

When the participants discovered unexpected items in the results which they thought unreasonable, issues regarding the trust of the website were identified. BHX offers a “fuzzy” approach for seeking health information that is very different from search engines, which always provide best matches to the search terms. In this study we observed that participants had different opinions about the unexpected results displayed. Below are some examples of a reported positive aspect about the unexpected items.

*(When seeing something unexpected came up...) I trust your system! I don't necessary think that means something is wrong. I think that means maybe there's a connection there (which) I wasn't aware of. It's more interesting rather than a problem.* (Participant #20)

*This (an unexpected thing) is the information that I don't have in my mind, so it was put there like opportunities of knowledge. Because I wasn't aware, it gives me awareness of things that are related to the topic. Many times I don't know what to look for. I think it gives me awareness.* (Participant #15)
Other participants suggested that the unexpected results would be a problem and endangered the trust between the user and the website. The primary goal of any design should offer the best results as possible.

That makes me worry. You start to bring up information which is perhaps gonna scaring people as well. It's about to get the right stuffs to the top first. (Participant #10)

(The accuracy) It's difficult to judge for me. Unless... for example, if I am an expert of a particular topic, then I can actually make a correct call, whether this is giving me the correct information. (Participant #23)

**Delightful User Experience**

The feedback from the participants reflected that the design of BHX delivered a delightful experience to them. The interactivity in the information exploration process gave them the feeling of gaining more control over the website, and thus increased their satisfaction. Also, the opportunities for acquiring new knowledge led to a higher engagement between the participants and the website.

The interactive nature of it... You have more control over whatever information you get. (Participant #24)

Exploring using this website (BHX) is easier. You have more options. Whereas the other website (BHC) is fixed, (where) you don't have much to control. (Participant #5)

It's good because it makes me feel more knowledge after clicking here and finding something. (Participant #15)

I do enjoy using this (BHX). Because there are some interesting topics here. I am definitely getting interesting topics here. There are many many topics popping up which I am happy to follow up. There are so many I can choose from. (Participant #6)
6.4.5. Summary

This section presents the rich results obtained in our evaluation of the BHX website. Despite of the relative small sample size, we maintained the diversity of our sample in terms of genders, occupations and the sources of recruitment. We acknowledge this limitation in this study, and therefore we adopt the mixed research method to further strengthen the interpretation of the results by using both qualitative and quantitative data. We will report on the findings in the next section.

6.5. Discussion

Generally speaking, the results show that BHX provided better experience for the participants who sought health information, when compared with the baseline live health website. The results reflect that the design of BHX is superior in supporting health information seeking in terms of usability, in both focused and exploratory search tasks. Furthermore, participants successfully obtained the required information and learnt new health knowledge, suggesting that the core goals of health information seeking behaviour can be achieved with the novel design of our prototype website. Meanwhile, no apparent performance degradation with the new design was observed in this study.

Both information diversity and serendipity were found to be improved with our design. Many consumer health websites supply information to users using three channels: menus and hyperlinks, search results, and related/recommended links (normally displayed at the bottom of a page). These approaches provide a limited range of information based on the context. This is not sufficient for the health information seeking process where broader information and serendipitous findings are needed (Herskovic et al. 2007; David Johnson 2014). In BHX, health information is presented as a dynamic list, in which users can explore other content easily with sliders, and shift the focus to different areas in the database. Serendipity items may appear in this process, as sliders are not precise keyword-based search queries. This
helps users to make discoveries at the moments when they are not clear as to what to look for.

Different usability metrics of BHX were recorded higher than the BHC website, showing the feasibility of making such designs available to general users without causing usability problems. An initial concern was that sliders might not be familiar to users, because it is very different from the usual way of making search queries. However, the results show that our approach of using sliders is still easy to use, because users were able to try, observe and learn the function of sliders, thanks to the interactive nature and the real time feedback.

In summary, our user-centred design of supporting the needs and behaviours of health information seekers, as implemented in the prototype Better Health Explorer, delivers better results in both focused and exploratory search scenarios.

In the following six sub-sections, we will further discuss six design considerations generalised from this study for designing and developing future health information websites and health information seeking applications respectively. We will start by discussing information strategies for health seekers, followed by introducing serendipity. Then, we will talk about the design strategies for aligning with information needs, considering user’s trust and enhancing interactivity.

### 6.5.1. Providing a Dynamic Information Scope

For both focused and exploratory search tasks, we have identified that seekers demand information from a dynamic information scope. While seekers often prefer to retrieve direct and relevant information to the current context, they would like to see more diverse options (e.g. information of other topics but still relevant) at the same time. The dynamic nature of the information scope helps seekers to understand the health issues from different perspectives.

We propose that the dynamic information scope is an outcome of the co-existence of the focused and exploratory search approaches in health information seeking (as
introduced in Section 4.5.3). In addition, the dynamic scope relates to the uncertainty that arises from health issues (White & Roth 2009; Wilson 1997). When possessing only little knowledge about the health problem, seekers will have an unclear search target. As a result, they look for more different information in different areas within the information scope, for learning and setting up a clear direction to handle the health scenario. After reading enough information, the search scope turns into a more focused one because the uncertainty reduces. The same level of diversity is not required at the point when seekers have low uncertainty.

In addition, the nature of search tasks affects information needs and the selected search approach. An ill-formed and open health scenario, such as self-initiated searches about certain symptoms, can lead to exploratory search and thus requires a wider range of health information. However, a search after a diagnosis often leads to focused search because of the pre-defined search goal (i.e. the diagnosis).

The user interface design of BHX uses the combination of sliders to facilitate information exploration in a dynamic information scope. Both qualitative themes (e.g. Dynamic Information Scope and Delightful User Experience) and quantitative results reflect the success in this design aspect, in comparison with BHC. Although many traditional health websites provide search functions, few of these websites allow exploratory search through offering a broad and dynamic range of information. In order to explore a new topic, users have to issue new search queries. In contrast, seekers with BHX can adjust the sliders and review the results spawned from the new criteria. This progress is more convenient and the cognitive workload is lower compared with making a new search query.

To summarise the above discussions, we consider that the access to a dynamic information scope is critical for supporting health information seeking behaviours, since health information seekers demonstrate complicated needs and heterogeneous behaviours throughout their searches.
6.5.2. Extending Information Diversity

Information diversity is potentially connected to the engagement with a website as observed in this study. While the correlation is not significant at the standard level of $p<0.05$, a marginal non-significance ($p<0.10$) is identified. Health website users lack engagement and persistence when using the online resources (Hardiker & Grant 2011; David Johnson 2014; Palotti et al. 2016), therefore maintaining the engagement is important to information providers. From this perspective, information diversity is a strategy that should be considered in the design.

In the context of health information exploration, extending information diversity means to provide a wide range of information in addition to what the user asks for. This is also a typical requirement for supporting exploratory search (White & Roth 2009). For instance, if one searches for “asthma”, the result should include treatments, preventions, related sickness, and possible consequences of asthma, in addition to the information about asthma itself.

There are several reasons to enhance information diversity. Although not statistically significant, the correlations show the possibilities that the information diversity links to the perceived usefulness of the site and the possibility of revisiting at a near-significant trend ($p<0.10$). We propose that these results are linked to the nature of health information seeking behaviours. Research has found that multiple types of information are involved in the health information seeking process (Andreassen et al. 2007). If seekers can retrieve most of the kinds of information required in one place, they will assess the website as being useful and thus have a greater chance of reusing it in the future. Such results suggest the potential benefits of enhancing information diversity.

To obtain more robust results in this area we would need to investigate the relationships of the information diversity, engagement, usefulness and revisiting of consumer health websites in future research. Due to the small number of samples, and the limited diversity from the content of a single information source, our statistic tests show only marginal significances. However, based on the observations and
qualitative quotes of this study, information diversity has its effects on health information seeking which is worth further investigation.

6.5.3. Supporting Serendipity

Serendipity plays an important role in general information seeking behaviours (Marchionini 2006; Foster & Ford 2003), as well as health information seeking behaviours (Johnson & Case 2012; Case 2002). From our study, we have identified that seekers are able to discover new health knowledge in exploratory search scenarios as suggested by the correlation analysis (correlation C3, see page 149), in comparison with BHC. We also observed different impact of serendipitous findings in focused and exploratory search tasks. Informed by the literature, lay-people often do not know the right terminologies for searching (Chapman et al. 2003; Keselman et al. 2008; Luo et al. 2008), or they have little idea about what to look for in exploratory search scenarios (Pearce et al. 2012). In this case, serendipitous results assist in suggesting hints and directions for the exploration. Not only in search activities, serendipity can also lead to accidental discovery of information when browsing (Apted & Choo 1971). Additionally, serendipity is deemed as a way of making unforeseeable connections across different knowledge and such connections are usually preferred, as people will favour using the least effort to find information (Case 2005).

Revealed in the qualitative theme (Serendipity and Curiosity), seekers demonstrate a positive attitude to serendipities. Seekers feel surprised and helpful when they spot the information which they do not considered on the screen, and even show excitement if the information “hit” their needs. Though serendipity is often found in exploratory search (Marchionini 2006; White et al. 2006), we argue that serendipity exists in both focused search and exploratory search, because of the interleaving search approaches in health information seeking (discussed in Section 4.5.3).

To facilitate serendipity, designers can adopt the fuzzy approach to handle search queries, by returning similar but not exact matches to the query (Toms 2000).
Although librarians or experts might prepare related links for the content, this approach provides a single static perspective of “relevancy” which may not be the same as the seeker’s perception. Other sophisticated recommendation systems can also suggest serendipitous findings based on the behaviours of other visitors.

Better Health Explorer gives an example of designing for serendipity. Instead of returning accurate search results, which is seen in most search engines, our design of providing sliders assists in health information exploration and enhances user experience. With the advantages identified in this evaluation, we propose to add serendipitous elements to search results and recommendation systems for supporting health information seeking behaviours.

6.5.4. Communication of Health Information Needs

This theme emerges from the post-task survey question about how “easy to tell the system what is needed”, which originates from the field of recommendation systems (Pu et al. 2011). It means the ability of the system to elicit users’ preferences and to allow feedback on the recommended results (Pu et al. 2011). We suggest that the same concept applies to health information seeking behaviours. In the context of this paper, it refers to the ability of a search tool to acquire users’ information needs, and allow the users to adjust their needs during the progress of their searches.

The correlations C1 and C4 (page 149) show that the ease of conveying the information needs to the system can result in a more successful search and learning outcomes. This can further be discussed in two stages: initialising information needs at the beginning of the search, and adjusting the needs in the middle of the search. Below are some current challenges in these two stages.

At the beginning of a search, seekers traditionally mainly rely on using navigation menus and search functions in current health websites to initiate the “journey” of finding information. Both mechanisms have different problems. Navigation menus suffer from the disparity between the medical terms that seekers know and those the
website use (Samuel et al. 2012), As a result they may not discover the appropriate links when the words used in the menu are not the ones that seekers expect. On the other hand, search engines require precise keywords for retrieving results, but laypeople generally cannot describe health issues using proper medical terms (Chapman et al. 2003; Keselman et al. 2008; Luo et al. 2008).

In the middle of the search process, the information needs often need to be adjusted. People will adopt the most appropriate search approach as the search develops, taking account into the information found and the knowledge which is still missing and needed. For example, a seeker starts with some search keywords, later finds out that the result is not what they want. In this case the search query has to be updated and changed. In fact, this query reformulation process is essential in the exploration process (White & Roth 2009). However, thinking up new search queries is difficult for some people, as it requires an adequate level of research skills and additional cognitive workload.

Designers should create innovative user interfaces for both initial and in-progress stages. In our prototype, sliders are used to replace the traditional keyword-based query mechanism, and have yielded a different outcome that leads people to find and to learn the information successfully. Faceted search is another possible solution to relieve the difficulties of query reformulation (Samuel et al. 2012). Another example is using a conversational agent to collect search criteria with a dialog, which is helpful to people with lower health and computer literacy (Bickmore et al. 2016). However, these examples should not limit designer’s creativity to ease the process of expressing information needs.

6.5.5. Considering Trust Implications

Trust is an important component of health information websites. Various guidelines have been proposed to ensure genuine and trustworthy online health information (Boyer et al. 1998; European Commission 2015). While these guidelines are focusing mainly on the quality and the accuracy of the content, the trust issues that from the
information presentation and the user interface design are seldom discussed. In this study, we have identified new challenges in the way of displaying and exploring health information with new designs.

By using a fuzzy approach for exploring information, it is inevitable that users will encounter some results that appear “weird” or “irrelevant”. From our observations, we identify two causes underlying this issue: the seeker does not recognise the connection between the displayed information and the current context; or the user does not fully perceive the meaning of the information presentation of the user interface.

We have identified two extreme responses when seekers observe the questionable results. Some users trust the website and believe that they do not possess the expertise to understand why these results appear. They realise that the “irrelevant” result is an opportunity to learn the unknown and results in serendipity findings. As seekers may not be able to judge the validity of the results in this case, therefore, the focus of the design should be put on the accuracy of the algorithm for providing truly relevant information, even with the introduction of serendipities.

Other seekers assume that the display of doubtful information is a fault of the system. These seekers often possess higher health literacy and are more knowledgeable about the health issue, so they believe that the system presents incorrect information. Eventually the trust between seekers and the system may cease. For this type of seekers, the solution is to increase the transparency of how the system works, by clearly explaining the reasons of displaying certain items in the user interface. For example, the design can adopt different colour codes and legends to indicate the results suggested by different heuristics or at different levels of confidence.

Regardless of the circumstances, designers need to be careful in presenting health information when using new interaction techniques. Users may have unexpected interpretations of the information presentation and the user interface, as compared to what the designer expects. A comprehensive understanding of the users and
usability tests focusing on the trust aspects can help to resolve such problems before release.

### 6.5.6. Enhancing Interactivity

Interactivity is one of the factors to make online information more preferable (Niu et al. 2010). Also, interactivity has positive impact on information seeking (Cline & Haynes 2001; Niu et al. 2010; Crutzen et al. 2012). This study shows that our design appears to have higher interactivity in comparison with a traditional consumer health website. Seekers prefer “the interactive nature” and having more control over the user interface. Demonstrated by our design, users prefer to manipulate the exploration of data through the user interface, observe the changes to the results, and learn from this process. In contrast, the traditional experience is like “finding a needle in a haystack”, which is less playful and enjoyable.

In addition, interactivity and engagement may be related to better performance and higher rates of returning to a health website. According to Flow research, a person who enters a mental state of complete engagement and immersion into an activity will have a higher success rate and a greater chance of reusing the system (Csikszentmihalyi 1975; Pearce et al. 2006). In the studies with BHX, participants were observed to engage with the elements supporting interactive exploration of health information. Therefore, we expect that a design with better interactivity will bring a positive outcome in seeking and learning consumer health information. Future research might focus on revealing the relationship among interactivity, engagement and user re-visits.

Interactivity is a desirable property in supporting health information seeking behaviours. However, we identify challenges to implement the interactive features based on our experience of this research. Introducing an interactive experience often requires a new UI. This may not be easily accepted by users, and is possible to cause trust implications as discussed above. Moreover, the existing content may not be directly usable in the new UI and needs to be manipulated. For example, in our
website, articles were pre-processed with a computer program to generate the metadata for the sliders and these metadata needed to be manually reviewed. The additional work is often time consuming and requires significant effort. To conclude, designers need to aware of these challenges brought by the interactivity.

6.6. Limitations

Several limitations exist in this evaluation. First of all, while most of the statistical tests are significant, the sample size is relatively small as compared with other quantitative studies. In order to reduce the impact of this limitation, we applied a mixed method approach to analyse both qualitative and quantitative data, where both datasets can complement to each other for interpreting the health information seeking behaviours.

In addition, the composition of the participants is mainly university members, which may not represent the general population of health information seekers. Future research will focus on a larger cohort of participants with a more diverse background. Besides, we evaluated all participants as a single group of health information seekers, and did not capture attributes such as occupations and education level. For future research, studies focusing on different user groups may discover additional findings distinct to these groups.

We acknowledge that this lab-based study cannot truly reflect the health information seeking behaviours in real-world scenarios. However, due to the resource constraints and ethical issues, it is not feasible to observe how people search for information when their information needs emerge (e.g. having sickness). In this study, we considered the study design and referred to different research to polish the search tasks. We believe that these measures could partially address this limitation.

Finally, only one website (i.e. Better Health Channel) was chosen as the baseline in this study, which limits the comparison only to the particular design of that website,
and therefore affects the generality of the results. Future work may evaluate the design implications in the context of other health websites or health information sources.

6.7. Summary

This paper presents a mixed method study of Better Health Explorer, which is a prototype tested for different health information seeking behaviours exposed in two types of scenarios (i.e. focused and exploratory). In addition to test the usability of various BHX features, this study seeks answers for the following research sub-question:

*RQ3-1: How can the design of consumer health websites support the full range of health information seeking behaviours?*

The qualitative and quantitative results suggest that different aspects can be improved in existing live health websites for better supporting health information seeking, including displaying diverse information, providing serendipitous findings, and offering an enjoyable and engaging experience. These findings lead to a fresh way of thinking about designing health websites that better support health information seekers and their heterogeneous health information seeking behaviours.

Additionally, a number of design strategies have been drawn from the data analyses. Based on the feedback from our sample, we conclude that six design considerations have their importance to supporting different kinds of health information seeking behaviours. These considerations provide a generalised answer to the above research sub-question for the design guidelines of health websites. Designers should further work on these aspects for building better consumer health information websites and health information seeking applications. Researchers can also build upon our findings to further study health information seeking behaviours in detail.
In the next chapter, we will focus on the overall findings of the studies in different phases of this PhD research, and then discuss their implications for a deeper understanding about health information seeking behaviours, as well as the design of consumer health websites and health information seeking applications.
Chapter 7.
Discussion and Conclusion

7.1. Introduction

This PhD research arises from the difficulties faced by health information seekers in obtaining health information. While there is a vast amount of online health information on the Internet, people are found to have a variety of challenges when accessing this information with search engines (Keselman et al. 2008; Zhang 2011).

Health information seeking is different from conventional information seeking in terms of the uncertainty introduced by health issues as well as false and conflicting information available on the Internet (Johnson & Case 2012; Wilson 1997). Health information seeking often involves accessing various kinds of information (Andreassen et al. 2007; Gavgani 2010; Bessell et al. 2002) for different audiences from health professionals to general consumers and carer (Younger 2010; Haak & Hooijdonk 2010; Alzougool et al. 2009; Alzougool et al. 2013). In addition, health information seeking causes behavioural changes after seekers retrieve the right
information (Calvert et al. 2013). With a successful outcome of health information seeking, people can gain more knowledge (Andreassen et al. 2005), and then use the knowledge to make informed decisions (Davison et al. 2002; Hersh 2009).

These characteristics of health information seeking lead to the emergence of exploratory search, which stands out from general keyword search or focused search. People have to conduct exploratory search to gather enough information in a wider breadth, in order to fulfil their above-mentioned goals. While there are a wealth of online health information and search tools available, successfully finding and gathering it remains a problem, due to the lack of tools for supporting exploratory search and assisting in navigation within health websites.

Therefore, it is noteworthy that researchers further investigate the needs of health information seekers, and design appropriate technologies to resolve the above problems and to smooth the health information seeking process. With this background, we adopted the design-oriented research methodology in this research (Fallman 2005). Conducting design-oriented research generally involves three iterations, which include (1) understanding the problem; (2) designing for solving the problem; and (3) generating new knowledge by evaluating the design.

The previous chapters illustrate the design-oriented research approach. We started by gaining an overview of health information seeking behaviours, and investigating the search approaches used in health information seeking behaviours using qualitative studies in Chapter 4 (understanding the problem). Then in Chapter 5, we used the in-depth understanding of health information seeking behaviours and the health information seeking behaviour model to derive design strategies of consumer health websites for supporting these behaviours (designing for solving the problem). Finally, in Chapter 6, we evaluated our prototype website and validated the design for supporting exploratory search in different scenarios. From this evaluation we generalised design strategies for future health website implementations (generating new knowledge from an evaluation). Our research shows that the design of health information seeking has much room for further improvements.
Although the exploratory search in health information seeking has been discussed in some literature (Cartright et al. 2011; Zarro 2012), there has not been much research considering how to design and support exploratory search in the context of health information seeking. As indicated in different literature, exploratory search involves learning and investigating rather than simply finding information (Marchionini 2006; White & Roth 2009), and therefore requires special features to support the extra aspects (White & Horvitz 2009). This research attempts to bridge the gap by proposing design strategies for exploratory health search using the user-centred approach.

Figure 7-1 provides an overview of the major research findings and outcomes in this PhD research.

Figure 7-1: The overview of the research outcomes in this thesis.
In Figure 7-1, we illustrate the research findings in each chapter, and their connections among each other. Below is a brief narrative of the diagram.

In Chapter 4, we found that health information seeking behaviours are triggered by certain factors originated from a scenario, such as being diagnosed with a health issue. These factors affect which search approaches (i.e. focused or exploratory, shown as blue in the figure) are selected. Meanwhile, the selected search approach improves the understanding of the scenario and modifies the queries as new information is acquired in the process. As depicted in the figure, the improvement on the understanding of the scenario may lead to subsequent changes of the used search approaches, resulting in the switches between search approaches.

In Chapter 5, we showed that the use of both search approaches and their dynamic changes throughout the information seeking process cause different health information seeking behaviours. Additionally, a model for describing these behaviours (shown as green in the figure) was presented in Chapter 5. This model takes the lens of user activities to classify health information seeking behaviours into four categories. These categories provide hints for building user-centred consumer health websites.

In Chapter 6, through a mixed-methodology study, we demonstrated that health information seeking behaviours are heterogeneous and shifting. Therefore, we proposed that we should design according to the characteristics of all these behaviours. As a result, a number of design strategies were generalised from our human-based study. These research outcomes highlight the necessity of designing health information websites according to the needs of health information seekers, and provide a series of theoretical work for future research about health information seeking behaviours.

The subsequent sections in this chapter will elaborate on the discussions of these research outcomes and design strategies. Firstly, we will discuss how novel knowledge is contributed from our research. Then, we will focus on a more effective design of health websites based on our findings. Finally, we will conclude our work and outline the implications of this research in other search context.
7.2. Discussion of Major Findings

In this thesis, we have argued that two basic types of search approach, namely focused and exploratory search, exist in health information seeking. Both search approaches result in information foraging (Pirolli & Card 1999; Fu 2012; Fu & Pirolli 2007) within the data sources of health information. These data sources include different databases or even the entire World Wide Web. Based on the studies in this research, we found that people demonstrate both types of search approach depending on a number of factors in the process of health information seeking. For instance: their level of knowledge about the health problem, their levels of curiosity, etc. As a wrap-up section of this dissertation, this section will discuss the following:

- Exploratory search in the health context;
- Factors causing exploratory search;
- The switching of search approaches;
- Health information seeking behaviours;
- Design for health information seeking behaviours; and
- Implications for searches in other contexts.

7.2.1. Exploratory Search in the Health Context

In Chapter 4, we have discussed that exploratory search is used in a number of scenarios to find health information, for example, finding information for others, or simply out of curiosity. This type of search reflects the desire to understand and to learn new knowledge. The existing literature of exploratory search suggests that the searching involves learning and investigation about the information of general topics (Marchionini 2006). Similarly, we observed the learning and investigating components in the exploratory search of health information.

Online health information is used in helping to making decisions (Davison et al. 2002; Hersh 2009), or dealing with life-changing diagnoses (Paul et al. 2016),
therefore health information seekers need to learn enough information to become informed about the health scenario. From a scholarly perspective, research has suggested that people perceive the existence of a “knowledge gap” in their mind when there is a need to find information (Case 2002). The purpose of exploratory search is to “bridge” or “fill up” the knowledge gap, and thus motivates information seekers to acquire new knowledge as much as possible. As such, exploratory search is used in health information seeking for satisfying the information need.

As made clearly by our studies, focused and exploratory search approaches are different from each other in terms of the breadth of search scopes, and the multiple focuses in the search. Figure 7-2, which is excerpted in one of our peer-reviewed articles (Pang et al. 2016), illustrates the differences of the two search approaches in the context of health information seeking.

![Focused Search vs. Exploratory Search](image)

**Figure 7-2: Focused search vs. exploratory search in health information seeking** (Pang et al. 2016).

Focused search in health information seeking concentrates on a specific target and a relatively small search scope around the search target (the diagram on the left in Figure 7-2). Users adopting the focused search approach usually have a clearer awareness of the health scenarios and a reasonable plan to search in their mind. This is similar to the classification of White and Roth, who identify both iterative search and exploratory search (White & Roth 2009). However, as observed in our studies, focused searchers who find health information may not perform multiple rounds of
searches around a topic as suggested in general iterative search. In some cases, these searchers may terminate the search once the needed information is found.

By contrast, as shown in our studies, exploratory search in the health context demonstrates a pattern of loosely connected search scopes, sparse search targets and multiple attempts of searches (the diagram on the right in Figure 7-2). Health information seekers need to explore in a number of areas in the information space, and require different information to build up the understanding throughout the process. While the search pattern is consistent with the concept of exploratory search in other contexts (White & Roth 2009; Marchionini 2006), we extend their work by showing that exploratory search in health information seeking involves a number of triggers and health information needs, which drive seekers to look for multiple facets of information in the health area, from official factual information to personal experience. Also, such information has different levels of complexity, ranging from plain language to scientific articles. These complications have not been observed in normal exploratory search before. This research re-establishes the differences of exploratory search between the health context and other general contexts.

Knowing the different search approaches is the first step towards a better design. As illustrated in Figure 7-1, these search approaches closely interact with the scenarios which trigger health information seeking. Therefore, studying these scenarios will help to understand when users transit between the two search approaches, which aids to design appropriate user interfaces to support different search approaches. The next sub-section will introduce the findings about the factors that cause information seekers to use the exploratory search approach, which can be used to guide the right design for the right occasion.

7.2.2. Factors Causing Exploratory Search

Five factors motivating health information seekers to adopt the exploratory search approach have been identified in Chapter 4 with a qualitative study. As we have discussed above, exploratory search demonstrates the properties of learning
knowledge and comprehensive searching. The five factors identified in this research are relevant to these properties of exploratory search, which will be explained accordingly below.

The first factor relates to people dealing with ongoing/immediate health issues or being diagnosed with a sickness. In these situations, people were observed in our study to be more exploratory in the health information seeking process. In these cases, as people have to handle the health-threatening situation, they need to obtain different aspects of information about the health issues, such as treatments and remedies. Exploratory search is used to build a complete picture of the situation, so that they can make informed decisions. Additionally, health problems are often associated with stress and anxiety (Wilson 1997). Stress/coping theory advises that people look for additional information to help them to cope with a difficult situation (Wilson 1997; Wilson 1981). Adopting exploratory search can further assist in the finding of health information since it leads to a wider search scope and has a greater chance of encountering more relevant information.

The second factor connecting to exploratory search is encountering conflicting health information on the Internet. In this scenario, seekers employ the exploratory search approach to resolve the conflicts, and therefore investigate multiple information sources to gain as much information as possible. In this process, they become more open minded to the information encountered, and compare the information with the existing knowledge for checking consistency.

The next factor links exploratory search to situational relevance. People with a higher level of situational relevance look for health information with exploratory search. The high level of situational relevance happens when they search for information on behalf other people who are important or highly relevant to the seeker (e.g. family members or close friends). It is common that people find health information for other people (Ofran et al. 2012; Kostagiolas et al. 2013), which displays the social aspect of health information seeking. In this circumstance, seekers will use all approaches for understanding the problems, looking for remedies and learning to provide support to the important people.
Curiosity is another factor that motivates exploratory search. In some cases, health information seeking can be triggered passively (Alzougool et al. 2008; Alzougool et al. 2013), for example, hearing of health information on television, learning about the health issues of a celebrity from news, and becoming interested in a medical topic during an everyday conversation. Although in this situation seekers may have a clearer search target and conduct focused search initially, they will often then adopt the exploratory search approach when encountering other interesting material throughout the process. A concrete example would be reading Wikipedia after hearing about a health problem. At the beginning, the seeker arrives at a Wikipedia article for the health issue using a search engine. Then, the seeker may open the links of other articles in the main text when he/she feels interested in those topics. The latter part of seeking behaviour is a typical exploratory search.

Finally, the clarity of the search goal is related to the search approaches used. Concrete search goals (such as those arise from a diagnosis) with enough information provided are more likely to result in a focused search. On the other hand, exploratory search is observed in many less well-defined tasks, for instance, searching with a number of symptoms observed. In such cases, the information about the search goals is not enough to reach the right information, or the search leads to a number of possibilities from the search result, therefore seekers have to explore around the information space to figure out what exact information is needed, for determining the search target and the search scope. This is comparable to the distinction between iterative search and exploratory search in the work by White et al. (White & Roth 2009). We extend this understanding to the health information seeking context based on our research outcomes.

The five factors that relate to exploratory search have been introduced and summarised. Designers of health websites and relevant applications can expect the exploratory search to occur, and must design for exploratory search, if the target audience is involved in these five factors. In the next sub-section, we will discuss the switching between the two search approaches, which has additional implications for designing and creating health information seeking tools.
7.2.3. The Switching of Search Approaches

The transition from focused to exploratory search is not one-way. Instead, we suggest that both focused and exploratory search approaches play a role in the health information seeking process. In an instance of health information seeking, both focused and exploratory search approaches may be used, depending on the scenarios triggering the search, and the development of the scenarios after acquiring new knowledge in the search process.

White and Roth have proposed that exploratory search changes towards focused search as the searching evolves (White & Roth 2009), because the level of uncertainty reduces when the seeker finds and learns information in the search process. We extend this concept and further propose that focused search can change back to exploratory search in health information seeking. In the health information seeking process, seekers may identify new and unfamiliar information relating to the current context (e.g. another highly relevant disease). As a result, the seeker's level of uncertainty will increase and drive the searching to more exploratory. Figure 4-3 (page 96) depicts the switching of focused and exploratory search approaches across different topics in the health information seeking process, which is synthesised from the navigation patterns of the participants in our study.

The co-existence and switching of both search approaches reflect the complexity of health information seeking. For a user-centred design approach, we need to further understand what users do in order to make design decisions. The research aiming at understanding users in the health context is also advocated in other work (Nordfeldt et al. 2013; Alzougool et al. 2013; van Gemert-Pijnen et al. 2011; Lee et al. 2015).

The next sub-section will describe the actual behaviours demonstrated by different search approaches, which is part of the conceptualisation towards a feasible design.
7.2.4. Health Information Seeking Behaviours

In this research, we have learnt that health information seeking behaviours are triggered by diverse health scenarios, for example, different types of information requested (ranging from condition to medication), and different motivations. These lead to different search approaches and different health information seeking behaviours as demonstrated in the information seeking process. As shown in Figure 7-1, the search approaches and the scenarios interact with each other, while at the same time the search approaches implicitly expose various health information seeking behaviours (as indicated with the green shading). In the context of this research, the health information seeking behaviours which are observable and measureable in the search process are user interactions with health websites and information retrieval tools. Knowledge of these interactions (such as reading and researching activities) captured in the conceptualisation of health information seeking behaviours can lead to strategies for designing health information websites and applications, which will be discussed below.

Our proposed model categorises health information seeking behaviours using two major groups of activities observed in health information seeking: Reading Engagement and Research Tactics. Reading Engagement states that a seeker prefers to commit either a long or a short time for reading; whereas Research Tactics captures the attitude of a seeker in terms of wanting to gain a comprehensive understanding of a topic or merely seeking basic facts in the seeking process. With the combination of the two categories of activities, we presented four distinct health information seeking behaviours (i.e. Quick Fact Seeking, Focused Reading, All-around Skimming, and Knowledge Digging) in Chapter 5. The conceptualisation helps to inform the potential design of consumer health websites and applications for health information seeking.

Research has proposed different ways to profile and classify users in the health context, which show varying health information seeking behaviours based on age (Chin et al. 2009; Chin & Fu 2012; Agree et al. 2015), in chronic and disabled conditions (Higgins et al. 2011; Fox 2008), and with professional occupations (Hersh 2009; Higgins et al. 2011). This research does not aim to add to the discussions of
classifying health information seekers, but to generalise all their behaviours as a whole for design purposes. Our model highlights the range of potential behaviours users might engage in when seeking online health information.

The model of health information seeking behaviours can assist designers in making applications that are sensitive to the variety of user behaviours, as it provides a lens for understanding the most obvious behaviours that can be observed within a health website, for example, the reading activities can be observed and measured easily. Additionally, our work is important for creating user interface elements for different types of searches and providing suitable information that match with user’s needs as reflected in their behaviours. Nevertheless, the motivations and the context of individual’s behaviour are not our focus.

In addition, this model supplements the existing information seeking theories. As noted in the literature review (Section 2.4), both the Kuhlthau’s and Ellis’ models imply exploratory activities in information seeking behaviours (Kuhlthau 1991; Ellis et al. 1993), but not much detail about these activities is provided. This model adds that people are expected to demonstrate different levels of research activities, as well as different reading attitudes, when people enter the browsing, selecting and exploring stages. Our model also indicates that the different health information seeking behaviours are dynamic and shiftable from one to another during the information seeking process. This is different from Kuhlthau’s and Ellis’ models which suggest information seeking behaviours follow a linear stage transition.

From the design perspective, each of these four behaviours leads to distinct design requirements for user interactions with health websites. Proposed in Chapter 5, user interface elements can be designed and built by understanding the user actions associated with these behaviours. These suggestions add feasible implementations to the current understanding of designing and building consumer health websites.

Below outline some examples of design guidelines for these behaviours.

- **Quick Fact Seeking** refers to retrieving the superficial information for some specific health topics. Seekers will terminate the search once the information
is found. For this type of behaviour, websites should provide a brief summary and key points relevant to the topic.

- **All-around Skimming** relates to the seeking behaviour that involves glancing through a wide range of information in a relatively fast manner. Excerpts and previews will be helpful to support this behaviour, for determining what content is useful within a potentially large number of search results.

- **Focused Reading** denotes concentrated reading on a particular topic, e.g. reading medical journal articles and detailed fact sheets. As lengthy reading is involved in this case, reader-friendly features (e.g. reader views in modern browsers, bookmarking, highlighting, etc.) are recommended to support this behaviour.

- **Knowledge Digging** indicates the intense reading associated with the in-depth research on a number of diverse health topics. Providing a broader range of information can assist users to investigate from multiple perspectives.

Our design proposal is an important contribution that goes beyond designing for a specific group of people, such as chronic patients (Nordfeldt et al. 2013; Macken et al. 2014), carers (Alzougool et al. 2013), and smokers who attempt to quit (Ploderer et al. 2014; Paay et al. 2015). In contrast, our approach considered the diversity behaviours and motivations of the health website audience. Despite the differences and diversity of users, websites that follow our design can still provide the features needed for finding information, which is an important step for improving findability (Eysenbach 2005), and providing accessible information (Goldberg et al. 2011).

To sum up, this section has reported on a design-oriented model of health information seeking behaviours. We will then explain design strategies that support such behaviours. These findings were derived from an evaluation on a prototype health website, which was used as a technological probe for assessing our work.
7.2.5. Designing for Health Information Seeking Behaviours

In this research we have found that all four types of health information seeking behaviours may occur in a search session, even in the same search task and with the same website. This highlights the importance of designing for all four types of behaviours, instead of only focusing on a few of them. In Chapter 5, we argued that these information seeking behaviours are implicitly demonstrated by health information seekers. They do not choose them and they may not be aware of them. Therefore, health websites are unlikely to be able to “ask” users to report which behaviours they would like to use in order to adapt to these choices. In addition, health information seeking behaviours are shiftable from one type to another, depending on the scenario. As such, it is infeasible to design for just one (or some) types of behaviours, and the applications must be able to adapt dynamically to changes in seeker needs.

Following the design-oriented research method, we built a prototype health information website based on the current literature and the findings of our prior studies in Chapter 5, for discovering and testing the appropriate design for the health information seeking behaviours described in our model. In Chapter 6, by summarising our experience of building this prototype, as well as the feedback from the users of this prototype, we proposed six design considerations for constructing consumer health websites, which will be discussed below. Our analysis shows that such a design can deliver more diverse information and higher engagement to users.

The first design consideration suggests that health information websites should provide a dynamic information scope to their users, as they need to access information in different information scopes to achieve the sense-making goals of health information seeking (Wilson 1997; Wilson 1999; Case 2002). For people who have a clear idea about the search goals (i.e. in focused search), they prefer to retrieve direct and relevant information. However, in open scenarios such as self-initiated searches for emerging symptoms, exploratory search is carried out and this requires a wider scope of information. In addition, we have learnt that the switching between focused and exploratory search approaches may occur multiple times in the same search...
instance, therefore the design has to provide access to both distinct sizes and focuses of information scopes, and allow effective transitions between them. In the prototype we implemented interactive sliders to allow users to change the scope and the design was shown effective in the evaluation.

The next design consideration relates to *information diversity*, which is potentially connected to the engagement with a health information website. Research has revealed that multiple types of information are involved in the health information seeking process (Andreassen et al. 2007). A similar observation was also identified in our preliminary study (Section 3.4.4). As noted in our study, if seekers can retrieve most of the kinds of information required in one place, they will engage with the site and thus have a greater chance of returning to it in the future. Additionally, since exploratory search is a part of health information seeking, enhancing information diversity is a way to support exploratory search and to result in better search outcomes (White & Roth 2009). Greater information diversity is not only useful in health information seeking, but also valuable in exploratory search for arbitrary search topics (Golovchinsky, Dunnigan, et al. 2012).

Another design consideration for health websites is about *serendipity*. Serendipity plays an important role in general information seeking behaviours (Marchionini 2006; Foster & Ford 2003), as well as health information seeking behaviours (Johnson & Case 2012; Case 2002). The feedback from our participants suggests that the design of consumer health websites should include serendipitous elements. In the exploratory search scenarios, seekers generally have little idea on the search goals (Fu 2012), serendipitous results assist in suggesting hints and directions for the exploration. Besides, serendipity is deemed as a way of making unforeseeable connections across different knowledge and such connections are usually preferred, as people will favour using the least effort in finding information (Case 2005). In the design of our prototype, serendipitous findings were achieved by showing relevant information and animated changes of the results when users changed the sliders. On the other hand, serendipity is used in other exploratory search tools to provide opportunities of accidental findings (Pearce et al. 2012; Pearce & Chang 2014).
In addition, designers need to consider and improve the user interface for *communicating health information needs*. Currently health information needs (i.e. the criteria of the information that the user asks for) are mostly communicated via menus and search keywords to health websites; and both UI design elements suffer from different problems. Navigation menus often use the medical terms that users do not expect (Samuel et al. 2012), and lay-users usually cannot describe health problems in accurate search keywords (Chapman et al. 2003; Keselman et al. 2008; Luo et al. 2008); whereas general search features provided by health websites do not support exploratory search properly. Exploratory search as a part of health information seeking demands multiple iterations of query reformulations to express health information needs (White & Roth 2009). We adopted a keyword-less approach to address this aspect in the prototype. Generally speaking, in order to better handle these cases, designers should create better user interfaces for allowing users to communicate their needs to consumer health websites and applications.

Moreover, the design has to *consider trust implications* when introducing new interaction techniques in health websites, which is a lesson learnt with our new design. While increasing serendipity and information diversity, users sometimes may become aware of unexpected information that emerges in the health information seeking process. Some users may see this as an opportunity to learn new knowledge, or may try to understand how the system works and why it appeared. Others may regard this as a fault of the system and no longer trust it. To rectify this issue, we suggest to improve the accuracy of the algorithm on one hand, while also increasing the transparency of the system by showing the reasons for the inclusion of information using visual cues.

Finally, health informational websites should *enhance their interactivity*. Interactivity is a factor to make online information more appealing to users (Niu et al. 2010), and has positive impact on information seeking (Cline & Haynes 2001; Niu et al. 2010; Crutzen et al. 2012). In the context of searching, previous research shows that interactivity can increase the user engagement with the search results (Golovchinsky, Dunnigan, et al. 2012). Interactivity brings more control over the user interface to seekers, and contributes to the engagement with health websites.
Reflected in our study, interactivity brings possibilities to users to experiment with different criteria and observe potential useful information appearing in the result list. This enhances the chance of getting the right information and engages users with the health information website. Therefore, the enhanced interactivity helps better conveying health information and maintaining user engagement.

7.2.6. Implications for Searches in Other Contexts

While the studies in this research were based on consumer health information and focused on the design of health websites, some of the findings in this research should be able to be applied to information seeking behaviours in other contexts. The following paragraphs briefly present the implications on these aspects.

While health information seeking behaviours have their unique characteristics, they share a few similarities with our types of searches, and thus making our research applicable to other contexts. First of all, our research outcomes are useful for scenarios in which seekers have little background, for example, people who are looking for products and services. Scholars have suggested that consumers explore the products and services based on user feedback (e.g. automobiles and restaurants) in some cases; whereas they need only basic production information for frequent-buying goods (e.g. groceries) (Huang et al. 2009). The different types of information seeking behaviours and the related design strategies discussed in previous chapters can be used in this context. In addition, the user interface of exploring information, as demonstrated in our prototype, can be used on other information that is diverse in their types but connected with each other. Some potential applications could be finding Netflix TV shows and library books.

The model proposed in Chapter 5 introduced four types of health information seeking behaviours, namely Quick Fact Seeking, All-around Skimming, Focused Reading and Knowledge Digging. While we observed these behaviours in the process of health information seeking, other research has reported similar findings. For instance, Quick Fact Seeking is comparable to known item search in Jiang et al.’s work (Jiang et
al. 2014); Focused Reading is used to learn rather than obtain facts in other types of searches (Li & Belkin 2008). This existing research describes the similar information seeking behaviours separately, whereas our work brought these pieces together as a single model. This model provides an additional lens to study information seeking behaviours of other topics. We expect to identify some of the four behaviours in other search scenarios.

In the design of the prototype, we emphasised the interactive and playful user interface, and such a design led to a positive outcome. The interactive and real-time responses to the slider changes seemed to elicit the interest of users, as well as to assist users to explore the database and discover the relevant content. Since this type of user interaction is neutral in terms of the search topic, we believe the similar design can be used for exploratory search in other topics and context. However, our version of slider dimensions may not be meaningful and usable in other disciplines. As such, new sets of sliders need to be created for searches of other topics.

Finally, while our research shows that serendipity plays an important role in exploratory search in the health context, it appears to be useful in other search contexts as well. The use of accidental finding of information was suggested by researchers in the 1970s (Apted & Choo 1971). A recent work proposes that such serendipitous discovery can lead to useful information and pleasure user experience (Thudt et al. 2012). With this background, we suggest that our ways of supporting serendipity, for example, the keyword-less exploration and the display of both relevant and less-relevant information at the same time, might be useful to enhance the chance of encountering useful information, as well as increasing user engagement in the applications of other areas.

### 7.2.7. Summary

This section integrates insights from the three research phases in this PhD. These insights cover both focused and exploratory search approaches, four health information seeking behaviours, the lessons learnt from the prototype website, the
design considerations for future designs, and the implications of better supporting information seeking behaviours in other contexts. The next section will review and reiterate the significant contributions of this research. In addition, limitations of this research and opportunities for future work will be discussed in the remaining parts of this chapter.

7.3. Contributions of This Research

The literature review in Chapter 2 identifies a number of gaps in the prior work related to this PhD research. In this section, we will revisit these research gaps and summarise the major contributions of this research.

7.3.1. Research Phase 1

While existing information seeking theories describe how people look for information (Kuhlthau 1991; Ellis & Haugan 1997; Pirolli & Card 1999; Bates 1989; Fu 2012), many of them do not specifically investigate the health information seeking aspects, and do not account for the changes introduced by the prevalence of the Internet and electronic environments. On the other hand, some literature about health information seeking is based on log analysis of search engine queries (Spink et al. 2004; Graham et al. 2006; Cartright et al. 2011). While log analysis is a powerful research approach, it cannot capture the interactions outside search engines. Hence, in Phase 1, we sought to identify factors that influence health information seeking, as well as the search query patterns of health information seeking with the current web technologies. These helped us to form a deeper understanding of health information seeking behaviours.

Below we revisit the research sub-questions for this research phase:

*RQ1-1: What factors have impact on the behaviour of health information seekers?*
RQ1-2: How do health information seekers demonstrate their information seeking behaviours in terms of their usage patterns?

Based on the findings from a preliminary study and a lab-based study, health information seekers are observed to switch between focused and exploratory search approaches for obtaining health information. Additionally, based on the interview feedback, we have identified five factors causing seekers to adopt an exploratory search approach. These outcomes can broaden the current understanding of both focused and exploratory search. Designers can accommodate an appropriate design for supporting of exploratory search in health websites, where the website visitors are expected to demonstrate these five factors of exploratory search.

In addition to the two search approaches, the behavioural patterns in the health information seeking process were analysed in terms of different styles of search tasks. The results suggest that focused search instances with relatively clear search targets are generally well supported by current search engines, but the same level of support does not apply to exploratory search. As a result, health information seekers use their own strategies to perform exploratory search with the current features provided by health websites. This shows the necessity of supporting exploratory search in the health information seeking context.

7.3.2. Research Phase 2

Building on the top of the findings from Phase 1, we further worked on a better design for health information seeking behaviours. As indicated in the literature review, existing information seeking theories provide no implications for designing, particularly in the consumer health context. To bridge this gap, this research attempted to develop a model for informing design guidelines of web technologies, with the following research sub-question:

RQ2-1: What is a model of health information seeking behaviour that will support the design of interactive technologies?
Drawn on the browsing and behavioural patterns from our observational study, a model of health information seeking behaviours was conceptualised to present a combination of the characteristics of health information seekers, in terms of the degree of Research Tactics and the level of Reading Engagement respectively. These two aspects represent two major categories of activities (i.e. researching and reading) identified in the health information seeking process. Besides, the application of this model is robust and flexible. Each type of health information seeking behaviours shows certain characteristics which are distinctive from the others. As such, the design of health websites can be derived from these shared behavioural characteristics.

Moreover, much of the current work about designing for health information seeking behaviours only discusses design at a theoretical level (Zarro 2012; Lee et al. 2014), and does not have many details on how to implement the design. From this point of view, another research sub-question was explored to inform the concrete design.

* RQ2-2: What are the design requirements for a consumer health website for better supporting health information seeking behaviours?

In designing a prototype health website, we introduced six requirements for the heterogeneous health information seeking behaviours. These requirements are consistent with the model of health information seeking behaviours and the related behavioural patterns identified in the study of Phase 1. As a part of this research, we implemented a prototype website (Better Health Explorer, BHX) that assembled these requirements for health information seeking behaviours. The website used a number of new user interface elements that comply with the requirements, and showed that the design can be applied in an empirical setting. Additionally, this website served the purposes of carrying on the evaluation phase in this research, and demonstrating certain features that could be used in existing health websites.

BHX contributes to the design of exploratory search engines in many ways. We introduced interactive, playful and engaging experience into health information seeking, and this search user interface could be used in other contexts. In addition to creating an environment for exploring information, the design of BHX allows the
degree of relevance between the targeted information and the information that is currently being read to be considered. This highlights a distinction between BHX and other exploration search tools. Moreover, the prototype website demonstrates an implementation for dynamically broadening search scopes and navigating among different search focuses, rather than filtering and narrowing down search results. This makes BHX different from faceted search and keyword search engines.

7.3.3. Research Phase 3

The last research focus is to evaluate the design derived in the prior studies and to generate design considerations for health information websites and applications, as well as future research. The following research sub-question was established for these purposes.

RQ3-1: How can the design of consumer health websites support the full range of health information seeking behaviours?

A lab-based study using a mixed-method research approach was conducted. The results show that our proposed design can increase the engagement of health information seekers with the website, and enhanced the user experience of the site. These are illustrated by acquiring more new knowledge, reading for a longer period of time, and a higher number of user interactions. These outcomes are particularly noticeable in exploratory search scenarios. By conducting an in-depth analysis on the participants' feedback, we have identified six design considerations that are crucial for supporting health information seeking. Designers are recommended to consider improving the effectiveness and usability on these aspects during the design of consumer health websites and health information seeking applications. In addition, the evaluation contributes to the research design of evaluations for exploratory search and health information seeking behaviours.
7.3.4. Overall Contributions

Finally, we would like to reiterate the main research question:

\[ RQ: \text{How can web technologies be designed to facilitate diverse information seeking behaviours within the health context?} \]

The series of studies in our research reflect the importance of understanding different health information seeking behaviours, and the needs of designing for accommodating these behaviours. While previous research has suggested designing for users and their needs (Lee et al. 2015; van Gemert-Pijnen et al. 2011; Alzougool et al. 2013), our research takes a further step and proposes designing for behaviours, e.g. reading, researching and exploring. In this regard, six design considerations are generalised from our research. These design considerations will lead to better support of the heterogeneous and shifting behaviours of health information seekers, and ease the process of obtaining online health information. Therefore, these elements should be applied in future design of consumer health websites. Additionally, the findings in this thesis are valuable for future HCI and health informatics research, particularly for investigating the issues of finding and obtaining health information, as well as other information seeking behaviours.

7.4. Limitations

After elaborating on the contributions of this dissertation, we must consider the limitations of this research. In the progress of designing and conducting the studies, we have made some methodological and practical decisions that may impact on the results and findings. The limitations listed below may have effects on the overall research design and the claims made in this dissertation.

In Chapter 4 and 6, we have presented two lab-based experiments, which asked participants to perform online health information seeking tasks. There was a limitation in the study design. With the laboratory environment and the artificial
search tasks, the settings of these studies may not truly reflect the scenarios triggering health information seeking behaviours in real lives. To minimise the impact of this limitation, we introduced semi-structured interview sessions in both studies, allowing participants to express their real experience verbally. In addition, in the design of artificial search tasks, we took guidance from the task setup and instructions of similar related research to enhance the validity of both studies.

The participants of this research were mainly recruited from the university. Therefore, it is possible that our findings are biased by this specific cohort of people, despite the fact that there were a small number of external participants as well. As the participants from universities are expected to possess higher education level and more knowledge, these factors may affect their health information seeking behaviours. Also, the sample size was too small to observe any differences between genders, ages and education levels, though the intention of this research was not to understand the differences across demographics. Future research could improve upon these limitations by performing research in other communities or across different groups of health information seekers.

Both studies in this research did not record demographic attributes such as education level, computer literacy level and the level of Internet search skills. These attributes may have impact on health information seeking behaviours. We were not able to analyse the data across these attributes because of the lack of this information. Despite of the limitation, the source of recruitment resulted in some level of diversity, and provided a combination of different demographics. Future work may capture these demographic attributes and analyse the results in partitions.

The last limitation of this research is that a single PhD student researcher completed the data collection and analysis. This may limit the consistency and the reliability of this research. Nevertheless, we used different measures to ensure the quality of this work. Firstly, the findings of this research have been submitted or published to peer-reviewed conferences and journals, and were formally presented in different academic venues. The reviewer responses and comments from conferences added external insights to this research. Secondly, we held supervisory meetings
fortnightly to discuss the research and the supervisors closely monitored the project to avoid significant errors. Lastly, the PhD advisory panel helped to oversee the research process and to provide additional advice on this research.

7.5. Opportunities for Future Work

This research provides new understanding on health information seeking behaviours and some design considerations based on qualitative and quantitative data. While promising outcomes are identified in this PhD research, a larger scale of future research could be carried out based on the directions illustrated in this work, including extending the information sources to include other health databases, measuring visitor statistics with the general public, etc.

While this research focuses on health information seeking behaviours on the web, there are many other channels to deliver health information, e.g. printed materials, television, radio, etc. Do people using these channels use different approaches to obtain information? How do their health information seeking behaviours differ from the findings of our research? These could be potential research questions for future investigation.

Besides, mobile usage is an increasing trend for health-related applications. We expect differences in health information seeking on mobile devices, due to the screen/network constraints, the differences of usage habit, and the time/venue limitations of using mobile devices. With these differences, how do we design health information seeking applications for this environment? This would be a fascinating topic for future work.

In this research, we have discussed the component of exploratory search in health information seeking, and have designed for supporting the exploratory search approach. While information seeking behaviours of other disciplines and topics also involve exploratory search, the conceptualisation, the findings and the design could be extended to areas other than the health discipline.
7.6. Concluding Remarks

This PhD research represents a journey that seeks a better design for supporting health information seeking behaviours. We started by identifying the necessity of using a user-centred approach in the health information seeking context, which is seldom discussed in the e-Health literature. By conducting a series of research activates, we gradually gained more understanding of health information seeking behaviours. We realised that health information seeking behaviours is a complicated but common information seeking process.

In terms of search approaches, we argued that exploratory search is a part of health information seeking behaviour, but that current health websites rarely support exploratory search. As such, we investigated health information seeking behaviours and present rich understanding of the characteristics of these behaviours. As the research progressed, we found that health information seeking behaviours are heterogeneous and shiftable, and therefore we have proposed six design considerations to support these behaviours.

In the later stages of this research, the prototyping and the evaluation results showed the importance and potential benefits of understanding and designing specially for these different health information seeking behaviours. Hence, we recommend that designers incorporate these findings in future consumer-based health information websites. We also hope that researchers will further develop our work in future investigations of health information seeking.
Bibliography


Bibliography


Kostagiolas, P. et al., 2013. Information seeking behaviour of parents of paediatric patients for clinical decision making: the central role of information literacy in a participatory setting. Information Research, 18, p.3.


Zhang, Y., 2013. An Exploratory Study of Users' Preferences and Use of Sources for Seeking Health Information. iConference 2013, pp.38–49.


Appendix A.

Materials Used in Research Phase 1

<table>
<thead>
<tr>
<th>Name of investigator(s):</th>
<th>Dr Sharton Chang, Dr Jon Pearce, Dr Karin Varspoor, Mr Patrick Pang</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. I consent to participate in this project, the details of which have been explained to me, and I have been provided with a written plain language statement to keep.</td>
<td></td>
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<tr>
<td>2. I understand that after I sign and return this consent form it will be retained by the researcher.</td>
<td></td>
</tr>
<tr>
<td>3. I understand that my participation will involve a questionnaire, interview and observation and I agree that the researcher may use the results as described in the plain language statement.</td>
<td></td>
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<tr>
<td>4. I acknowledge that:</td>
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<tr>
<td>(a) the possible effects of participating in the questionnaire, interview and observation have been explained to my satisfaction;</td>
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<tr>
<td>(b) I have been informed that I am free to withdraw from the project at any time without explanation or prejudice and to withdraw any unprocessed data I have provided;</td>
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<tr>
<td>(c) the project is for the purpose of research;</td>
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<tr>
<td>(d) I have been informed that the confidentiality of the information I provide will be safeguarded subject to any legal requirements;</td>
<td></td>
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<tr>
<td>(e) I have been informed that with my consent the interview will be audio-recorded and I understand that the files will be stored at University of Melbourne and will be destroyed after five years;</td>
<td></td>
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<tr>
<td>(f) my name will be referred to by a pseudonym in any publications arising from the research; however, it is still possible that someone may still be able to identify you due to the number of people we seek to interview is very small.</td>
<td></td>
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<tr>
<td>(g) I have been informed that a copy of the research findings will be forwarded to me, should I agree to this.</td>
<td></td>
</tr>
</tbody>
</table>

I consent to this interview being audio-recorded [ ] yes [ ] no (please tick)

I wish to receive a copy of the summary project report on research findings [ ] yes [ ] no (please tick)

Participant signature: __________________________ Date: __________________________

(Consent Form)
Appendix A: Materials Used in Research Phase 1

Dr Shanton Chang (supervisor)
Department of Computing and Information Systems
ph: 8344 1583

Dr Jon Pearce (supervisor)
ph: 8344 1405

Dr. Karin Verspoor (supervisor)
ph: 8344 4902

Mr Patrick Pang (PhD student)
ph: 8344 1527

Project: “Understanding Exploratory Search in Seeking Health Information”

Introduction
You are cordially invited to participate in our research project. The aim of the study is to investigate the way people search health related information on the Internet. Current search engines and websites are not specifically designed for looking up health information. As a result, users may feel difficulties while searching health information. Your help is able to enrich the understanding of people’s search behaviour, and thus assist to improve the design of search engines. This project has been approved by the Human Research Ethics Committee.

What will I be asked to do?
Should you agree to participate, you would be asked to come into our lab at a time convenient to you. We would ask you to search information for our pre-define health scenarios using our lab computer. The computer screen and the list of visited websites would be digitally recorded. In this experiment, we would interview you at different time, in order to obtain your feedback regarding to these tasks. With your permission, the interview would be digitally recorded. We estimate that the total time commitment required of you would be around an hour.

How will my confidentiality be protected?
We intend to protect your anonymity and the confidentiality of your responses to the fullest possible extent, within the limits of the law. Your name and contact details will be kept in a password-protected computer file from any data that you supply. You will be referred to by a pseudonym in any publications. We will remove any references to personal information, however, it is possible that someone may still be able to identify you due to the small number of participants. The data will be kept securely in the department for five years from the date of publication, before being destroyed.

How will I receive feedback?
Once the thesis arising from this research has been completed, a brief summary of the findings will be available to you on application at the Department of Computing and Information Systems. It is also possible that the results will be presented at academic conferences.

Do I have to take part?
Participation in this study is voluntary. Should you wish to withdraw at any stage, or to withdraw any unprocessed data you have supplied, you are free to do so without prejudice. Your decision to participate or not, or to withdraw, will not affect your relationship with this department or affect any services you may receive now or in the future.

Where can I get further information?
Please contact the researchers if you have any questions or if would like more information about the project. The contact telephone number is: 8344 1527.

If you have any concerns about the conduct of the project which you do not wish to discuss with the research team please contact the Manager, Human Research Ethics, Office for Research Ethics and Integrity, The University of Melbourne, on phone: 8344 2073, or fax: 8347 6739.

How do I agree to participate?
If you would like to participate, please indicate that you have read and understood this information by signing the consent form and returning it.

HREC 1340097.1
June 2013

(Plain Language Statement)
Appendix A: Materials Used in Research Phase 1

INTERACTION DESIGN LAB
Understanding Exploratory Search in Seeking Health Information (HREC 1340097)

NOTE: This document should be printed double-sided!

Task 1: Pre-test Interview (15 Minutes)

Lab Study Checklist

☐ Welcoming and PLS
☐ Consent Form
☐ Reset Browser History
☐ Start Audio and Screen Recording

Semi-structured Interview Questions

1. Under what circumstances would you go to the Internet for health information?

2. How often do you search for health information on the Internet?

3. What device (e.g. mobile, iPad, laptop, desktop computer…) do you use to search for health information?

4. What sort of information were you seeking?

5. At which sites did you search that information?

6. How long did the search last?

7. Can you describe briefly about that experience?

8. Why did you think search on the Internet was useful or not useful at that time?

9. What were the difficulties or problems you found during your search?

(Study Protocol)
Appendix A: Materials Used in Research Phase 1

INTERACTION DESIGN LAB
Understanding Exploratory Search in Seeking Health Information (HREC 1340097)

Task 1: Looking for Information for Caring a Patient (Up to 15 Minutes)

Please take the scenarios as situations you might need to realistically address. Try to remember key messages you find rather than a "copy and paste" approach to answer the questions for the scenario.

Scenario: One of your family members has recently been diagnosed Type 2 Diabetes. You decided to try your best to take care of him/her and avoid anything which could worsen the health condition. Therefore, you go to the Internet and look for information of taking care of him/her. As you’re living together, your daily life needs to be changed in different ways as well. What special attention should be paid in your daily life? What kinds of changes are needed in your everyday life?

Please write up to 5 key changes in your own words:

•
•
•
•
•

(Task Instruction for Task 1)
Task 2: Looking for Information for a Health Problem (Up to 15 Minutes)

Urination can become a health problem when it becomes too excessive at night. As the person needs to wake up to go to the bathroom, the sleep is interrupted and the sleep quality is heavily affected. This seems quite common in many people's lives, however, there is only little covered in Wikipedia, possibly due to lack of volunteers interested in this topic. Your task is to suggest key aspects of this phenomenon to be added into its Wikipedia page.

*How Wikipedia Works:* Every page in Wikipedia is created by volunteers on the Internet. Starting from a small page with little content, content is gradually added and revised by people all over the world. By improving the pages in Wikipedia, we are helping others that are interested in the same topic, as well as the growth of the Wikipedia community.

Please write up to 5 key aspects you suggest to be added in your own words:

- 
- 
- 
- 
- 

(Task Instruction for Task 2)
Appendix A: Materials Used in Research Phase 1

INTERACTION DESIGN LAB
Understanding Exploratory Search in Seeking Health Information (HREC 1340097)

Post-Task Survey

Choose (√) one option for each of the following questions:

Q1. Gender:  □ Male    □ Female

Q2. Age:
 □ 20 or under   □ 21-30   □ 31-40   □ 41-50   □ over 50

Q3. Are you a:
 □ Student of the University of Melbourne
 □ Staff of the University of Melbourne
 □ None of Above

Please indicate (√) your best option towards the statements below:

<table>
<thead>
<tr>
<th>Statement</th>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Neither Agree nor Disagree</th>
<th>Agree</th>
<th>Strongly Agree</th>
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</thead>
<tbody>
<tr>
<td>Q4 I learnt new health information about the scenario after these tasks.</td>
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<td>Q5 I am successful in finding the needed information.</td>
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<td>Q6 I have no difficulties in finding the needed information.</td>
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<td>Q7 I have a pleasant experience in finding the needed information.</td>
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<td>Q8 I felt engaged with the tasks just now.</td>
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<td>Q9 I feel that there are differences between searching for and exploring information online.</td>
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<tr>
<td>Q10 I was searching most of the time in the tasks.</td>
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<tr>
<td>Q11 I was exploring most of the time in the tasks.</td>
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--- END OF SURVEY ---

(Post-task Survey)
Appendix A: Materials Used in Research Phase 1

INTERACTION DESIGN LAB
Understanding Exploratory Search in Seeking Health Information (HREC 1340097)

Retrospective Interview Section (15 Minutes)
Semi-structured Interview Questions

1. What were the differences in the way you approached the 2 tasks? Why?

2. What emotions (i.e. happy, sad, frustrated, engaged, annoying...) did you experience? (Also see Q8)

3. What would you suggest are the differences between searching for and exploring information? (Also see Q9)

4. Why do you suggest you’re searching/exploring most of the time? (Also see Q10, Q11)

5. What were the difficulties in finding information?

6. How well did you know the information for the task at the beginning?

7. How did you develop your understanding of the scenarios throughout the task?

8. Why did you decide to make or not to make a new search query? How did you decide on the keywords for the new search query?

9. What made you investigate/study information about certain topics while you’re doing something?

10. What features in the websites you visited were particularly helpful or not helpful for the task? For example: menus, sitemaps, search recommendations...

(Interview Questions)
We Need Your Help!

We are researchers from the Department of Computing and Information Systems, The University of Melbourne. We are studying how people search for health information on the Internet. With an hour of time, you can help the design of the next-generation search system for health information.

You will be invited to our Interaction Design Lab and given some fictional health scenarios. You will be provided with a computer to search for related information online, and afterwards our researcher will hold a short interview to understand your thinking undergone during the searches. For more details, please read the Plain Language Statement (PLS). This project is approved by the Human Research Ethics Committee (HREC ID 1340097).

As a small token of thanks, Chinese tea and snacks will be offered at the venue.

Join Now!

If you are over 18 and interested to participate, please fill out the form below. Our researchers will contact you soon to arrange a time that is convenient to you. We're looking forward to your participation!

We will be running this study on weekdays from 30th Sept to 1st Dec. If you have a preferred time (day of the week, morning/afternoon) please indicate this below.

Name*: 
E-mail Address*: 
Contact Number*: 
Preferred Time:

(Participant Recruitment and Registration Website – Part 1)
Message:

*denotes a required field.

Further Contact

Mr. Patrick Pang
E-mail:
Phone: 0481 284 231 or (03) 8344 1527
Appendix B.

Technical Details of Better Health Explorer (Research Phase 2)

The relevant content of the following publications has been integrated into this chapter:

B.1. Introduction

This appendix outlines the technical details of our prototype website (Better Health Explorer) for health information exploration. Better Health Explorer is a web-based application created with different modern web technologies. For the server-side code, we adopted Django 1.7 framework which ran on a Python 3.4 interpreter. The user interface was implemented with standard HTML5, JavaScript and CSS3 technologies. These are currently prominent web technologies. The display and animated transitions of tiles were built using D3 (Version 3) data visualisation library. The complete source code was published on GitHub\footnote{https://github.com/cipang/better-health-explorer}.

The major technical work contains two components: information tagging and information matching. The information tagging process generates metadata for the sliders from existing health information in the raw database. The information matching involves retrieving the data matching the user input (i.e. sliders and filters). The following sections will describe the two components accordingly.

B.2. Information Tagging

Health information, which is stored as independent articles in our prototype website, must be analysed with the information tagging process for use with the sliders. For every article in the database, this process generates scores for the dimensions discussed in Chapter 5 (i.e. relevance, care giving/facts, text/image, readability). This is similar to the indexing process of conventional search engines but captures distinct attributes. Below we briefly explain the algorithms used to tag the articles for different sliders.
**Relevance:** Relevance scores are computed between pairs of articles, since relevancy is determined relative to the active focus article. This is different from the strategies used in information retrieval in which the relevancy is judged with respect to a search query (Baeza-Yates & Ribeiro 1999). In this work, we use a number of factors and heuristics to determine the relevance between a pair of articles, including:

- The number of words in common: We calculate the number of common words in a pair of articles after eliminating the stop words. The more words the articles have in common, the stronger their connection.

- The number of hyperlinks in common: Similarly, hyperlinks contribute to the relevance between two articles. If there are more hyperlinks connecting to common targets, or the pair of articles mutually link to each other, we assess it as a greater relevance.

- The categories that both articles belong to: Each article was assigned a category manually by the author. If articles are placed in the same categories, they are determined to be more relevant to each other.

- The number of common keywords: The authors of the original articles assigned keywords to describe the content and make articles searchable. A higher number of common keywords reflects a greater number of topics shared by the articles, and thus represents a higher relevance.

- The information provider: A number of information providers are represented in the health information in our database. These providers usually are organisations or specialists of certain diseases (such as Diabetes Australia and Quit Victoria). Articles from the same provider are considered more relevant to each other.

**Care giving/Facts:** For this dimension, we adopt a heuristic strategy based on measuring the occurrences of specific key terms in the body text. For example, words such as “caring”, “managing”, “family” suggest care-giving articles, whereas articles with words like “treatment” are likely fact-based articles.
Text/Image: For this dimension, we compute the number of words and images in articles. Articles with more words are assigned to one end of the slider, and articles with more images (or videos) are placed to another end of the slider.

Readability: We use the Flesch-Kincaid readability formula to measure the reading difficulty level of the content (Kincaid et al. 1975). This is a common method of testing readability of general English text, but it is not specifically designed for health information and medical content.

Each slider contains 21 possible ratings numbered from 0 to 20. After generating the scores of articles, the tagging algorithm sorts the data and evenly distributes all articles amongst the 21 ratings. In this arrangement, each slider rating has a similar amount of associated articles. This design is to ensure that an article has a fair chance for displaying on the screen; otherwise, the chance would be affected by the number of articles mapped onto a single slider rating.

B.3. Information Matching

When a user modifies the settings of the sliders, the information matching process retrieves articles that are similar to the slider settings. The information matching algorithm adopts a two-stage model. First, the algorithm retrieves a list of articles which equal or closest to the selected relevance value. This limits the information scope within certain range of relevance to the current article. Then, we calculate the cosine similarly values of the slider settings and the retrieved relevant articles, where the tagged scores of the articles on the three other dimensions are compared with the slider values. The comparison result is sorted by similarity value in descending order and displayed on the screen.

This two-stage method allows users to discover information that best matches with the composition of all user preferences as specified through the sliders, meanwhile we assign the “relevance” with a higher priority when retrieving information. As a result, information that is extremely unrelated but matching other sliders will be
Appendix B: Technical Details of Better Health Explorer (Research Phase 2)

removed. This can avoid trust issues as discussed in Chapter 6. Figure B-1 lists the
code snippet of the information matching algorithm.

```python
def _cosine_similarity(v1, v2):
    sumxx, sumxy, sumyy = 0, 0, 0
    for i in range(len(v1)):
        x, y = v1[i], v2[i]
        sumxx += x * x
        sumyy += y * y
        sumxy += x * y
    return sumxy / math.sqrt(sumxx * sumyy)

def article_match_with_silders(current, sliders, checkboxes, filters):
    # First use similarity to filter, then compute score
    # within the result pool.
    sim = sliders[0]

    # Obtains the selected dimensions.
    a = [x[1] for x in zip(checkboxes, sliders) if x[0]]

    # Obtains other articles and compares their
    # similarities.
    other_articles = _get_articles_for(current, filters)
    sim_dict = _get_all_sims(current)
    pool = [(x, sim_dict.get(x, 0.0)) for x in other_articles]

    # Sort by the difference.
    pool.sort(key=lambda x: abs(x[1] - sim))
    pool = map(lambda x: x[0], pool[0:100])

    result = list()
    for attr in ArticleAttr.objects.\
        select_related("article")\.
        filter(article__id__in=pool):
        attr_sim = sim_dict[attr.article_id]
        v = (attr_sim, attr.media, attr.care, attr.reading)
        b = [x[1] for x in zip(checkboxes, v) if x[0]]
        score = _cosine_similarity(a, b)
        result.append((attr, score, attr_sim))

    return result.sort(key=lambda x: x[1])
```

**Figure B-1:** Code snippet of the information matching algorithm.
B.4. Summary

In summary, this appendix has presented our implementation of slider-based user interface for health information exploration, which was used in Better Health Explorer. We acknowledge that the algorithms used for tagging information are simple and our methodology was based on existing annotations in the source data. Future research could experiment with other methods, particularly the methods used in the natural language processing and machine learning areas, for classifying information into different dimensions that could also be reflected in sliders.
Appendix C.

Materials Used in Research Phase 3

Research Participants Wanted

A New Way of Exploring Online Health Information

We are looking for participants to try our web app for exploring health information on the Internet.

You are invited to our lab to use and have a chat about this app.

With just an hour of your time, you will be helping to build better health websites for us!

If you are interested, please sign up here:

http://go.unimelb.edu.au/8oin

Enquiry: cipang@unimelb.edu.au or call 0481 284 231
Human Research Ethics Committee Approved/HREC 1544659

(Recruitment Advertisement)
Appendix C: Materials Used in Research Phase 3

Consent Form for Persons Participating in a Research Project

PROJECT TITLE: Evaluating Exploratory Search in Seeking Health Information

Name of participant:

Name of investigator(s): A/Prof. Shanton Chang, A/Prof. Karin Verspoor, Dr. Jon Pearce, Mr. Patrick Pang

1. I consent to participate in this project, the details of which have been explained to me, and I have been provided with a written plain language statement to keep.

2. I understand that after I sign and return this consent form it will be retained by the researcher.

3. I understand that my participation will involve an interview and observation and I agree that the researcher may use the results as described in the plain language statement.

4. I acknowledge that:
   (a) the possible effects of participating in the interview and observation have been explained to my satisfaction;
   (b) I have been informed that I am free to withdraw from the project at any time without explanation or prejudice and to withdraw any unprocessed data I have provided;
   (c) the project is for the purpose of research;
   (d) I have been informed that the confidentiality of the information I provide will be safeguarded subject to any legal requirements;
   (e) I have been informed that with my consent the interview will be audio-taped and I understand that audio-tapes will be stored at University of Melbourne and will be destroyed after five years;
   (f) my name will be referred to by a pseudonym in any publications arising from the research; however, it is still possible that someone may still be able to identify you due to the number of people we seek to interview is very small.
   (g) I have been informed that a copy of the research findings will be forwarded to me, should I agree to this.

I consent to this interview being audio-taped □ yes □ no (please tick)

I wish to receive a copy of the summary project report on research findings □ yes □ no (please tick)

Participant signature: ___________________________ Date: ________________________________

Department of Computing and Information Systems
The University of Melbourne, Victoria 3010 Australia
T: +61 3 9345 1500 F: +61 3 9345 4596

Human Ethics Application 1544559 version 1, June 2015

(Consent Form)
PARTICIPANT INFORMATION

1. Age: __________________

2. Gender: ☐ Male ☐ Female

3. Are you a:
   ☐ Student of the University of Melbourne
   ☐ Staff of the University of Melbourne
   ☐ None of Above

For the following questions, please answer either “yes” or “no” without disclosing any details of the health issues to the researcher:

4. Have you ever had any of the following health issues?
   (a) Diabetes (b) Osteoporosis
   ☐ Yes ☐ No

5. Have you ever had any of the following health issues?
   (a) Hypertension (b) Asthma
   ☐ Yes ☐ No
## PREPARATION CHECKLIST

- Participant No. Assignment
- Task Order Assignment
- TClock
- Welcoming and PLS
- Consent Form
- Reset Browser History

<table>
<thead>
<tr>
<th>Task Order</th>
<th>Start Time</th>
<th>End Time</th>
<th>Nav. Page Read</th>
<th>Real Page Read</th>
<th>Qry/Slide</th>
<th>Fish/Link Click</th>
<th>Recom Link</th>
<th>Filter</th>
<th>Notes</th>
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</tbody>
</table>

**General Notes:**

Version 1.8
PRIVATE AND CONFIDENTIAL
HREC.1544659

(Study Form – Page 2)
Maximum Time Limit: 10 minutes

Please approach the scenario as a situation you might need to realistically address, and use the website provided by the researcher (Better Health Channel, BHC) to complete this task:

Imagine one of your family members has recently been diagnosed with Type 2 Diabetes. As you’re living together, your daily life might need to be changed in different ways as well. Please identify three kinds of changes that might be needed in your everyday life.
Appendix C: Materials Used in Research Phase 3

**EVALUATING EXPLORATORY SEARCH IN SEEKING HEALTH INFORMATION**
Interaction Design Lab, Department of Computing and Information Systems
The University of Melbourne

Please complete this questionnaire:

<table>
<thead>
<tr>
<th>Research Tactics</th>
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</tr>
</thead>
<tbody>
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</tr>
<tr>
<td>Focused Reader</td>
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<th>Strongly Disagree</th>
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<tbody>
<tr>
<td>2 I was uncertain about what information to look for before starting the task.</td>
<td>1 2 3 4 5</td>
<td></td>
</tr>
<tr>
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<tr>
<th>Question 11-18 are about your experience using the website.</th>
<th>Strongly Disagree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 I found using the website (BHC) enjoyable.</td>
<td>1 2 3 4 5</td>
<td></td>
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<tr>
<td>13 I would use the website (BHC) at home if it were made available.</td>
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</tr>
<tr>
<td>14 Overall, the website (BHC) was useful.</td>
<td>1 2 3 4 5</td>
<td></td>
</tr>
<tr>
<td>15 Overall, I was satisfied with the website (BHC).</td>
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</table>

(Study Form – Page 4)
Appendix C: Materials Used in Research Phase 3

EVALUATING EXPLORATORY SEARCH IN SEEKING HEALTH INFORMATION
Interaction Design Lab, Department of Computing and Information Systems
The University of Melbourne

A2

Maximum Time Limit: 10 minutes

Please approach the scenario as a situation you might need to realistically address, and use the website provided by the researcher (Better Health Channel, BHC) to complete this task:

Imagine one of your family members has recently been diagnosed hypertension. As you’re living together, your daily life might need to be changed in different ways as well. Please identify three kinds of changes that might be needed in your everyday life.
## Appendix C: Materials Used in Research Phase 3

**EVALUATING EXPLORATORY SEARCH IN SEEKING HEALTH INFORMATION**
Interaction Design Lab, Department of Computing and Information Systems
The University of Melbourne

Please complete this questionnaire:

1. Which of the following best described you in this task? (Circle the appropriate one)

<table>
<thead>
<tr>
<th>Research Tactics</th>
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</tr>
</thead>
<tbody>
<tr>
<td>All-around Skimmer</td>
<td>Research Tactics: Extensive</td>
<td>Reading Engagement: Low</td>
</tr>
<tr>
<td>Knowledge Digger</td>
<td>Research Tactics: Extensive</td>
<td>Reading Engagement: High</td>
</tr>
<tr>
<td>Quick Fact Seeker</td>
<td>Research Tactics: Basic</td>
<td>Reading Engagement: Low</td>
</tr>
<tr>
<td>Focused Reader</td>
<td>Research Tactics: Basic</td>
<td>Reading Engagement: High</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Low</th>
<th>High</th>
</tr>
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</table>

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<thead>
<tr>
<th>Question 2-5 are about how did you learn the knowledge.</th>
<th>Strongly Disagree</th>
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<tbody>
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<td>1 2 3 4 5</td>
<td></td>
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<td></td>
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<td>4 I learnt new knowledge throughout the task.</td>
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<td>9 I had enough time to look for the information I needed.</td>
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<table>
<thead>
<tr>
<th>Question 11-16 are about your experience using the website.</th>
<th>Strongly Disagree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 I found using the website (BHC) enjoyable.</td>
<td>1 2 3 4 5</td>
<td></td>
</tr>
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<td>1 2 3 4 5</td>
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</tbody>
</table>

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HREC 1544659

(Study Form – Page 6)
Maximum Time Limit: 10 minutes

Please approach the scenario as a situation you might need to realistically address, and use the website provided by the researcher (Better Health Explorer, BHX) to complete this task:

Imagine one of your close friends has recently been diagnosed osteoporosis. As you’re living together, your daily life might need to be changed in different ways as well. Please identify three kinds of changes that might be needed in your everyday life.
EVALUATING EXPLORATORY SEARCH IN SEEKING HEALTH INFORMATION
Interaction Design Lab, Department of Computing and Information Systems
The University of Melbourne

B1

Please complete this questionnaire:

1. Which of the following best described you in this task? (Circle the appropriate one)

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<thead>
<tr>
<th>Research Tactics</th>
<th>Extensive</th>
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</tr>
</thead>
<tbody>
<tr>
<td>All-around Skimmer</td>
<td>Research Tactics: Extensive</td>
<td>Reading Engagement: Low</td>
</tr>
<tr>
<td>Knowledge Digger</td>
<td>Research Tactics: Extensive</td>
<td>Reading Engagement: High</td>
</tr>
<tr>
<td>Quick Fact Seeker</td>
<td>Research Tactics: Basic</td>
<td>Reading Engagement: Low</td>
</tr>
<tr>
<td>Focused Reader</td>
<td>Research Tactics: Basic</td>
<td>Reading Engagement: High</td>
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</table>

<table>
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<tr>
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<th>Question 2-5 are about how did you learn the knowledge.</th>
<th>Strongly Disagree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>2. I was uncertain about what information to look for before starting the task.</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>3. The design (not the content) of the website (BHX) helped me to figure out what information I should look for.</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>4. I learnt new knowledge throughout the task.</td>
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<td>2</td>
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<tr>
<td>5. I was successful in getting the information I needed.</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>6. I found it easy to tell the website (BHX) what I needed.</td>
<td>1</td>
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<td>7. I was presented with diverse information on the topic through the design (not the content) of the website (BHX).</td>
<td>1</td>
<td>2</td>
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<tr>
<td>8. I was presented with topics that I hadn’t thought of before but was interesting to me.</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>9. I had enough time to look for the information I needed.</td>
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<tr>
<td>10. I found using the website (BHX) enjoyable.</td>
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<td>2</td>
</tr>
<tr>
<td>11. I felt engaged with the website (BHX).</td>
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</tr>
</tbody>
</table>

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HREC 1544659

(Study Form – Page 8)
Maximum Time Limit: 10 minutes

Please approach the scenario as a situation you might need to realistically address, and use the website provided by the researcher (Better Health Explorer, BHX) to complete this task:

Imagine one of your close friends has recently been diagnosed with asthma. As you’re living together, your daily life might need to be changed in different ways as well. Please identify three kinds of changes that might be needed in your everyday life.
### Appendix C: Materials Used in Research Phase 3

#### Evaluating Exploratory Search in Seeking Health Information

Interaction Design Lab, Department of Computing and Information Systems  
The University of Melbourne

Please complete this questionnaire:

<table>
<thead>
<tr>
<th>Research Tactics</th>
<th>All-around Skimmer</th>
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</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Research Tactics: Extensive</td>
<td>Research Tactics: Extensive</td>
</tr>
<tr>
<td></td>
<td>Reading Engagement: Low</td>
<td>Reading Engagement: High</td>
</tr>
<tr>
<td>Basic Extensive</td>
<td>Quick Fact Seeker</td>
<td>Focused Reader</td>
</tr>
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<td></td>
<td>Research Tactics: Basic</td>
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</tr>
<tr>
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#### Question 2-5 are about how did you learn the knowledge.

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<tr>
<th>Question</th>
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Appendix C: Materials Used in Research Phase 3

EVALUATING EXPLORATORY SEARCH IN SEEKING HEALTH INFORMATION
Interaction Design Lab, Department of Computing and Information Systems
The University of Melbourne

Participant ID: C

Maximum Time Limit: 10 minutes

Please approach the scenario as a situation you might need to realistically address, and use the website provided by the researcher (Better Health Channel, BHC) to complete this task:

Imagine you are going to a party and will discuss health information with your friends. Use the website provided by us to identify some interesting health topics. Continue reading until you think it is enough for the discussion.
Please complete this questionnaire:

1. Which of the following best described you in this task? (Circle the appropriate one)

<table>
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<tr>
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<td></td>
</tr>
<tr>
<td>Research Tactics: Extensive</td>
<td>Research Tactics: Extensive</td>
<td></td>
</tr>
<tr>
<td>Reading Engagement: Low</td>
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<td></td>
</tr>
<tr>
<td>Quick Fact Seeker</td>
<td>Focused Reader</td>
<td></td>
</tr>
<tr>
<td>Research Tactics: Basic</td>
<td>Research Tactics: Basic</td>
<td></td>
</tr>
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<td>Reading Engagement: Low</td>
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<td></td>
</tr>
</tbody>
</table>

Low | High

Reading Engagement

<table>
<thead>
<tr>
<th>Question 2-5 are about how did you learn the knowledge.</th>
<th>Strongly Disagree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 I was uncertain about what information to look for before starting the task.</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>3 The design (not the content) of the website (BHC) helped me to figure out what information I should look for.</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>4 I learnt new knowledge throughout the task.</td>
<td>1</td>
<td>2</td>
</tr>
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</table>

<table>
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<tr>
<th>Question 6-10 are about how did you find the information.</th>
<th>Strongly Disagree</th>
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</thead>
<tbody>
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<td>5 I was successful in getting the information I needed.</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>6 I found it easy to tell the website (BHC) what I needed.</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>7 I was presented with diverse information on the topic through the design (not the content) of the website (BHC).</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>8 I was presented with topics that I hadn’t thought of before but was interesting to me.</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>9 I had enough time to look for the information I needed.</td>
<td>1</td>
<td>2</td>
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</tbody>
</table>

<table>
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<tr>
<th>Question 11-18 are about your experience using the website.</th>
<th>Strongly Disagree</th>
<th>Strongly Agree</th>
</tr>
</thead>
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<tr>
<td>10 I found using the website (BHC) enjoyable.</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>11 I felt engaged with the website (BHC).</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>12 I felt the website (BHC) was easy for me to use.</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>13 I would use the website (BHC) at home if it were made available.</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>14 Overall, the website (BHC) was useful.</td>
<td>1</td>
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<td>15 Overall, I was satisfied with the website (BHC).</td>
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Appendix C: Materials Used in Research Phase 3

EVALUATING EXPLORATORY SEARCH IN SEEKING HEALTH INFORMATION
Interaction Design Lab, Department of Computing and Information Systems
The University of Melbourne

Participant ID: D

Maximum Time Limit: 10 minutes

Please approach the scenario as a situation you might need to realistically address, and use the website provided by the researcher (Better Health Explorer, BHX) to complete this task:

Imagine you are going to a party and will discuss health information with your friends. Use the website provided by us to identify some interesting health topics. Continue reading until you think it is enough for the discussion.
Appendix C: Materials Used in Research Phase 3

### EVALUATING EXPLORATORY SEARCH IN SEEKING HEALTH INFORMATION

Interaction Design Lab, Department of Computing and Information Systems
The University of Melbourne

Please complete this questionnaire:

1. Which of the following best described you in this task? (Circle the appropriate one)

<table>
<thead>
<tr>
<th>Research Tactics</th>
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| Low Reading Engagement | High Reading Engagement |

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Version 1.8
PRIVATE AND CONFIDENTIAL
HREC 1544659

(Study Form – Page 14)
Appendix C: Materials Used in Research Phase 3

Project: "Evaluating Exploratory Search in Seeking Health Information" (HREC 1544/659)

Introduction

You are cordially invited to participate in our research project. The aim of the study is to investigate how a software can help people explore health related information on the Internet. This project has been approved by the Human Research Ethics Committee.

What will I be asked to do?

Should you agree to participate, you will be asked to come into our lab at a time convenient to you. We will ask you to explore online information for pre-defined health topics using our software. The computer screen and your actions performed on the computer will be recorded. We will interview you at the end of the experiment for feedback about the software. With your permission, the interview will be recorded. We estimate that the total time commitment required of you would be around an hour.

How will my confidentiality be protected?

We intend to protect your anonymity and the confidentiality of your responses to the fullest possible extent, within the limits of the law. Your details will be kept in a password-protected computer file. You will be referred to by a pseudonym in any publications. We will remove any references to personal information. However, it is possible that someone may still be able to identify you due to the small number of participants. The data will be kept securely in the department for five years before being destroyed.

Do I have to take part?

Participation in this study is voluntary. Should you wish to withdraw at any stage, or to withdraw any unprocessed data you have supplied, you are free to do so without prejudice. Your decision to participate or not, or to withdraw, will not affect your relationship with this department or affect any services you may receive now or in the future.

Where can I get further information?

Please contact the researchers if you have any questions or if you would like more information about the project by e-mail: shanton.chang@unimelb.edu.au, or on phone: 0344 1583.

If you have any concerns about the conduct of the project which you do not wish to discuss with the research team, please contact the Executive Officer, Human Research Ethics, The University of Melbourne, ph: 8344 2073; fac 9347 6739.

How do I agree to participate?

If you would like to participate, please indicate that you have read and understood this information by signing the consent form and returning it.
Appendix C: Materials Used in Research Phase 3

Evaluating Exploratory Search in Seeking Health Information

Reservation
Please select a time that fits you and fill in your contact information. You will receive an email confirmation soon after your reservation is processed. Thank you for your participation!

Choose a Session *: Feb 29 (Mon) 09:00-10:00 - Venue
Name *: John Appleseed
Email Address *: john.appleseed@mail.com
Contact Number *: 0400400400
Remarks

* indicates required fields.

Submit

(Participant Recruitment and Registration Website)