

# **Development of A Patient-Centered Symptom Management Mobile Application**

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by

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## **Abstract**

The evolution of Patient Reported Outcomes (PROs), has made an essential impact on patient-centered symptom management. PROs enable us to measure the patient's feels about their symptoms during treatment. ePROs (electronic PROs) are interfaces that allow a patient or health care provider to manage symptoms using an application such as mobile computing applications. The growth of mobile technologies in the healthcare sector has enabled us to take advantage of features like data manipulation, portability and standardization enable a better patient-driven symptom management.

The Pan-Canadian Oncology Symptom Triage and Remote Support (COSTaRS) is a paper-based symptom management guideline designated for nurses. The objective of COSTaRS is to help and improve the decision-making process and create a consistent symptom management reporting system. Although this tool introduces numerous advantages in cancer symptom management, it also induces a number of issues for patients due to being overwhelming. Moreover, a noticeable portion of drawbacks originates from the paper-based nature of COSTaRS. In addition, cancer care symptom management mobile applications do not offer proper evidence-based centered symptom management system to the users. The purpose of this study is to design and developed the mobile version of COSTaRS for patients and caregivers. We identify problems with the current paper-based structure and related academic and non-academic works and then, we design and evaluate a mobile version of COSTaRS that takes advantage of advances in mobile technology. We leverage COSTaRS knowledge to create a mobile application for symptom management. We create an evidence-based platform for cancer treatment-related symptom management. A usability testing has been conducted for evaluation of the COSTaRS mobile application. The results of this study verify the usability of COSTaRS mobile application.

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## List of Acronyms

| Acronym | Definition                                                               |
|---------|--------------------------------------------------------------------------|
| APP     | Application                                                              |
| SDK     | Software Development Kit                                                 |
| IS      | Information System                                                       |
| HTTP    | Hypertext Transfer Protocol                                              |
| API     | Application Program Interface                                            |
| PROM    | Patient-reported Outcome Measures                                        |
| ASyMS   | Advanced Symptom Management System                                       |
| RN      | Registered Nurse                                                         |
| RPN     | Registered Practical Nurse                                               |
| UX      | User Experience                                                          |
| UI      | User Interface                                                           |
| JSON    | JavaScript Object Notation                                               |
| QUIM    | Quality in Use Integrated Measurement                                    |
| PSSUQ   | Psychometric Evaluation of the Post-Study System Usability Questionnaire |

# **CHAPTER 1: INTRODUCTION AND BACKGROUND**

## **1.1 - Background**

An individual going through the cancer experience would undergo different stages, from detection and screening to survival state or death (Yarbro, Frogge, and Goodman, 1999).

Symptom management for cancer treatment-related symptoms, is known to be one of the major procedures which is commonly being performed by oncology nurses. To promote nursing care, evidence-based practice (EBP) is an approach that systematizes nurse-care setting. EBP is composed of patient experiences and preferences, research materials and also clinical expertise (So, 2016). Considering each of these factors, maximizes the overall achieved results for the patient's treatment.

For providing an evidence-based practice guideline, it is necessary to have sufficient, trustworthy evidence for supporting a particular intervention (Fineout-Overholt and Melnyk, 2011).

Moreover, ambulatory care has been adopted for the majority of cancer patients outside hospitals, introducing a new challenge for providing high quality and standardized care for non-hospitalized settings. In Canada, more than half of cancer nurses offer remote support using telephone and email, for the patients (Stacey et al. 2015). COSTaRS (pan-Canadian Oncology Symptom Triage and Remote Support), is a collection of evidence-based practice guides in paper-form format, designed for trained cancer nurses, which has been practiced for years. COSTaRS is exercised by calling the patient, filling the practice guide form and documenting the results.

In this study, we are introducing, implementing and testing a smartphone version of COSTaRS, as a self-report application for cancer patients, and also caregiver like family members. We investigate the disadvantages of current COSTaRS practice guides and even the previous studies on mobile symptom management topic. Moreover, we will explore the commercial mobile application that offers symptom management for cancer-related treatment symptoms. Our study includes the transition from the paper-based COSTaRS to a mobile digital version, which is portable and able to handle electronic data that can be used by the cancer patients or their caregivers.

## **1.2 - Symptom Management**

Symptoms are typically experienced by cancer patients during treatment and can make a massive impact on their lives. Lack of effective symptom management can result in unbearable or life-threatening symptoms for the patient (Walsh and Rybicki, 2006). Moreover, tracking cancer treatment-related symptoms and their cause, can assist oncology experts with decision-making about the patient's condition (Stazzone and Brown, 2012). An efficient and smart symptom management system can make a noticeable impact on the treatment process (Izumi et al. 2003). Nurses are crucial actors in symptom management since they play a leading role in it. Home care nurses are well-positioned to conduct assessments, triage, and provide symptom management for individuals receiving cancer treatment in the community (Lefkowitz et al. 2014).

One of the efficient practices of symptom management is the use of evidence-based knowledge (Lynch, 2014). It is a combination of academic research and clinical expertise while also considering the patient's goals and objectives. Moreover, the utilization of evidence-based

guidelines can improve effectiveness and efficiency in the health care system and also enhances the process of patient-centered care (McCulloch, Hemsley and Kelly, 2014).

In the process of symptom management, it is crucial to follow a specific course of action to achieve the desired outcome (Johnson et al. 2005). Most patients with advanced cancer believe that suffering is an inevitable part of cancer and also its treatment process. A positive approach can highly improve the information collected in symptom management process by starting with general questions and continuing with more specific ones. Patients may fail to report their symptoms correctly, they also may not mention the right severity level, or even in some cases, they may not point out that a sign exists. Sometimes, patients may avoid mentioning the cause of a symptom unless they are asked directly (Teunissen et al. 2007).

When dealing with a patient, the provider of symptom management, should clarify the necessities and recognize that a layperson's language may not directly be translated into medical language (Dong et al. 2016). For instance, a patient may not be familiar with the medical term "anorexia." Moreover, "loss of appetite" may mean nausea, vomiting, constipation, or early satiety. Also, for "Numbness," It may mean a loss of sensation or lack of proper feeling. On the other hand, Symptoms should also be classified and measured using a consistent measurement tool which can be numerical or categorical to improve the monitoring process (Dong et al. 2016).

Giving priority to symptoms is another crucial step in the procedure. Advanced cancer often brings multiple and severe symptoms (Walsh and Rybicki, 2006). Evaluating the symptoms that are most life-threatening and vital, and where the treatment process should be dealt with is another important step in the process. Understanding the background of a patient is also needed to have a bigger picture of the situation. Nausea and vomiting, for instance, might be caused by gastric outlet obstruction, hypercalcemia, increased intracranial pressure, esophagitis, opioid use,

or constipation (Teunissen et al. 2007). Most of the times, the next step after recording symptoms is developing a management strategy such as giving or changing the course of medication and other lifestyle factors.

There are also several symptoms that are caused by the use of medications which can be associated with the drug itself and the course of taking it (Eisenberg et al. 1994). Thus, symptom management requires that symptoms be monitored before taking medication as well as during and after, to manage any adverse issues (Wu, Wang, and Lin 2007).

### **1.3 - COSTaRS Introduction**

In 2008, a set of symptom management practice guides was introduced under the name of COSTaRS (pan-Canadian Oncology Symptom Triage and Remote Support), to improve the remote symptom management process (Stacey, 2016). COSTaRS is a symptom assessment and triage tool, for remote support of symptom management for cancer patients. It enhances the consistency and quality of symptom management procedure by using evidence-based practices and guidelines (Stacey et al. 2013). The tool is designed to be utilized by oncology nurses and entails 15 practice guides for the symptom management process during cancer-related treatments. COSTaRS has been tested in terms of usability by cancer nurses, experts and multiple studies. Moreover, it has been updated and revised through years of its use (Ludwig et al. 2017).

## **1.4 - Motivation**

The current COSTaRS symptom management guides have gone through several revisions and improvements since the first introduction of COSTaRS. However, there are limitations and challenges with different aspects of this tool, such as reporting, data handling, patient analysis, the scope of COSTaRS and the usability of the tool.

The practice guides are form-based questionnaires that are designed to be used by a trained nurse who makes a call to a cancer patient to input the information concerning the patient's symptom. Commonly, the data is written on paper forms and archived. With the increased use of IT systems, the paper-based process cannot efficiently enable symptom management at its full potential. Although the 15 symptom practice guides (COSTaRS) are successful as remote support for symptom management, they also have several drawbacks. First, when a practice guide is filled by a nurse it has to be transmitted and stored physically in the patient's file which is relatively a slow process. Moreover, this procedure is time-consuming, costly and prone to human error since a nurse has to be assigned to dedicate his/her time to create a symptom report and store the information. In addition, it imposes the difficulty of transforming the data to a computer from paper-based forms, that makes the analysis of the data difficult. On top of that, it may provide security issues since there is no encryption applied to forms, which means if a report is lost in the process, it can be easily read.

We suggest that developing a standardized electronic version of COSTaRS would facilitate and promote symptom management to the fullest potential. Also, an electronic version will enable easier accessibility and higher flexibility as it can target patients and caregivers as users.

Caregivers frequently play an essential role in the symptom management process. A patient or the caregiver will be able to generate reports and manipulate the reports on their device. In this

study, a mobile application will be developed to overcome the drawbacks in the existing paper-based symptom management system from the patient's perspective. The concept of symptom management and transformation to a smartphone application entails multiple fields of research, such as patient involvement, patient adherence, caregiver burdens and system integration. However, this study is primarily focused on the design and usability aspect of the mobile app.

## **1.5 - Research Objectives and Contributions**

In this study, we develop an innovative approach to symptom management by introducing a smartphone version of COSTaRS in which the patient or the caregiver would be able to create symptom reports and manipulate them on their own devices and also share the report with doctors and clinicians. We seek to improve the symptom management system for cancer treatment-related symptoms by introducing a mobile version of COSTaRS with the advantages of electronic data and mobile application usage. In addition, our goal is to take advantage of the practice-based concept of the current COSTaRS. Moreover, in this study, design-science for creating an artifact is used as the method of research.

There are many different ways to improve a symptom management system. However, we are approaching the issue from a usability perspective. From patient and caregiver perspective, we develop a mobile symptom management tool which offers a user-friendly interface for inputting and assessment of symptoms, informing the user about self-care strategies and then allowing users to create their own strategies for future reference, analysis and decision-making.

## 1.6 - Thesis Outline

Here is the structure of this thesis:

- The second chapter is a literature review of relevant literature.
- The third chapter reviews the commercial mobile applications for cancer symptom management available in the market and, we also compare the applications.
- The fourth chapter explains the research method selected for this study.
- The fifth chapter explores our case study where we go through the development, practice and assessment of COSTaRS. We describe the method for our design and analyze the requirements.
- The sixth chapter explores the implementation of the proposed application, where we explain the different stages of design for the mobile COSTaRS application.
- The seventh chapter evaluates the mobile COSTaRS application based on usability metrics.
- The eighth chapter discusses the results and contributions to the study. We also go through future works and how this study can be expanded.

## CHAPTER 2: LITERATURE REVIEW

In this chapter, we will review the literature in the field of mobile symptom management and implementation of mobile symptom management applications. We will be reviewing different approaches and solutions in mobile symptom management to understand how to conduct mobile symptom management design based on the existing COSTaRS practice guides.

### 2.1 - Research Methodology for Literature Review

One of the crucial points in approaching the literature review is the methodology for how the literature is retrieved (Lau and Kuziemsky, 2017). In this thesis, we adopted a five step systematic review methodology (Khan et al. 2003). We followed the steps described in the methodology in Figure 1 (Khan et al. 2003).

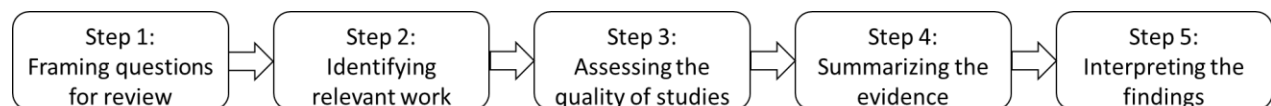


Figure 1: 5 steps of a systematic review (Khan et al. 2003).

#### First Step

In the first step of the systematic review, we will specify the issue in an easy to perceive form. At this step, we express the research question in a structured way as generic keywords to be feed to the next level (Khan et al. 2003).

## Second Step

At this stage, we search the keywords in multiple resources. Our resources are Google Scholar, PubMed and Scopus, which approximately covers all the academic works in our field of study (Martín-Martín et al. 2018). Keywords will be formulated to receive more accurate and precise results (Budgen and Brereton, 2006). The formulation is according to the target of interest in the research. In formulating the terms, we will use Boolean operators: "AND," "OR" for combining and "NOT" for excluding. The related works that are suggested by the search engines will also be reviewed (Khan et al. 2003).

## Third Step

At this step, the quality of the results will be evaluated according to the relevance to the purpose of the review. The results will be determined to be filtered in the study, according to the inclusion and exclusion criteria (Meline 2006). As the method suggests, the requirements for inclusion and exclusion in this study is based on three criteria: exposure of Interest, participants and outcomes (Table 1). In this review, the title, abstract and the results of the findings will be reviewed.

Table 1: Inclusion and exclusion of reviews criteria (Meline 2006)

| Criterion            | Description                                                                                   |
|----------------------|-----------------------------------------------------------------------------------------------|
| Exposure of Interest | The study has to be in the scope of interest according to our objective.                      |
| Participants         | The review should not be limited to certain types of participants, which affects the results. |

|         |                                                                                         |
|---------|-----------------------------------------------------------------------------------------|
| Outcome | The results of a study have to be related and similar to the objective of our research. |
|---------|-----------------------------------------------------------------------------------------|

#### **Fourth Step**

The results coming from the third step will be summarized based on the goal of the review; therefore, the key points in each work will be captured while considering objective of this study and the degree of relevance to the topic (Khan et al. 2003).

#### **Fifth Step**

In the last step, we will discuss and explore the finding based on their relevance and contribution to the topic of the research. Moreover, the contribution of each study will be explored (Khan et al. 2003).

## **2.2 - Studies on Symptom Management**

In this section, we review the literature for the primary question of the thesis. Here are the research questions:

1. “How can the current paper-based COSTaRS (pan-Canadian Oncology Symptom Triage and Remote Support) symptom management system be improved by developing the mobile version of COSTaRS for patients and caregivers?”.
2. “How to develop an innovative practice-based mobile application for symptom management with high level of usability?”.

In order to find publications relevant to our objectives, here are the search terms we used:

1. (“symptom management” OR “triage management”) AND (“mobile” OR “mobile application”) AND (“app”).
2. (“symptom management”) AND (“assessment” OR “evaluation” OR “drawbacks” Or “barriers”).
3. (“mobile symptom management”).
4. (“paper-based to electronic”).
5. (“caregiver”) AND (“symptom management”).

The search phrases were used in different search engines. The potential for relevance was examined, and the irrelevant results were excluded from the study based on the mentioned inclusion/exclusion rules.

## **2.3 - Search Findings**

From all the results in the search process. Fifteen papers were identified to be included in this review by following the inclusion and exclusion criteria (Meline, 2006). According to our objective and the research questions, the identified articles have been categorized into four classifications.

- Barriers to symptom management.
- Paper-based to electronic transition in the clinical domain.
- Symptom management of mobile applications.
- Role of caregivers in symptom management.

### **2.3.1 - Barriers to Symptom Management**

In 2005, a study conducted to identify barriers to symptom management in hospice. Survey-based research on nurses in palliative care was undertaken to determine the obstacles (Johnson et al. 2005). The most detected barrier was the inability of the family and caregivers to maintain the treatments. In other words, one of the prominent challenges of cancer patients is enduring and committing to the treatments.

In 2015, a study carried out to evaluate the cancer treatment-related symptoms and explore barriers to the symptom management of cancer patients (Nayak et al. 2015). This study shows that most of the patients have an incorrect understanding of their symptoms. Moreover, communication, financial and personal profession, were the other barriers for symptom management. Majority of the patients were having a hard time expressing their symptoms due to having primary education and language problems (Nayak et al. 2015). Moreover, the study shows this is crucial that experts make sure patients receive proper care and information at the right time.

### **2.3.2 - Paper-based to Electronic Transition in Clinical Domain**

In 2001, a study conducted to assess the parallel utilization of electronic and paper-based patient records (Naderi et al. 2001). The documentation was compared in both methods. The result of the study depicts that roughly 4% to 13% of the documents were missing in electronic records and 1% in the case of paper-based records. The research shows that using electronic and paper-based patient record can cause inconsistency in the patient's records. Moreover, electronic records are dramatically more efficient compared to paper-based records (Naderi et al. 2001).

In 2009, a research carried out to investigate the evidence required to backup measurement equivalence in the case of electronic and paper-based patient-reported outcome (PRO), (Coons et al. 2009). The result of the study presents that electronic PRO questionnaire coming from a paper-based questionnaire have to provide the same or higher level of reliability. Moreover, the extent of a transition is defined by the potential effect on the meaning and the content of the reference item (Coons et al. 2009). The study points out that electronic PRO brings many facilitators compare to equivalent paper-based PRO. Moreover, electronic PROs improve system noticeably.

In 2009, a study was carried out to compare clinical trial paper-based data collection (PDC) to an alternative internet-based electronic data collection (EDC). The purpose of the study was to model PDC and EDC for estimation of the cost of process (Pavlović, Kern, and Miklavčič, 2009). For cost assessments, the factors in the model were: data quality, efforts and staff prices. The result of the study shows that EDC reduces the cost of data collection by 55% and by modifying the scenarios of parameters EDC can potentially result in 49% to 62% of savings compared to PDC (Pavlović, Kern, and Miklavčič, 2009). Moreover, EDC improves the handling of the data for the user.

In 2015, research was conducted to validate the electronic version of PROs to be reliable to use (Campbell et al. 2015). The study concluded that according to the scale of modification, ensuring the equivalence is more challenging. The study found that electronic format is preferred when

the formats are equivalent. Besides, when the electronic PRO is validated, it is preferred by the user over paper-based PROs (Campbell et al. 2015).

### **2.3.3 - Symptom Management Mobile Applications**

In 2014, a study conducted to determine the feasibility of a mobile app for breast cancer patient receiving chemotherapy (Min et al. 2014). The app was designed for sleep problem-related to data collection. It was tested in 90 days with self-reporting sleep disturbance data collected daily. The result of the study approves the feasibility of such an app (Min et al. 2014). Moreover, it demonstrates data collection through mobile application technology for a cancer patient is preferred.

In 2014, a study conducted to evaluate a mobile app that allows the user to access the Connect system which is an online service for supporting cancer patients with their health issues and symptom management (Mirkovic, Kaufman, and Ruland, 2014). The app improves decision making and communication. The app has four main sections; message, assessment, advice and forum. The assessment module allows the user to self-triage the symptom they chose to report (Mirkovic, Kaufman, and Ruland, 2014).

In 2015, a study developed a new remote patient monitoring system as an advanced symptom management for radiotherapy patients, to improve the symptom experience, targeting lung cancer patients (Maguire et al. 2015). The study suggests having regular supportive care is crucial for the patients. Patient-reported outcome measures (PROMs) delivers real-time data instantly to the healthcare provider. As a result, it initiates an early intervention. The result of this study suggests that the use of this technology is acceptable to patients and also feasible

(Maguire et al. 2015). The patients that were involved in the study found ASyMS as a positive contribution to the treatment. Moreover, healthcare professionals also found it beneficial, acceptable and feasible.

In 2015, a research about a mobile application for monitoring chemotherapy side-effects in patients suffering from hematological malignancies was conducted. The study is based on remote patient intervention and symptom management system (PRISMS) (Breen et al. 2015). The studied system is a nurse-led telehealth intervention for remote monitoring of chemotherapy-side effects in Australian hematological cancer patients. In case the patients require extra attention during this procedure, an email alert will be sent to the treatment team so that they can provide clinical intervention by contacting the patient (Breen et al. 2015). The results of this study show that the real-time remote monitoring of the patient's side-effects can noticeably increase the effectiveness of the nursing role and the overall outcome for the patient.

In 2017, a research was conducted in which a mobile application for patient's adherence to the therapy was developed, and the usability and the acceptability of the interface were assessed. The patients were going through oral chemotherapy (Fishbein et al. 2017). The app was designed based on user feedback, usability and acceptability tests. The app was composed of medication reminders and also a self-reporting system for medication adherence and symptoms. Moreover, there is an informative section that provides the user with nutritional information, individualized symptom management feedback and also social networking is included (Fishbein et al. 2017).

In 2017, a study based on the comparison of a mobile application for electronic support of breast cancer patients and traditional support for Chinese female cancer patients was conducted (Zhu et al. 2017). The purpose was to promote symptom management and social support to improve the quality of life and mental health. The electronic support is defined with four modules: learning

forum, discussion forum, ask an expert forum and personal stories forum (Zhu et al. 2017). The result of this study shows that implementing electronic support in the form of mobile application can noticeably improve the overall symptom management process and patient's psychological well-being.

In 2018, a study evaluated a mobile phone technology for cancer patients receiving chemotherapy to find usability, functionality and design issues (Moradian et al. 2018). The patients fill out their symptom in a Patient Reported Outcome Measuring system (PROM) to assess their condition, which is followed by self-care advice (Moradian et al. 2018). The results of the study show that the user finds new technology to have a higher degree of usability.

#### **2.3.4 – Role of Caregivers in Symptom Management**

In 2008, a study was conducted to understand the relationship between the quality of outcome with involvement and knowledge of the caregiver (Bevan and Pecchioni, 2008). The results of the study showed that providing cancer knowledge resources for the caregivers will improve the quality of the care and the involvement of the caregiver will also result in a better outcome for the patient (Bevan and Pecchioni, 2008).

In 2011, a study showed that a considerable portion of cancer care is being delivered at home by caregivers (Van Ryn et al. 2011). They provide help for the cancer patient from assisting in daily activities to handling cancer treatment-related symptoms. Nevertheless, half of the caregivers are not receiving the necessary pieces of training and around 25%, are not confident enough in the quality of the care they provide for the patient (Van Ryn et al. 2011). Also, there are limited resources for caregivers to provide care.

## 2.4 - Discussion

The reviews identified barriers to symptom management with lack of information resources being a critical challenge that cancer patients are facing. The findings show that symptom management systems fail to allow symptom management knowledge to be used by cancer patients. Also, the outcomes of these reviews show that the caregivers play an essential role in the symptom management process. However, the application developers do not target them as users and applications are designed specifically for patients. Another issue is the inability of the patients to express their symptoms using electronic symptom reporting applications effectively.

Electronic PROs enable many advantages compared to paper-based PROs when the ePRO is designed and tested correctly. Also, the automated data collection dramatically reduces costs and facilitates analysis and learning from the data.

Reviewing the studies on the symptom management mobile applications, shows that these apps are mainly focused on triage of symptom by asking about the severity of the sign. Moreover, they provide limited or no informative resources concerning symptom management. Table 2 shows the list of mobile applications extracted from the studies. In addition, these applications do not offer practice-based symptom management.

Table 2: Applications resulted from studies

| <b>Application ID</b> | <b>Application Name</b> | <b>Platform</b> | <b>Evaluation Method</b> | <b>Reference</b> |
|-----------------------|-------------------------|-----------------|--------------------------|------------------|
|-----------------------|-------------------------|-----------------|--------------------------|------------------|

|    |           |              |                                   |                                       |
|----|-----------|--------------|-----------------------------------|---------------------------------------|
| S1 | Pit-a-Pat | Android/ iOS | Feasibility study                 | (Min et al. 2014)                     |
| S2 | Connect   | Android/ iOS | Usability study                   | (Mirkovic, Kaufman, and Ruland, 2014) |
| S3 | ASyMS-R   | Android      | Usability study                   | (Maguire et al. 2015)                 |
| S4 | PRISMS    | Android      | Telehealth system study           | (Breen et al. 2015)                   |
| S5 | CORA      | Android/ iOS | Usability and acceptability study | (Fishbein et al. 2017)                |
| S6 | BCS       | Android      | Feasibility study                 | (Zhu et al. 2017)                     |
| S7 | ASyMS     | Android      | Usability study                   | (Moradian et al. 2018)                |

## 2.5 - Chapter Summary

In this chapter, we discussed the literature review regarding the main aspects of the objective of this study. We used inclusion and exclusion guidelines to determine the outcome of our search.

We categorized the results and described the outcome of each investigation for all the categories.

Finally, we discussed the results of our finding to better present the correlation between our objective and the reviews.

## **CHAPTER 3: REVIEW OF MARKET APPLICATIONS**

In the previous chapter, we discussed the literature review of cancer symptom management apps. To have a thorough study of the previous works similar or related to ours, we have to take commercial market applications into account. All mobile applications developed to support cancer symptom management are not resulted from academic studies. The objective of this chapter is to gain an in-depth understanding of the existing market for apps on cancer symptom management.

### **3.1 - Targeting Mobile Applications**

Android and iOS together hold over 97% of the smartphone operating systems market worldwide (StatCounter, 2019). Moreover, Google Play and App Store are official mobile app markets for Android and iOS and contain the most number of apps on each platform accordingly, with the most number of users (Dogtiev, 2018). Google Play search algorithm, output the app by searched keywords, according to the rate of the usage, user feedbacks and recommendations (Bankhead, 2018). App Store also finds the app based on keywords, usage rate, app name, subtitle, description and user ratings (Apple, 2019). We searched the following keywords in the Google Play and App Store: "cancer," "symptom management," "oncology," "chemotherapy," "radiotherapy." The results have been included or excluded in our study based on the app description and offered features in relation with our research.

### 3.2 - Findings

Seven mobile applications, have been chosen to be included in this study. Among the search results, there is a significant number of applications that provide information on cancer treatment and oncology topics. Moreover, there are fund-raising applications for cancer-related issues and researches. Some lifestyle applications offer information on cancer prevention. The applications that were unrelated to symptom management in cancer treatment were excluded. Moreover, the applications that targeted nurses, doctors and physicians as users were also excluded. Many applications offer different services for variety aspects of a cancer patient lifestyle, conditions and issues. However, the purpose of this study is symptom management for cancer-related treatment symptoms. Therefore, the results have been determined to be included in this study based on the concept of cancer treatment-related symptom management.

### 3.2 - Findings: Mobile Applications

Here we describe the functionality and features of each application. The applications are listed in Table 3.

Table 3: Commercial symptom management mobile applications

| <b>Application ID</b> | <b>Application Name</b>        | <b>Platform</b> | <b>Reference</b>                |
|-----------------------|--------------------------------|-----------------|---------------------------------|
| C1                    | Cancer.Net Mobile              | Android/ iOS    | (ASCO, 2018)                    |
| C2                    | BELONG Beating Cancer Together | Android/ iOS    | (BelongTail, 2019)              |
| C3                    | Self Care During Cancer        | Android/ iOS    | (NearSpace, 2018)               |
| C4                    | Palliative Care Symptom Guide  | Android/ iOS    | (Smashed Crab Studio Ltd, 2016) |

|    |                             |         |                                           |
|----|-----------------------------|---------|-------------------------------------------|
| C5 | For Cancer Care             | Android | (American Energy Corporation, 2017)       |
| C6 | Chemo Brain                 | Android | (Katharine Hargrove, 2018)                |
| C7 | chemoWave: cancer care tool | iOS     | (Treatment Technologies & Insights, 2019) |

**Cancer.Net Mobile** assists the user to plan and handle the treatment. It provides information regarding cancer (ASCO, 2018). The app records the questions and answers inputted by the user, also it records and take pictures of their medication, and stores the dosage and frequency of use. The app tracks symptoms with the severity level that the user determines. Scheduling medicines and reminding the user are additional features of the app.

**BELONG Beating Cancer Together** helps the user to find support groups, oncologists, researchers and nurses for answering questions (BelongTail, 2019). It provides social network features for the user. Moreover, it personalizes the notifications and user information.

**Self Care During Cancer** is an app for patients getting treated for cancer, which is used for self-assessment of symptoms (NearSpace, 2018). It also introduces self-care strategies and allows sharing of the results of self-assessment using email.

**Palliative Care Symptom Guide** offers a set of guides for common symptom in cancer and advanced progressive disease (Smashed Crab Studio Ltd, 2016). Moreover, the app provides information about medication for handling the symptoms.

**For Cancer Care** informs the user about common side effects of cancer treatment procedures like chemotherapy and medications (American Energy Corporation, 2017). Also, the app indicates the conditions that require immediate medical attention. The objective of the app is to reduce unnecessary visits to the emergency room.

**Chemo Brain** helps the user to keep a record of their symptoms and perceptions. Moreover, the app allows the user to email the logs (Katharine Hargrove 2018). Mainly, the app is composed of symptoms and prescriptions sections, and no informative content is provided.

**chemoWave: Cancer Care Tool** allows the user to track their treatment and activities. The app includes information about the symptoms and conditions (Treatment Technologies & Insights, 2019). The results can be shared using the app. Besides, it tracks physical condition shifts, mood changes, pain occurrences, medications, appointments, treatments and procedures, sleep, meals, water consumption and more. User can add notes and images to their records.

### **3.2 - Findings: Comparison and Discussion**

In this section, we compare the features and functionalities of each app in Table 4. We have brought the resulted applications from the literature review chapter for having a thorough comparison. According to the objective of this study, we are comparing the offered features on the selected applications. The comparison features are as follow:

- The application is supported on both Android and iOS, which includes more than 97% of smartphone users (StatCounter, 2019).
- The application allows the user to express the severity of their symptom on a particular scale.
- The results created by the user can be shared.
- The application informs the user about self-care strategies for handling the symptoms.
- The application provides information about the medication taken by the patient for handling the symptoms.

- The application tracks the symptoms, medication and the self-care strategies of the patient.
- Whether the application is designed to be utilized in a clinical setting in a specific cancer center.

Table 4: Comparison of selected applications

| Application ID | Cross-platform | Self-triage symptom | Allows sharing results | Offers self-care strategies | Provides information on medication | Tracks symptoms | Tracks medication | Tracks self-care strategies | Used in clinical settings | Result of a study or commercial |
|----------------|----------------|---------------------|------------------------|-----------------------------|------------------------------------|-----------------|-------------------|-----------------------------|---------------------------|---------------------------------|
| C1             | Yes            | Yes                 | No                     | Yes                         | Yes                                | Yes             | Yes               | Yes                         | No                        | Commercial                      |
| C2             | Yes            | No                  | Yes                    | Yes                         | No                                 | No              | No                | No                          | No                        | Commercial                      |
| C3             | Yes            | Yes                 | Yes                    | Yes                         | No                                 | Yes             | No                | No                          | No                        | Commercial                      |
| C4             | Yes            | No                  | No                     | Yes                         | Yes                                | No              | No                | No                          | No                        | Commercial                      |
| C5             | No             | No                  | No                     | Yes                         | Yes                                | No              | No                | No                          | No                        | Commercial                      |
| C6             | No             | No                  | Yes                    | No                          | No                                 | Yes             | Yes               | No                          | No                        | Commercial                      |
| C7             | No             | Yes                 | Yes                    | Yes                         | Yes                                | Yes             | Yes               | Yes                         | No                        | Commercial                      |
| S1             | Yes            | Yes                 | No                     | No                          | No                                 | Yes             | No                | No                          | No                        | Study                           |
| S2             | Yes            | Yes                 | No                     | Yes                         | No                                 | Yes             | No                | No                          | Yes                       | Study                           |
| S3             | No             | Yes                 | No                     | No                          | No                                 | Yes             | No                | No                          | No                        | Study                           |
| S4             | No             | Yes                 | No                     | Yes                         | No                                 | Yes             | No                | No                          | Yes                       | Study                           |
| S5             | Yes            | Yes                 | No                     | No                          | Yes                                | Yes             | Yes               | No                          | No                        | Study                           |
| S6             | No             | No                  | Yes                    | Yes                         | Yes                                | No              | No                | No                          | Yes                       | Study                           |
| S7             | No             | Yes                 | No                     | Yes                         | No                                 | Yes             | No                | No                          | Yes                       | Study                           |

The selected applications offer different sorts of services to the user. Some of the applications provide social media features where the patients can find another patient in a similar condition. Moreover, some of the applications have forums in which users can express their problems or ideas and also, they can have access to oncology experts and learn about the latest researches and the news in oncology spectrum. However, the applications do not support a practice-based input format to have a thorough understanding of the condition of the patient. The applications offer the self-triage of the symptom and do not record the underlying disease and causation of the patient's symptom which may be determined in an evidence-based structure and can be utilized for superior decision making and tracking of the symptom. The fundamental difference between the commercial apps mentioned in this chapter and our study is that these apps are not used on a clinical basis, unlike our case, although the apps offer symptom management to the user.

The applications are designed and developed with the purpose of improving and providing services in certain features, such as tracking symptom, self-care strategies and also tracking medications reporting results and enabling clinical setting. None of the application offers this feature in a single application. In order to have a reliable and efficient mobile software as a decision-making tool, this is required to integrate these features in a single application which is not offered in the market.

### **3.3 - Chapter Summary**

In this chapter, we reviewed the commercial applications that support cancer symptom management. We targeted these applications according to the objective of this study and provided descriptions for each selected application. We compare the final results, where the

applications for the previous chapter were also included. Finally, we discussed and compared the results.

## **CHAPTER 4: METHODS**

In this chapter, we will describe our methods to answer the research questions. Adopting an appropriate approach depending on the objective of a study is the main point in stages of research (Marshall 1996).

### **4.0 - Research Questions**

The research questions that we seek to answer in this study is as follow:

1. “How can the current paper-based COSTaRS (pan-Canadian Oncology Symptom Triage and Remote Support) symptom management system be improved by developing the mobile version of COSTaRS for patients and caregivers?”
2. “How to develop an innovative practice-based mobile application for symptom management with high level of usability?”

### **4.2 - Epistemology**

In this study, we are utilizing the design-science method in information system discipline (Hevner et al. 2004). The purpose of this method is to expand and improve the limitations of creating an innovative artifact. In design-science, creating and implementing a designed artifact is the result of the comprehension of boundaries and knowledge domain (Hevner et al. 2004). Design-science creates innovative products that bring improvements to the structure. Our research involves the creation of a mobile application to promote symptom management. Therefore, the design-science paradigm was selected for this study. Moreover, design-science creates and evaluates information technology artifacts as solutions for structural problems

(Hevner et al. 2004). Similar academic works in the field of design science have also been considered to be utilized in this study. Research in the field of design science like Hevner and Chatterjee (2010), Vaishnavi and Kuechler (2008), Sein et al (2011) and also Hevner 2004, are less detailed than recent works like Gregor & Hevner (2013). Recent design science approaches, discuss the contributions and communications of design science to knowledge in depth (Gregor et al. 2017). However, in case of our objective, adopting other design science methodology will not make a noticeable change in the process of the research and will result in the same steps. Design science is a problem-solving process that introduces seven guidelines as a requirement for a practical design-science study (Figure 2).

| <b>Guideline</b>                        | <b>Description</b>                                                                                                                                                      |
|-----------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Guideline 1: Design as an Artifact      | Design-science research must produce a viable artifact in the form of a construct, a model, a method, or an instantiation.                                              |
| Guideline 2: Problem Relevance          | The objective of design-science research is to develop technology-based solutions to important and relevant business problems.                                          |
| Guideline 3: Design Evaluation          | The utility, quality, and efficacy of a design artifact must be rigorously demonstrated via well-executed evaluation methods.                                           |
| Guideline 4: Research Contributions     | Effective design-science research must provide clear and verifiable contributions in the areas of the design artifact, design foundations, and/or design methodologies. |
| Guideline 5: Research Rigor             | Design-science research relies upon the application of rigorous methods in both the construction and evaluation of the design artifact.                                 |
| Guideline 6: Design as a Search Process | The search for an effective artifact requires utilizing available means to reach desired ends while satisfying laws in the problem environment.                         |
| Guideline 7: Communication of Research  | Design-science research must be presented effectively both to technology-oriented as well as management-oriented audiences.                                             |

Figure 2: Design-Science Research Guidelines (Hevner et al. 2004).

At this point, we map out the seven guidelines in our study. we describe the corresponding aspect of each guideline in the case of our study.

#### **4.2.1 - Design of the Mobile Application**

The first guideline, requires the design of an artifact to solve an essential organizational problem (Hevner et al. 2004). The artifact also encompasses the methods used in the development. The artifact in our case is the innovative COSTaRS mobile application, and the purpose of this artifact is to improve and excel the current symptom management system from a usability perspective. We chose Ionic as our hybrid mobile application development platform (ionic n.d.). Ionic allows us to create a single source code for development of multiple platforms that are easy to be integrated. The backend is hosted by Firebase, which is a Google application development platform that is utilized for the development of the high-quality mobile application (Google n.d.). The Firebase connection and storage is highly secured.

#### **4.2.2 - Investigating the Barriers to Symptom Management**

The second guideline describes the purpose of the research in information systems as gaining knowledge about the current structure (Hevner et al. 2004). In our study, we investigate the barriers of symptom management and how we can address these through mobile symptom management. Moreover, we analyze the issues and requirement to design a mobile application to address symptom management barriers. This issue is the starting point of our study.

#### **4.2.3 - Assessment of the COSTaRS Mobile Application**

The third guideline aims to evaluate the design by means of evaluation methods effectively. The outcome of our study is a mobile application (Hevner et al. 2004). This is a usability study, therefore, to evaluate our prototype, we target usability metrics. Considering our product as a mobile application, we utilize functional testing (Selvam and Karthikeyani, 2011) (usability study) by using the analysis of usability testing, for evaluation of the application.

#### **4.2.4 - Contributions of the COSTaRS Mobile Application**

To have useful research, we provide contributions for symptom management from our mobile application as the fourth guideline suggests (Hevner et al. 2004). Our contribution is an innovative approach to mobile symptom management for improving symptom management via a mobile application (design artifact). Our study, is descriptive research since we are describing the characteristics of an artifact in the form of the COSTaRS mobile application (Shields and Rangarajan, 2013).

#### **4.2.5 - Mobile Application Rigor Development Process**

The fifth guideline of design-science is related to how the design is carried out in a particularly rigorous process (Hevner et al. 2004). In order to ensure the rigorousness of the study, we cover reliability and validity. In case of reliability, we establish a high degree of confidence using our testing process which will result in consistent outcomes in multiple application of the testing (Hughes, 1999). In addition, to ensure validity, we analyze the user's input extracted from the testing and also the requirements of our product. In this study, we are utilizing the lifecycle

template of user experience design to develop the mobile application (Hartson and Pyla, 2012), which is an iterative process to design. Moreover, the analysis of the literature review and background studies are integrated into the process.

#### **4.2.6 - Search process in mobile symptom management**

A vital part of design-science is the search process to output the best design according to the sixth guideline of design-science (Hevner et al. 2004). To develop the best plan for our application, we are investigating and discussing studies in the field of mobile symptom management and also commercial mobile applications developed for this purpose. Moreover, we will go through the process of transition from the paper-based and system to a digital architecture for self-reporting in our case study.

#### **4.2.7 - Implementation of the Mobile Application**

The seventh guideline of design-science entails the implementation of the artifact. Our study also encompasses useful information for the collaborator of symptom management, namely, nurses, doctors, physician and clinicians that have dealt with symptom management systems process (Hevner et al. 2004). We will make contributions to the mobile COSTaRS app.

### **4.3 - Thesis methodology diagram**

According to design-science principals, we mapped out our research process in this study. The process is shown in Figure 3.

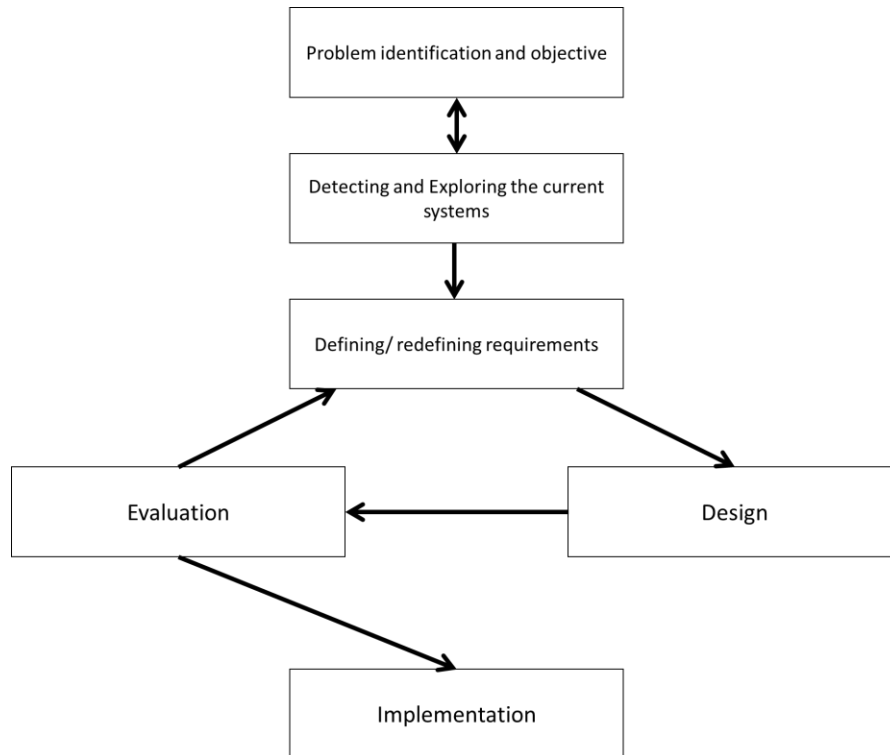


Figure 3: Illustration of the research process.

#### 4.4 - Chapter Summary

In this chapter, we discussed the process of our research to gain the desired results in academic settings. We explained why we chose this method and how each guideline in the method will map out in our study. Every instruction in the method has been described in terms of implementation in the case of our research.

## **CHAPTER 5: CASE STUDY - COSTARS**

The Pan-Canadian Oncology Symptom Triage and Remote Support (COSTaRS) is composed of 15 practice guides (Stacey et al. 2016). The practice guides are designed for telephone support, targeting nurses as users. Moreover, COSTaRS was created by a team of experienced nurses. It summarized the clinical guidelines to provide excellent symptom and triage management. COSTaRS project was initially designed to move the evidence-based guidelines from huge documents to concise practice guides that are two pages, to improve symptom management and documentation (IKT Research Network n.d.).

### **5.1 – COSTaRS: Development**

In 2008, a team, representing eight Canadian provinces, founded a committee, to create cancer treatment-related symptom practice guides (Stacey, 2016). For transferring clinical knowledge to practice guides, a knowledge-to-action framework was used for the development of COSTaRS (Figure 4). The development was in collaboration with CAN-IMPLEMENT, which provides practical instructions to help experts in using evidence-based practice guides in their institution (Harrison et al. 2013). Application of research into healthcare settings can be complicated and problematic. To overcome this barrier, the result of the research has to be synthesized with end user needs. Moreover, the evidence-based knowledge needs to be tailored for implementation. Knowledge generation and the implementation of existing and new solutions is an intricate cyclical process that has been summarized by Graham as the "knowledge-to-action" framework (Harrison et al. 2010). Creating and implementing knowledge entails a complex cyclical process which has been depicted in action cycle (Figure 4).

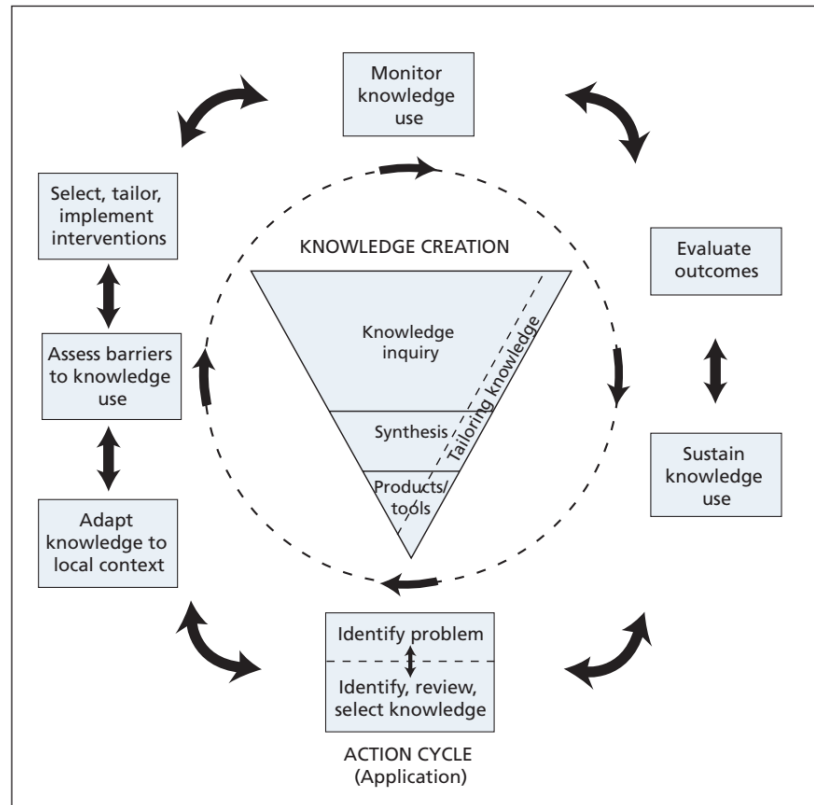


Figure 4: Action Cycle (Harrison, 2010).

Along with the researchers, the COSTaRS founding committee was composed of RNs, an information system researcher, nurse leaders and a library scientist. A systematic review was carried out for detection of the practice guidelines in previous recent years (Stacey et al. 2012). From the best outcome of the study and the available evidence, the instructions were developed. Moreover, the practice guides were designed to excel in decision making in clinical settings (Gagliardi et al. 2011).

The Appraisal of Guideline for Research and Evaluation (AGREE), was designed to overcome inconsistency issues in practice guides. Moreover, the tool also evaluates the rigorousness in the practice guides design (AGREE Next Steps Consortium, 2009). In addition, AGREE determines

how the information has to be reported in guidelines. Using the AGREE instrument (Brouwers et al. 2010), the quality of the reviewed practice guides were evaluated. Edmonton Symptom Assessment System (ESAS) is widely utilized as a symptom assessment tool for advanced cancer and palliative patients, which determines the levels of distress in a scaled-based format (Richardson and Jones, 2009).

Related questions were added to COSTaRS guidelines from the Edmonton Symptom Assessment System (ESAS) (Lefkowitz et al. 2014). The guidelines were tested on nurses to ensure the quality of usability. Also, the practice guides were reviewed by experts in Canada. The Canadian Institutes of Health Research (CIHR) funded the project to carry out a study for assessment and implantation of symptom practice guides in different oncology programs from 2013 to 2015.

In 2016, two new practice guides were added (pain and sleep problems). Therefore, the final version of COSTaRS consists of 15 practice guides.

Here are the 15 symptoms in the practice guides:

- Anxiety
- Appetite Loss
- Bleeding
- Breathlessness/dyspnea
- Constipation
- Depression
- Diarrhea
- Fatigue/tiredness
- Febrile neutropenia
- Mouth sores/stomatitis

- Nausea/vomiting
- Pain
- Peripheral neuropathy
- Skin reaction
- Sleep problems

## **5.2 - COSTaRS: Training**

There are various training programs offered for the physician or the nurse who plays a role throughout the symptom management process for cancer patients. It is necessary for them to receive this training before providing care (Stacey, 2014). Generally, in oncology nurse care programs, training programs are whether performed in class activity for a group or electronic learning which can be online courses or traditional courses including different teaching tools, namely, lectures, demonstrations, case studies and instructing materials that can be simulated patients, videos and card games or even a combination of learning tools and materials. The COSTaRS team carried out studies concerning available telephone-based symptom support training programs for nurses in ambulatory oncology programs in Canada (Stacey et al. 2014), to create the training materials. They also evaluated the training to ensure the efficiency and effectiveness (Stacey, 2013). In the case of COSTaRS, 30-45 training workshop (Stacey et al. 2016), and also the online tutorial which is designed to be used by oncology nurses is designed for utilizing COSTaRS (Canadian Oncology Symptom Triage and Remote Support n.d.).

## 5.2.1 - COSTaRS: Online Training Module

There is an online training module that starts with the "login" page, where the user inputs their desired username and password. The online training goes through several pages starting from COSTaRS background, definition and purpose of implantation and information on using the practice guides. The training module also asks for the user's input. The module receives the user input about the common patient symptoms that they manage and whether it is in person or over the phone, and also their experience with practice guides if they have any. Figure 5, is a screenshot of the training module describing the necessary action on each section of the practice guide (Ohri.ca n.d.).

**Nausea & Vomiting Practice Guide**

Nausea: A subjective perception that emesis may occur. Feeling of queasiness.  
Vomiting: A forceful expulsion of stomach contents through the mouth and may include retching (gastric and esophageal movement without vomiting – dry heaves).<sup>6,10</sup>

**1. Assess severity of nausea/vomiting (Supporting evidence: 4 guidelines)**

Tell me what number from 0 to 10 best describes your nausea

No nausea 0 1 2 3 4 5 6 7 8 9 10 Worst possible nausea<sup>8(ESAS)</sup>

Tell me what number from 0 to 10 best describes your vomiting?

No vomiting 0 1 2 3 4 5 6 7 8 9 10 Worst possible

How worried are you about your nausea/vomiting?

Not worried 0 1 2 3 4 5 6 7 8 9 10 Extremely worried

**Ask patient to indicate which of the following are present or absent**

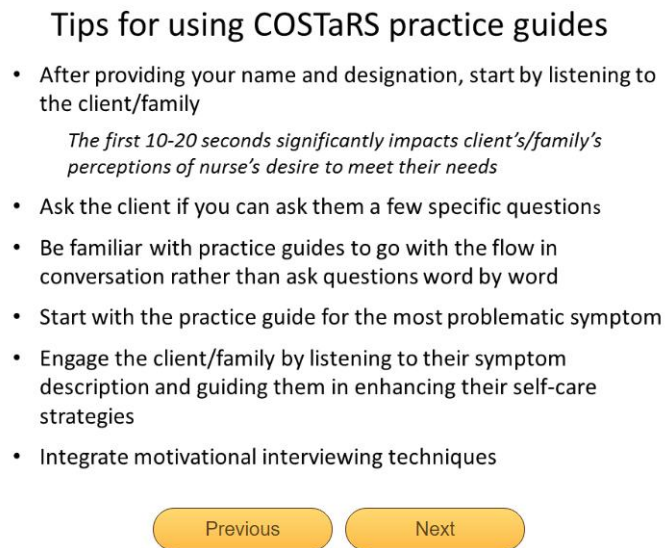
|                                                                                                                                                                    |             |                          |                    |                          |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------|--------------------------|--------------------|--------------------------|
| Patient rating for nausea (see ESAS above) <sup>7,8,9</sup>                                                                                                        | 1-3         | <input type="checkbox"/> | 4-10               | <input type="checkbox"/> |
| Patient rating for vomiting (see ESAS above) <sup>1,6,8</sup>                                                                                                      | 1-3         | <input type="checkbox"/> | 4-6                | <input type="checkbox"/> |
| Patient rating of worry about nausea/vomiting (see above) <sup>5</sup>                                                                                             | 0-5         | <input type="checkbox"/> | 6-10               | <input type="checkbox"/> |
| How many times per day are you vomiting or retching? <sup>1,6,7,10</sup>                                                                                           | ≤1          | <input type="checkbox"/> | 2-5                | <input type="checkbox"/> |
| <input type="checkbox"/> No vomiting                                                                                                                               |             |                          | ≥6                 | <input type="checkbox"/> |
| Have you been able to eat within last 24 hours? <sup>7,10</sup>                                                                                                    | Yes         | <input type="checkbox"/> | No                 | <input type="checkbox"/> |
| Have you been able to tolerate drinking fluids? <sup>8,7,10</sup>                                                                                                  | Yes         | <input type="checkbox"/> | No                 | <input type="checkbox"/> |
| Are you feeling dehydrated, which can include feeling dizzy, a dry mouth, increased thirst, fainting, rapid heart rate, decreased amount of urine? <sup>6,10</sup> | No          | <input type="checkbox"/> | Yes, some          | <input type="checkbox"/> |
|                                                                                                                                                                    |             |                          | Yes, significantly | <input type="checkbox"/> |
| Do you have any blood in your vomit or does it look like coffee grounds? <sup>5</sup>                                                                              | No          | <input type="checkbox"/> | Yes                | <input type="checkbox"/> |
| <input type="checkbox"/> No vomiting                                                                                                                               |             |                          |                    |                          |
| Do you have any abdominal pain or headache? <sup>6</sup>                                                                                                           | No/Mild 0-3 | <input type="checkbox"/> | Moderate 4-6       | <input type="checkbox"/> |
|                                                                                                                                                                    |             |                          | Severe 7-10        | <input type="checkbox"/> |

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Figure 5: © Ottawa Hospital Research Institute – Training module: symptom assessment.

At the end of the training module, there is an evaluation form asking about the online training and the user's feedback. Finally, the module ends with a quiz followed by creating the certificate

for the user. Figure 6, show tips provided for using the practice guides in an online training module. Figure 7 is the screenshot of the final certificate.



### Tips for using COSTaRS practice guides

- After providing your name and designation, start by listening to the client/family  
*The first 10-20 seconds significantly impacts client's/family's perceptions of nurse's desire to meet their needs*
- Ask the client if you can ask them a few specific questions
- Be familiar with practice guides to go with the flow in conversation rather than ask questions word by word
- Start with the practice guide for the most problematic symptom
- Engage the client/family by listening to their symptom description and guiding them in enhancing their self-care strategies
- Integrate motivational interviewing techniques

Previous Next

Figure 6: © Ottawa Hospital Research Institute – Training module: tips for usage.

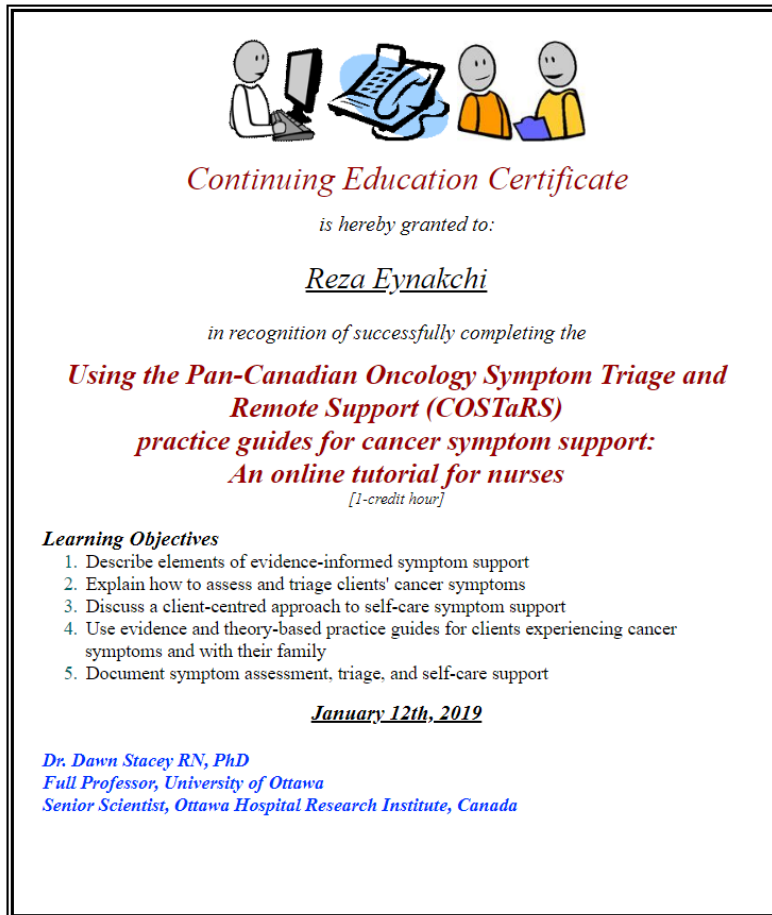


Figure 7: © Ottawa Hospital Research Institute – Training module: certificate.

### 5.3 - COSTaRS: Documentation

In COSTaRS remote support, commonly, the cancer patient is contacted through a phone call, and the nurse uses a paper-based form to collect the input of the patient (Stacey et al. 2016). Typically, the paper-based form will be recorded in the patient's file. The results are documented through one or more of the below-mentioned courses of action:

- A. COSTaRS result will directly be filed and added to the patient's record in paper form.
- B. COSTaRS result will be added to the patient's electronic record.

- C. The results will be inputted on erasable and reusable plasticized practice guides and then transferred to common forms as a COSTaRS result.
- D. Summarization of the COSTaRS results and inputting in a usual standard form.

In the process of documentation, whether one or more of the mentioned actions is performed, the documentation of the result has to at least contain the severity of the symptom (Ohri.ca n.d.). Either, the recorded symptom is mild, moderated or severe, according to the practice guide's evaluation. Moreover, the medications are reviewed for handling the symptom and also the self-care strategies that the patient accepts to follow is recorded.

## **5.4 – COSTaRS: Practice**

COSTaRS practice guides are initially utilized in two cases (Canadian Oncology Symptom Triage and Remote Support n.d.):

- A. If the patient or/and family expresses a concern regarding the symptom either by making a phone call or in person.
- B. When the severity of a symptom is assessed over or equal to 4 on a scale of 10 in the meeting with the patient.

COSTaRS practice guides are designed for trained oncology nurses. Each practice guide is divided into five sections (Canadian Oncology Symptom Triage and Remote Support n.d.). The sections are as follow:

1. Evaluation of symptom's severity.
2. Triage the patient according to the highest severity for symptom management.
3. Summarizing the medication being used by the patient for the symptom.
4. Summarizing self-care strategies.
5. Summarizing and documentation the decided plan with the patient.

As an example, Figure 8, is an example of Breathlessness/ Dyspnea practice guide:

|                                                                                                                                                                                                                                                                                                                                               |                                                                     |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------|
| <p style="text-align: center;"><b>Breathlessness/Dyspnea Practice Guide</b></p> <p>Breathlessness/Dyspnea: A subjective experience described as breathing discomfort of varying intensities.<sup>1-4</sup> Includes descriptors such as hard to breathe, feeling smothered, tightness in chest, unable to catch breath, panting, gasping.</p> | <p>Name</p> <p>Date of Birth</p> <p>Sex</p><br><p>Date and Time</p> |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------|

Figure 8: © 2016 Stacey for the COSTaRS Team. Ottawa Hospital Research Institute & the University of Ottawa, Canada - COSTaRS: heading section.

Each practice guide starts with a short description of the symptom and also the situations or conditions that will fall into this specific practice guide as well (Figure 8). Moreover, there is an empty input field for name, date of birth, sex, date and time.

**1. Assess severity of the breathlessness (Supporting evidence: 2 guidelines)<sup>2,3</sup>**

Tell me what number from 0 to 10 best describes your shortness of breath?

No shortness of breath    0   1   2   3   4   5   6   7   8   9   10    Worst possible shortness of breath <sup>5(ESAS)</sup>

How worried are you about your shortness of breath?

Not worried                      0   1   2   3   4   5   6   7   8   9   10    Extremely worried

Figure 9: © 2016 Stacey for the COSTaRS Team. Ottawa Hospital Research Institute & the University of Ottawa, Canada – COSTaRS: symptom assessment section.

The first section is the severity assessment of the symptom, which is based on the Edmonton Symptom Assessment System, known as ESAS (Nekolaichuk, Watanabe, and Beaumont, 2008). At this section, the severity of the symptom is evaluated (Figure 9). Commonly this is recorded on the scale of 0 to 10, where 0 represents no symptom, and 10 is the worst possible symptom. This section also contains complementary questions, depending on the symptom, to gain a better understanding of the severity.

| Ask patient to indicate which of the following are present or absent                                                     |                                                                                                               |                          |                                                                                                                                                                                                                                         |                          |                                                                                                           |                          |
|--------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------|--------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------|-----------------------------------------------------------------------------------------------------------|--------------------------|
| Patient rating (see ESAS above) <sup>3,5</sup>                                                                           | 1-3                                                                                                           | <input type="checkbox"/> | 4-6                                                                                                                                                                                                                                     | <input type="checkbox"/> | 7-10                                                                                                      | <input type="checkbox"/> |
| Patient rating of worry about shortness of breath (see above) <sup>2</sup>                                               | 0-5                                                                                                           | <input type="checkbox"/> | 6-10                                                                                                                                                                                                                                    | <input type="checkbox"/> |                                                                                                           |                          |
| With what level of activity do you experience this shortness of breath?                                                  | Moderate activity                                                                                             | <input type="checkbox"/> | Mild activity                                                                                                                                                                                                                           | <input type="checkbox"/> | At rest                                                                                                   | <input type="checkbox"/> |
| Do you pause while talking every 5-15 seconds? <sup>5</sup>                                                              | No                                                                                                            | <input type="checkbox"/> |                                                                                                                                                                                                                                         |                          | Yes                                                                                                       | <input type="checkbox"/> |
| Do you have pain in your chest when you breathe? <sup>3</sup>                                                            | No                                                                                                            | <input type="checkbox"/> |                                                                                                                                                                                                                                         |                          | Yes                                                                                                       | <input type="checkbox"/> |
| Is your breathing noisy, rattily or congested? <sup>3</sup>                                                              | No                                                                                                            | <input type="checkbox"/> |                                                                                                                                                                                                                                         |                          | Yes                                                                                                       | <input type="checkbox"/> |
| Did you wake suddenly with shortness of breath? <sup>3</sup>                                                             | No                                                                                                            | <input type="checkbox"/> |                                                                                                                                                                                                                                         |                          | Yes                                                                                                       | <input type="checkbox"/> |
| Do you have a fever > 38° C? <sup>3</sup> <input type="checkbox"/> Unsure                                                | No                                                                                                            | <input type="checkbox"/> |                                                                                                                                                                                                                                         |                          | Yes, with breathlessness                                                                                  | <input type="checkbox"/> |
| Does your shortness of breath interfere with your daily activities at home and/or at work? Describe.                     | No                                                                                                            | <input type="checkbox"/> | Yes, some                                                                                                                                                                                                                               | <input type="checkbox"/> | Yes, significantly                                                                                        | <input type="checkbox"/> |
|                                                                                                                          |  <b>1 Mild (Green)</b>       |                          |  <b>2 Moderate (Yellow)</b>                                                                                                                            |                          |  <b>3 Severe (Red)</b> |                          |
| <b>2. Triage patient for symptom management based on highest severity (Supporting evidence: 1 guideline)<sup>3</sup></b> | <input type="checkbox"/> Review self-care.<br><input type="checkbox"/> Verify medication use, if appropriate. |                          | <input type="checkbox"/> Review self-care.<br><input type="checkbox"/> Verify medication use, if appropriate.<br><input type="checkbox"/> Advise to call back if symptom worsens, new symptoms occur, or no improvement in 12-24 hours. |                          | <input type="checkbox"/> Refer for medical attention immediately.                                         |                          |

If patient is experiencing other symptoms, did you also refer to the appropriate practice guides? If yes, please specify:

**Additional comments:**

Figure 10: © 2016 Stacey for the COSTaRS Team. Ottawa Hospital Research Institute & the University of Ottawa, Canada – COSTaRS: triage section.

In the severity assessment section, there is a set of questions in the form of a table, which will be answered by the patient (Figure 10). The set of questions differs depending on the symptom (Stacey 2016). There are three input columns in this table were, mild, moderate and severe assigned to the columns according to the weight of that respond on the determining the severity of the symptom, each respond may fall into one of these columns. This format assists the nurse in making a better judgement regarding the severity of the symptom (Stacey et al. 2016). Commonly, capturing one answer from the user in the severe column will make the symptom

categorized as critical. However, generally, this will come down to the nurse's judgment to categorize the symptom's severity (Stacey et al. 2016).

When the severity of the symptom is determined, the second section begins, which is “triage the patient for symptom management based on highest severity.” In this section, the action or set of activities that are required to be done are explained (Stacey et al. 2016). Commonly, if the severity is determined as “mild” the instruction advises proceeding to the self-care strategies. However, depending on the symptom and the severity associated with it, different directions to follow are provided. Some cases may require to refer the patient to medical attention immediately at this point (Stacey et al. 2016).

The practice guide instructs the nurse to use any other COSTaRS practice guide if it was required. And this is followed by a space for adding comments to the symptom management document (Stacey et al. 2016).

Patient Name \_\_\_\_\_

**3. Review medications patient is using for shortness of breath, including prescribed, over the counter, and/or herbal supplements (Supporting evidence: 3 guidelines)<sup>1-3</sup>**

| Current use              | Examples of medications for shortness of breath*                                                                                                  | Notes<br>(e.g. dose, suggest to use as prescribed) | Evidence       |
|--------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------|----------------|
| <input type="checkbox"/> | Oxygen <sup>1,2</sup>                                                                                                                             |                                                    | Expert Opinion |
| <input type="checkbox"/> | Immediate-release oral or parenteral opioids - morphine (Statex <sup>®</sup> ), hydromorphone (Dilaudid <sup>®</sup> ), fentanyl <sup>1,2,3</sup> |                                                    | Effective      |

\* Palliative oxygen is not recommended.<sup>1</sup>

Figure 11: © 2016 Stacey from the COSTaRS Team. Ottawa Hospital Research Institute & the University of Ottawa, Canada – COSTaRS: medication section.

In the third section (Figure 11) of the practice guide, the nurse will ask the patient about the medication taken by the patient for the symptom, or the medication the patient has for the symptom whether the medicine is prescribed, over the counter, or it is herbal (Stacey et al. 2016). This is advised that the patient use prescribed medicine. The table in this section includes “Notes” column, in which information like, dosage and direction of use for medicine is provided. And lastly, the “Evidence” column that holds information about the effectiveness of the medicine(s) (e.g. effective, likely effective, or expert opinion).

**4. Review self-care strategies (Supporting evidence: 3 guidelines)<sup>1,3,4</sup>**

| Patient already uses         | Strategy suggested/ education provided | Patient agreed to try    | Self-care strategies                                                                                                                                                                                                             |
|------------------------------|----------------------------------------|--------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1.                           |                                        |                          | What is your goal for managing when you feel short of breath?                                                                                                                                                                    |
| 2. <input type="checkbox"/>  | <input type="checkbox"/>               | <input type="checkbox"/> | What helps when you are short of breath? Reinforce as appropriate. Specify:                                                                                                                                                      |
| 3. <input type="checkbox"/>  | <input type="checkbox"/>               | <input type="checkbox"/> | Have you tried to use a fan or open window to increase air circulation directed at your face? <sup>1</sup>                                                                                                                       |
| 4. <input type="checkbox"/>  | <input type="checkbox"/>               | <input type="checkbox"/> | Have you tried to turn down the temperature in your house? <sup>1,3</sup>                                                                                                                                                        |
| 5. <input type="checkbox"/>  | <input type="checkbox"/>               | <input type="checkbox"/> | Are you trying to rest in upright positions that can help you breath? <sup>1,3</sup>                                                                                                                                             |
| 6. <input type="checkbox"/>  | <input type="checkbox"/>               | <input type="checkbox"/> | Are you trying different relaxation and breathing exercises (e.g. diaphragmatic breathing, pursed lip breathing)? <sup>1,3,4</sup>                                                                                               |
| 7. <input type="checkbox"/>  | <input type="checkbox"/>               | <input type="checkbox"/> | If you have a wheelchair, portable oxygen or walking aids, are you trying to use them to help with activities that cause your shortness of breath? <sup>1,4</sup>                                                                |
| 8. <input type="checkbox"/>  | <input type="checkbox"/>               | <input type="checkbox"/> | If you have difficulty eating, are you taking nutrition supplements <sup>1</sup>                                                                                                                                                 |
| 9. <input type="checkbox"/>  | <input type="checkbox"/>               | <input type="checkbox"/> | Would more information about your symptoms help you to manage them better? If yes, provide appropriate information or suggest resources. <sup>1,3</sup>                                                                          |
| 10. <input type="checkbox"/> | <input type="checkbox"/>               | <input type="checkbox"/> | Have you tried a program such as cognitive behavioural therapy (relaxation therapy, guided imagery) to help manage your shortness of breath? <sup>1,3</sup> (Can decrease anticipatory worry associated with exertional dyspnea) |

Figure 12: © 2016 Stacey for the COSTaRS Team. Ottawa Hospital Research Institute & the University of Ottawa, Canada – COSTaRS: self-care section.

The fourth section is "Review self-care strategies" (Figure 12). The purpose of the section is to engage and advise the patient/family on the intervention that they would accept to try concerning the symptom handling (Stacey et al. 2016). In this section, the nurse records the strategies that are already being used by the patient and also suggests to apply self-care strategies. The nurse

also records the recommended, informed policy and finally the strategies that patients accept to try.

**5. Summarize and document plan agreed upon with caller (check all that apply)**

|                          |                                                                                                                                                      |
|--------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------|
| <input type="checkbox"/> | No change, continue with self-care strategies and if appropriate, medication use                                                                     |
| <input type="checkbox"/> | Patient agrees to try self-care items #: _____<br>How confident are you that you can try what you agreed to do (0=not confident, 10=very confident)? |
| <input type="checkbox"/> | Patient agrees to use medication to be consistent with prescribed regimen<br>Specify: _____                                                          |
| <input type="checkbox"/> | Referral (service & date): _____                                                                                                                     |
| <input type="checkbox"/> | Patient agrees to seek medical attention; specify time frame: _____                                                                                  |
| <input type="checkbox"/> | Advise to call back in 12-24 hours if no improvement, symptom worsens, or new symptoms occur                                                         |

|             |                  |             |
|-------------|------------------|-------------|
| <b>Name</b> | <b>Signature</b> | <b>Date</b> |
|-------------|------------------|-------------|

Figure 13: © 2016 Stacey for the COSTaRS Team. Ottawa Hospital Research Institute & the University of Ottawa, Canada – COSTaRS: documentation section.

The final part of the practice guide is "Summarize and document plan agreed upon with caller." In this section (Figure 13), the plan which was agreed on with the patient/family is documented (Stacey et al. 2016). Moreover, it is recorded if the patient is referred to, and the agreed self-care item to try. Moreover, the confidence level of the nurse if the patient tries the self-care item and if this is required to call back the patient/family in next 12-24 hours.

Figure 14 and 15 are showing an example of a completed COSTaRS symptom guide for Tracy White (a fictitious patient) (Ballantyne and Stacey, 2016).

**Nausea & Vomiting Protocol**  
**Remote Assessment, Triage, and Management of**  
**Nausea & Vomiting in Adults Undergoing Cancer Treatment**  
(not for patients undergoing bone marrow transplant)

Nausea: A subjective perception that emesis may occur. Feeling of queasiness.  
 Vomiting: A forceful expulsion of stomach contents through the mouth and may include retching (gastric and esophageal movement without vomiting – dry heaves.)<sup>6,10</sup>

Name *Tracy White*  
 Date of Birth *May 1, 1964*  
 Sex *F*  
 Hospital card number  
 Date and Time *Nov 17/14 2pm*

**1. Assess severity of nausea/vomiting** (Supporting evidence: 4 guidelines)<sup>1,6,7,10</sup>

Tell me what number from 0 to 10 best describes your nausea

No nausea 0 1 2 3 4 5 6 7 8 9 10 Worst possible nausea<sup>8(ESAS)</sup>

Tell me what number from 0 to 10 best describes your vomiting?

No vomiting 0 1 2 3 4 5 6 7 8 9 10 Worst possible vomiting<sup>8(ESAS)</sup>

How worried are you about your nausea/vomiting?

Not worried 0 1 2 3 4 5 6 7 8 9 10 Extremely worried

**Ask patient to indicate which of the following are present or absent**

|                                                                                                                                                                    |                                      |                                     |              |                                               |                    |                          |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------|-------------------------------------|--------------|-----------------------------------------------|--------------------|--------------------------|
| Patient rating for nausea (see ESAS above) <sup>1,4,8</sup>                                                                                                        | 0-3                                  | <input type="checkbox"/>            | 4-10         | <input type="checkbox"/>                      |                    |                          |
| Patient rating for vomiting (see ESAS above) <sup>1,4,8</sup>                                                                                                      | 0-3                                  | <input type="checkbox"/>            | 4-6          | <input type="checkbox"/>                      | 7-10               | <input type="checkbox"/> |
| Patient rating of worry about nausea/vomiting (see above) <sup>6</sup>                                                                                             | 0-5                                  | <input type="checkbox"/>            | 6-10         | <input type="checkbox"/>                      |                    |                          |
| How many times per day are you vomiting or retching? <sup>1,6,7,10</sup>                                                                                           | <input type="checkbox"/> No vomiting |                                     |              |                                               |                    |                          |
|                                                                                                                                                                    | ≤1                                   | <input type="checkbox"/>            | 2-5          | <input checked="" type="checkbox"/> yesterday | ≥6                 | <input type="checkbox"/> |
| Have you been able to eat within last 24 hours? <sup>6,7,10</sup>                                                                                                  | Yes                                  | <input checked="" type="checkbox"/> | No           | <input type="checkbox"/>                      |                    |                          |
| Have you been able to tolerate drinking fluids? <sup>6,7,10</sup>                                                                                                  | Yes                                  | <input checked="" type="checkbox"/> |              |                                               | No                 | <input type="checkbox"/> |
| Are you feeling dehydrated, which can include feeling dizzy, a dry mouth, increased thirst, fainting, rapid heart rate, decreased amount of urine? <sup>6,10</sup> | No                                   | <input type="checkbox"/>            | Yes, some    | <input checked="" type="checkbox"/>           | Yes, significantly | <input type="checkbox"/> |
| Do you have any blood in your vomit or does it look like coffee grounds? <sup>6</sup>                                                                              | No                                   | <input type="checkbox"/>            |              |                                               | Yes                | <input type="checkbox"/> |
|                                                                                                                                                                    | <input type="checkbox"/> No vomiting |                                     |              |                                               |                    |                          |
| Do you have any abdominal pain or headache? <sup>6</sup>                                                                                                           | No/Mild 0-3                          | <input type="checkbox"/>            | Moderate 4-6 | <input checked="" type="checkbox"/>           | Severe 7-10        | <input type="checkbox"/> |
| Does your nausea/vomiting interfere with your daily activities at home and/or at work? <sup>6</sup> Describe.                                                      | No                                   | <input type="checkbox"/>            | Yes, some    | <input checked="" type="checkbox"/>           | Yes, significantly | <input type="checkbox"/> |

**2. Triage patient for symptom management based on highest severity** (Supporting evidence: 2 guidelines)<sup>6,7</sup>

|                                                                                                               |                                                                                                                                                                                                                                         |                                                                   |
|---------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------|
| <b>1 Mild</b>                                                                                                 | <b>2 Moderate</b>                                                                                                                                                                                                                       | <b>3 Severe</b>                                                   |
| <input type="checkbox"/> Review self-care.<br><input type="checkbox"/> Verify medication use, if appropriate. | <input type="checkbox"/> Review self-care.<br><input type="checkbox"/> Verify medication use, if appropriate.<br><input type="checkbox"/> Advise to call back if symptom worsens, new symptoms occur, or no improvement in 12-24 hours. | <input type="checkbox"/> Refer for medical attention immediately. |

If patient is experiencing other symptoms, did you also refer to the appropriate protocols? If yes, please specify:

Additional Comments: *Constipated. See attached*

Figure 14: © 2011 Stacey for the COSTaRS Project – filled COSTaRS sample: sections 1 and 2.

Patient Name \_\_\_\_\_

**3. Review medications patient is using for nausea/vomiting, including prescribed, over the counter, and/or herbal supplements** (Supporting evidence: 7 guidelines)<sup>1-5,9,10</sup>

| Current use                         | Examples of Medications for nausea/vomiting                                                                                   | Notes (e.g. dose, suggest to use as prescribed) | Type of Evidence                     |
|-------------------------------------|-------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------|--------------------------------------|
| <input checked="" type="checkbox"/> | ondansetron (Zofran®), granisetron (Kytril®), dolasetron (Anszemet®) <sup>1-5,9,10</sup>                                      | with oralip.                                    | Systematic review                    |
| <input type="checkbox"/>            | dexamethasone (Decadron®) <sup>1,2,3,5,9,10</sup>                                                                             | "                                               | (Large RCT and/or systematic review) |
| <input type="checkbox"/>            | fosaprepitant, aprepitant (Emend®) <sup>1-5</sup>                                                                             | 96pcn                                           | Systematic review                    |
| <input type="checkbox"/>            | metoclopramide (Maxeran®) <sup>1-5,9,10</sup>                                                                                 | 96pcn                                           | Systematic review                    |
| <input type="checkbox"/>            | prochlorperazine (Stemetil®) <sup>1,2,3,9,10</sup>                                                                            | 96pcn                                           | Systematic review                    |
| <input type="checkbox"/>            | Other: lorazepam (Ativan®) <sup>1-3,5,9,10</sup> , nabilone, dronabinol <sup>2,3</sup> , haloperidol (Haldol®) <sup>2,3</sup> |                                                 | (Large RCT and/or systematic review) |

**4. Review self-care strategies** (Supporting evidence: 6 guidelines)<sup>2-5,6,10</sup>

| What strategies are already being used? | Strategy suggested/ education provided | Patient agreed to try               | Self-care strategies                                                                                                                                                                                                                                                                                                                     |
|-----------------------------------------|----------------------------------------|-------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1. <input checked="" type="checkbox"/>  | <input type="checkbox"/>               | <input type="checkbox"/>            | What helps when you have nausea/vomiting? Reinforce as appropriate. Specify: <i>using Stemetil infrequently - not using Maxeran</i>                                                                                                                                                                                                      |
| 2. <input checked="" type="checkbox"/>  | <input type="checkbox"/>               | <input type="checkbox"/>            | Are you trying to drink clear fluids (e.g. water, sports drinks, broth, gingerale, chamomile tea)? <sup>6,10</sup>                                                                                                                                                                                                                       |
| 3. <input type="checkbox"/>             | <input type="checkbox"/>               | <input type="checkbox"/>            | Have you tried relaxation techniques that may include guided imagery, music therapy, progressive muscle relaxation? <sup>2,3,5,6,10</sup>                                                                                                                                                                                                |
| 4. <input type="checkbox"/>             | <input type="checkbox"/>               | <input type="checkbox"/>            | Are you taking anti-emetic medications before meals so they are effective during/after meals? <sup>5,6</sup>                                                                                                                                                                                                                             |
| 5. <input type="checkbox"/>             | <input type="checkbox"/>               | <input type="checkbox"/>            | If vomiting, are you limiting food and drink until vomiting stops? After 30-60 minutes without vomiting, sip clear fluids. When clear fluids stay down, add dry starchy foods (e.g. crackers, dry toast, dry cereal, pretzels). If starchy food stay down, add protein rich foods (e.g. eggs, chicken). <sup>6</sup>                     |
| 6. <input type="checkbox"/>             | <input type="checkbox"/>               | <input checked="" type="checkbox"/> | Are you trying to:<br>- eat 5-6 small meals or snacks? <sup>2,5,6</sup><br>- eat foods that minimize your nausea and are your "comfort foods"? <sup>2,5</sup><br>- avoid greasy/fried, highly salty, and spicy foods? <sup>2,5,6</sup><br>- eat foods that are cold, avoiding extreme temperatures and strong odors? <sup>2,5,6,10</sup> |
| 7. <input type="checkbox"/>             | <input type="checkbox"/>               | <input type="checkbox"/>            | Are you sitting upright or reclining with head raised for 30-60 minutes after meals? <sup>6</sup>                                                                                                                                                                                                                                        |
| 8. <input type="checkbox"/>             | <input type="checkbox"/>               | <input checked="" type="checkbox"/> | Are you wearing loose clothing? <sup>6</sup>                                                                                                                                                                                                                                                                                             |
| 9. <input checked="" type="checkbox"/>  | <input type="checkbox"/>               | <input type="checkbox"/>            | Are you rinsing your mouth before eating and keeping your mouth clean (brushing, rinsing)? <sup>6</sup>                                                                                                                                                                                                                                  |
| 10. <input type="checkbox"/>            | <input type="checkbox"/>               | <input type="checkbox"/>            | Have you tried acupuncture or acupressure to help with your nausea/vomiting? <sup>4,5,6</sup>                                                                                                                                                                                                                                            |
| 11. <input type="checkbox"/>            | <input type="checkbox"/>               | <input type="checkbox"/>            | Have you spoken with a dietitian? <sup>10</sup>                                                                                                                                                                                                                                                                                          |
| 12. <input type="checkbox"/>            | <input type="checkbox"/>               | <input checked="" type="checkbox"/> | Would more information about your symptoms help you to manage them better? <sup>4</sup> If yes, provide appropriate information or suggest resources.                                                                                                                                                                                    |

**5. Summarize and document plan agreed upon with caller (check all that apply)**

- ☐ No change, continue with self-care strategies and if appropriate, medication use
- ☐ Patient agrees to try self-care items #:
- ☐ How confident are you that you can try what you agreed to do (0=not confident, 10=very confident)?
- ☐ Patient agrees to use medication to be consistent with prescribed regimen. Specify:
- ☐ Referral (service & date):
- ☐ Patient agrees to seek medical attention; specify time frame:
- ☒ Advise to call back in 12-24 hours if no improvement, symptom worsens, or new symptoms occur

Name \_\_\_\_\_ Signature \_\_\_\_\_ Date *Nov 7/14*

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Version 3.2 (Mar/13)

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Figure 15: © 2011 Stacey for the COSTaRS Project– filled COSTaRS sample: sections 3, 4 and 5.

## 5.5 - Assessment: Barriers and Facilitators

COSTaRS has been used throughout different health care settings, and although it has brought noticeable improvements compared to previous methods of symptom management (Stacey et al. 2013), from following clinical guidelines to documentation (Ludwig et al. 2017), it also introduces many barriers. Three studies were conducted from 2015 to 2017 to assess COSTaRS in particular. During this period COSTaRS did not go through a thorough change, and the concept of telehealth remote symptom management set of practice guides stayed quite the same and implemented through the same course of actions (Stacey 2016). Therefore, we are looking into this study to gain a deeper understanding of the advantages and disadvantages of COSTaRS, to be able to effectively determine the specifications and requirements for COSTaRS mobile application (McMillan and Schumacher 2010). We are starting from the first study in 2015 to the latest in 2017. The barriers and facilitators are being indexed by ID for future reference.

A study was carried out with three ambulatory oncology programs in 2013 (Stacey et al. 2015). Table 5 represents barriers. The barriers and facilitators were explored in four levels to associate the factors with levels of utilization of the practice guides. The levels are protocol level, nurse level, client level and organization level.

Table 5: First study - barriers to practice guides (Stacey et al. 2015)

| Barriers |                             |                      |             |               |                    |
|----------|-----------------------------|----------------------|-------------|---------------|--------------------|
| ID       | Theme                       | Practice Guide level | Nurse level | Patient-level | Organization level |
| B101     | Too long/overwhelming       | ●                    |             |               |                    |
| B102     | Not enough space            | ●                    |             |               |                    |
| B103     | Not for symptom clusters    | ●                    |             |               |                    |
| B104     | Not self-evident how to use | ●                    |             |               |                    |
| B105     | Not enough information      | ●                    |             |               |                    |

|      |                                                       |   |   |   |   |
|------|-------------------------------------------------------|---|---|---|---|
| B106 | Order of components                                   | ● |   |   |   |
| B107 | Use of footnotes                                      | ● |   |   |   |
| B108 | Tick boxes may not be sufficient                      | ● |   |   |   |
| B109 | ESAS scale subjective                                 | ● |   |   |   |
| B110 | The learning curve to use protocols (Practice Guides) |   | ● |   |   |
| B111 | Lack of flexibility                                   |   | ● |   |   |
| B112 | Lack of awareness of the protocols                    |   | ● |   |   |
| B113 | Added work                                            |   | ● |   |   |
| B114 | Too many questions will be irritating to patients     |   | ● |   |   |
| B115 | Communication challenges                              |   |   | ● |   |
| B116 | Individuality/patient preferences                     |   |   | ● |   |
| B117 | Lack of comprehension                                 |   |   | ● |   |
| B118 | Lack of time, the high workload on nursing staff      |   |   |   | ● |
| B119 | Lack of integration into the electronic health record |   |   |   | ● |
| B120 | Lack of clear mandate                                 |   |   |   | ● |
| B121 | Competing system changes                              |   |   |   | ● |
| B122 | Workplace distractions                                |   |   |   | ● |
| B123 | Lack of easy access to protocols                      |   |   |   | ● |
| B124 | Lack of consistency with organizational practices     |   |   |   | ● |
| B125 | Lack of education/training, resources                 |   |   |   | ● |
| B126 | Service inefficiencies                                |   |   |   | ● |

Table 6, shows the facilitators in the first study.

Table 6: First study - facilitators of practice guides (Stacey et al. 2015)

| Facilitators |                                          |                      |             |               |                    |
|--------------|------------------------------------------|----------------------|-------------|---------------|--------------------|
| ID           | Theme                                    | Practice Guide level | Nurse level | Patient-level | Organization level |
| F101         | Well organized                           | ●                    |             |               |                    |
| F102         | The systematic approach across protocols | ●                    |             |               |                    |

|      |                                                    |   |   |   |   |
|------|----------------------------------------------------|---|---|---|---|
| F103 | Comprehensive                                      | ● |   |   |   |
| F104 | Facilitates documentation                          | ● |   |   |   |
| F105 | Evidence-based                                     | ● |   |   |   |
| F106 | Disclosure                                         | ● |   |   |   |
| F107 | Development                                        | ● |   |   |   |
| F108 | Relevant to current practice                       | ● |   |   |   |
| F109 | User-friendly                                      | ● |   |   |   |
| F110 | Plain language                                     | ● |   |   |   |
| F111 | Potential efficiencies                             | ● |   |   |   |
| F112 | Orientation tool                                   | ● |   |   |   |
| F113 | Within the scope of nursing practice               | ● |   |   |   |
| F114 | Reassuring                                         | ● |   |   |   |
| F115 | Current practice is more standardized              |   | ● |   |   |
| F116 | Tailored for each patient                          |   | ● |   |   |
| F117 | Use protocols as a resource                        |   | ● |   |   |
| F118 | Acceptable                                         |   | ● |   |   |
| F119 | Need to try it in practice                         |   | ● |   |   |
| F120 | Quality assurance/performance appraisals           |   | ● |   |   |
| F121 | Use for building capacity with new nurses          |   | ● |   |   |
| F122 | Confidence using protocols                         |   | ● |   |   |
| F123 | Need to have a similar resource for patients       |   |   | ● |   |
| F124 | Perceived improved patient outcome                 |   |   | ● |   |
| F125 | Provide education/training                         |   |   |   | ● |
| F126 | Include key stakeholders                           |   |   |   | ● |
| F127 | Provide easy access to protocols                   |   |   |   | ● |
| F128 | Clear mandate/expectations                         |   |   |   | ● |
| F129 | Dedicated space and time to provide remote support |   |   |   | ● |
| F130 | Increase awareness of protocols                    |   |   |   | ● |
| F131 | More efficient use of nursing resources            |   |   |   | ● |

In 2015, a study was conducted to assess the usability factors of COSTaRS symptom management guides by studying nurses providing remote caring for cancer patients (Nichol et al. 2016). Table 7, represents the barriers in this study. Similar to the previous assessment study, we have the same four levels of assessment.

Table 7: Second study - barriers to practice guides (Nichol et al. 2016)

| Barriers |                                             |                      |             |               |                    |
|----------|---------------------------------------------|----------------------|-------------|---------------|--------------------|
| ID       | Theme                                       | Practice Guide level | Nurse level | Patient-level | Organization level |
| B201     | Too long                                    | ●                    |             |               |                    |
| B202     | Large paper volume                          | ●                    |             |               |                    |
| B203     | Inadequate for multiple concurrent symptoms | ●                    |             |               |                    |
| B204     | Reliance on previous experience             |                      | ●           |               |                    |
| B205     | Learning curve                              |                      | ●           |               |                    |
| B206     | Too unwell                                  |                      |             | ●             |                    |
| B207     | Annoyed by repetitive questions             |                      |             | ●             |                    |
| B208     | Lack of time                                |                      |             |               | ●                  |
| B209     | Perceived extra costs                       |                      |             |               | ●                  |
| B210     | Paper-based documentation system            |                      |             |               | ●                  |

Table 8, shows the facilitators in the second study.

Table 8: Second study - facilitators of practice guides (Nichol et al. 2016)

| Facilitators |                             |                      |             |               |                    |
|--------------|-----------------------------|----------------------|-------------|---------------|--------------------|
| ID           | Theme                       | Practice Guide level | Nurse level | Patient-level | Organization level |
| F201         | Highly usable               | ●                    |             |               |                    |
| F202         | Fill a void                 | ●                    |             |               |                    |
| F203         | Promote continuity of care  | ●                    |             |               |                    |
| F204         | Educate and empower clients | ●                    |             |               |                    |
| F205         | Current nursing role        |                      | ●           |               |                    |

|      |                                          |  |   |  |   |
|------|------------------------------------------|--|---|--|---|
| F206 | Interested in using evidence-based tools |  | ● |  |   |
| F207 | Current remote symptom support role      |  |   |  | ● |
| F208 | Audit and feedback process               |  |   |  | ● |
| F209 | Education and training                   |  |   |  | ● |
| F210 | Mandate to be evidence-based             |  |   |  | ● |
| F211 | Other uses for protocols                 |  |   |  | ● |

A mixed-methods study was carried out to evaluate the factors that affect RNs and RPNs in telephone remote support or in-home visits in 2017 (Ludwig et al. 2017). In this study, six home care, nursing agencies participated. Moreover, the study used interviews, chart audits and a survey. The study results, were composed of nurse-level factors, practice guide-level, patient-level factors and organizational-level factors (Ludwig et al. 2017). Table 9, shows the factors affecting the use of practice guides.

Table 9: Third study - factors affecting utilization of practice guides (Ludwig et al. 2017)

| ID   | Themes                                                | Percentage of qualitative data | Factor Level   | Barrier/Facilitator |
|------|-------------------------------------------------------|--------------------------------|----------------|---------------------|
| B301 | Long and overwhelming                                 | 18%                            | Practice Guide | Barrier             |
| B302 | Inadequate for symptom clusters                       | 0.6%                           | Practice Guide | Barrier             |
| B303 | Tick boxes may be insufficient                        | 0.6%                           | Practice Guide | Barrier             |
| B304 | Inadequate on medications and natural health products | -                              | Practice Guide | Barrier             |
| B305 | ESAS is subjective                                    | 0.6%                           | Practice Guide | Barrier             |
| B306 | Not enough space                                      | -                              | Practice Guide | Barrier             |
| B307 | Not self-evident to use                               | -                              | Practice Guide | Barrier             |
| B308 | Not formatted to monitor change                       | -                              | Practice Guide | Barrier             |
| B309 | User-friendly or not?                                 | 2%                             | Practice Guide | Barrier/Facilitator |
| F301 | Comprehensive and evidence-based                      | -                              | Practice Guide | Facilitator         |
| F302 | Eases documentation                                   | -                              | Practice Guide | Facilitator         |

|      |                                                   |       |                |             |
|------|---------------------------------------------------|-------|----------------|-------------|
| F303 | Relevant to nursing practice                      | -     | Practice Guide | Facilitator |
| F304 | Potential efficiencies                            | -     | Practice Guide | Facilitator |
| F305 | The systematic approach across practice guides    | -     | Practice Guide | Facilitator |
| F306 | Bilingual                                         | -     | Practice Guide | Facilitator |
| B310 | Lack of time/high workload                        | 16%   | Nurse          | Barrier     |
| B311 | Learning curve                                    | 5.3%  | Nurse          | Barrier     |
| B312 | Resistance to change                              | 2.6%  | Nurse          | Barrier     |
| B313 | Lack of awareness                                 | 14%   | Nurse          | Barrier     |
| B314 | Unclear on the trigger for use                    | -     | Nurse          | Barrier     |
| F311 | Use practice guides as a resource                 | -     | Nurse          | Facilitator |
| F312 | More standardized                                 | -     | Nurse          | Facilitator |
| F314 | Build nurses' capacity                            | -     | Nurse          | Facilitator |
| F315 | Enhanced nursing practice                         | -     | Nurse          | Facilitator |
| F316 | Quality assurance                                 | -     | Nurse          | Facilitator |
| F317 | Fits with RPN scope of practice                   | -     | Nurse          | Facilitator |
| F318 | Tailor use of practice guides to each patient     | -     | Nurse          | Facilitator |
| B315 | Too many questions will be irritating to patients | 13%   | Patient        | Barrier     |
| B316 | Communication challenges                          | 2.6%  | Patient        | Barrier     |
| B317 | Patient preference                                | 2.6%  | Patient        | Barrier     |
| B318 | Lack of comprehension                             | 1.3%  | Patient        | Barrier     |
| F319 | Consistent symptom management across settings     | -     | Patient        | Facilitator |
| F320 | Need a similar resource for patients              | -     | Patient        | Facilitator |
| B319 | Competing system changes                          | -     | Organizational | Barrier     |
| B320 | Difficulty transporting paper copies              | 2%    | Organizational | Barrier     |
| B322 | Burden of training                                |       | Organizational | Barrier     |
| F321 | Provide easy access to practice guides            | 16%   | Organizational | Facilitator |
| F322 | Training with refresher sessions                  | 15.3% | Organizational | Facilitator |
| F323 | Fit with documentation                            | 8%    | Organizational | Facilitator |
| F324 | A stepwise approach to implementation             | -     | Organizational | Facilitator |

|      |                                |      |                |             |
|------|--------------------------------|------|----------------|-------------|
| B325 | Other key stakeholders unaware | -    | Organizational | Facilitator |
| B326 | Clear mandate/expectations     | 2.6% | Organizational | Facilitator |

## 5.6 - Discussion of Assessments

Here we are investigating the results of the assessment studies to gain an in-depth understanding of the research problem. The same approach in terms of methodology has been applied in mentioned assessment studies. In these studies, the barriers and facilitators are categorized into four primary levels: practice guide, nurse, patient and organization.

The outcomes of the studies represent that in the practice guide level, the most significant barrier is being too long and overwhelming. The second is inefficiency when it comes to addressing multiple symptoms at the same time, which substantially, is associated with the first barrier due to being too long even as one symptom report. The next barriers are understood to be considerable paper volumes accumulation, lack of space for making more input, insufficiency of tick boxes and inefficiency in observing the changes.

At the nurse-level, the learning curve is known to be the most substantial barrier. Second, is the high workload due to using the practice guides and third is the inflexibility of the practice guides.

At the patient-level, the primary barrier has too many questions, which is unpleasant for the patient. The next obstacle is a lack of patient's engagement and also the communication challenges in the case of non-native speakers.

Finally, at the organization-level, the prominent barrier is the high workload imposed in implementations and training. Secondly, it is the paper-based aspect which is costly in terms of

storing and transporting, not interoperable with electronic records, and lacking proper flexibility with changes in the system.

## **5.7 - Method**

In this study, a design process lifecycle template approach (Hartson and Pyla 2012) is being implemented for developing COSTaRS mobile application. This approach consists of four elemental activities; analyze, design, implement and evaluate. The template will be followed for architectural and also the mobile app design in this study.

The cycle starts from the design, which is based on the contextual inquiry and analysis of the objective of this study (Hartson and Pyla 2012). The analysis of the case study results in a deeper understanding of the problem. Next, the requirements are extracted and prioritized, which will be inputted to the design phase.

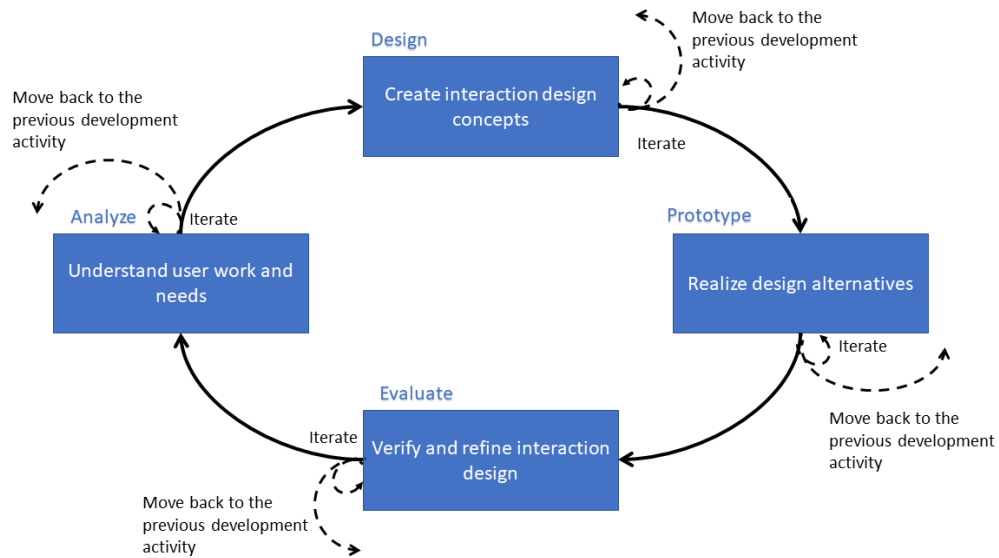


Figure 16: lifecycle template depicting the process (Hartson and Pyle 2012).

## 5.8 - Meetings with COSTaRS Steering Committee and Collaborators

Since the idea of COSTaRS mobile app was introduced, there have been many meetings with the COSTaRS steering committee, and also the with stakeholders. Moreover, a workshop on COSTaRS in October 2017 resulted in the identification of requirements for a COSTaRS mobile application. Table 10, shows the extracted requirement from meeting with collaborators.

Table 10: Requirements extracted from meetings with collaborators

| ID | Statements                                                                                   |
|----|----------------------------------------------------------------------------------------------|
| R1 | The idea of COSTaRS has to be followed and transferred to the mobile version (Donlin, 2004). |

|     |                                                                                                                                                                                                          |
|-----|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| R2  | The content of the COSTaRS has to be leveraged, reconciled and adapted by the app.                                                                                                                       |
| R3  | Promoting the availability of COSTaRS. The app has to be runnable on different smartphone platforms.                                                                                                     |
| R4  | A flexible platform for introducing new changes.                                                                                                                                                         |
| R5  | Cancer center administrator has access to the data on the back-end and also gives access to the desired user.                                                                                            |
| R6  | The user can only access the app using username/password authentication.                                                                                                                                 |
| R7  | The app cannot be accessed without authorization for the first time running the app. The user has to be able to log out.                                                                                 |
| R8  | The app supports fatigue and sleeps problem symptoms only.                                                                                                                                               |
| R9  | The app decides if the set of responses are presenting a mild, moderate or severe state.                                                                                                                 |
| R10 | The app sends notifications regularly, to remind the user to report symptoms. Moreover, upon submitting a moderate or severe symptom, the app reminds the user to report the symptom relatively earlier. |
| R11 | The app has to be able to create a document format of the report where user can email the report to physicians and/or collaborators.                                                                     |
| R12 | Reports have to be saved both locally on the device and the server and retrievable later.                                                                                                                |
| R13 | The app should be functional without being connected to the internet.                                                                                                                                    |
| R14 | The server does not store any identifying information from the patients.                                                                                                                                 |

## 5.9 - Extracting Requirements from Assessment Studies

In this section, we define the requirements extracted and resulted from the assessment studies to fill the gap between design requirements and contextual analysis (Hartson and Pyla, 2012).

Considering the scope and objective of this study, we will not generate a requirement statement for all the mentioned barriers and facilitators from the three assessment studies (Patino and

Ferreira, 2018). In other words, in our study, the user is changed to the patient or/and caregiver and the paper-based symptom management system is replaced by an electronic version.

Therefore, the user issues focused on the patient or/and caregiver instead of the nurse in the mobile version of COSTaRS. In addition, the barriers concerning the nurses and organizations to some extent, are no longer considered in our study (B104, B106, B109, B110, B111, B112, B113, B116, B117, B118, B120, B121, B122, B123, B124, B125, B126, B203, B204, B205, B206, B208, B209, B210, B304, B305, B307, B309, B311, B312, B313, B314, B315, B317, B381, B319, B320 are excluded in Tables 5, 7 and 9 ). This study has targeted the fatigue and sleep problem symptoms (R8 in Table 10). However, symptom clustering is associated with the occurrence of multiple symptoms in patients (Walsh and Rybicki, 2006) (B103, B115, B303 are excluded in Table 5 and 9).

In this study, we have decided to implement fatigue and sleep problem symptom management in our application (Tran et al. 2018). Fatigue is chosen due to being the most experienced symptom. Moreover, fatigue and sleep problems commonly do not require immediate attention or medication treatment (Tran et al. 2018).

The advantages and disadvantages of COSTaRS practice guides are taken into consideration in requirement analysis since, in our study, the transition of paper-based to computer-based reports provides an approximate equivalent product (Noyes and Garland, 2008). Therefore, we extract sets of barriers/facilitator, or single barriers/facilitator and we assign it to a requirement (Table 11).

Table 11: Extracted requirements from barriers and facilitators.

| ID | Requirements | Associated Barrier(s)/<br>Facilitator(s) |
|----|--------------|------------------------------------------|
|----|--------------|------------------------------------------|

|     |                                                                                          |                                                 |
|-----|------------------------------------------------------------------------------------------|-------------------------------------------------|
| R15 | The workload of the process has to be reduced for the user.                              | B101, B113, B201, B203, B207, B301, B310, B315, |
| R16 | User should be able to add more input in addition to the pre-defined answer in the form. | B102, B107, B108, B303, B306                    |
| R17 | The app has to provide compatible data with an electronic health record.                 | B119, B202                                      |
| R18 | The user should be able to view their results later.                                     | B308                                            |
| R19 | The app should support multiple languages for the user.                                  | B316                                            |

### 5.10 - Mobile COSTaRS: Requirements - Priorities

Prioritization is one of the critical stages of software product planning where different aspects of the requirements are considered, and stakeholders will decide by considering the objectives, and the constraints of the product (Berander and Andrews, 2005). In this study, we are using the numeric assignment as our prioritization technique, which is based on an ordinal scale (Berander and Andrews, 2005). This technique is chosen for two reasons. First, in our multiple meetings and discussions with stakeholders, we identified and modified the requirements (Davis, 2003). Second, in this study, we have investigated the perspectives in different levels (e.g. nurse, patient and organization), which makes the numerical assignment a suitable decision. As it was discussed with the COSTaRS committee, the requirements are prioritized to map out the design process and more efficiently target the desired requirements. The prioritized requirements have been decided according to the value that they bring, time to develop and also the feasibility.

Priorities are divided into high, medium and low priority (Wieggers, 1999) according to the meetings and discussions and also the objective of the study.

Table 12: Prioritization of requirement statements

| <b>Priority</b> | <b>Requirement statement</b>                                          |
|-----------------|-----------------------------------------------------------------------|
| High            | R1, R2, R3, R4, R5, R6, R7, R8, R9, R10, R11, R12, R13, R14, R15, R18 |
| Medium          | R16, R17                                                              |
| Low             | R19                                                                   |

we prioritize the requirements for mobile COSTaRS in order to map out our process to design (Table 12).

## **5.11 - Chapter Summary**

In this chapter, we introduced and discussed our case study in terms of development, training and the evaluation. We went through the assessment studies of COSTaRS in order to investigate the research problem. We discussed the results of these assessments and generated requirements according to it. The determined requirements were prioritized, considering accumulated inputs of collaborators.

## **CHAPTER 6: RESULTS**

In this chapter, we will introduce our design for the mobile version of COSTaRS. Moreover, we will implement the design as a prototype mobile application. We will go through each step and level of the design where we point out our approach to satisfy the requirements and to reach an optimal design considering the purpose of this study.

### **6.1 - Mobile COSTaRS: Description and Transformation**

To develop the COSTaRS mobile application, we are transforming the current paper-based symptom management guides to an electronic version. Two levels of transformation are taking place. First, we are transforming the paper-based symptom management to an electronic version, namely a mobile application. Second, we are modifying the current remote telehealth symptom management to a self-report symptom management version, where the patient interacts with the mobile app to perform symptom management. The intended user of the mobile application can be either the patients themselves or/and the care caregiver of the patient who can be a family member or a spouse. The purpose of the mobile application is to take advantage of current COSTaRS knowledge and create a highly responsive and user-centred mobile application, which can be accessed on multiple platforms. We will use the same textual content as the paper-based COSTaRS since plain language with Flesch–Kincaid grade of level 6.4 (Flesch 1948) is used which eases the readability for our user.

## 6.4 - High-level Design: Elements

In this section, by utilizing the requirement analysis approach according to the UX lifecycle template, we designed the high-level architecture of the system. This provides us with the idea of the overall structure of the application (Medvidovic and Taylor, 2010). Figure 17, shows the high-level design and how collaborations will interact with the mobile application. This design is the result of the iterative design process by following the design cycle (Hartson and Pyla, 2012). Here we define actors who play one or multiple roles in our design. The actors in the architecture are as follow:

- Cancer center admin
- Patient or caregiver
- Physicians/ Collaborator team members

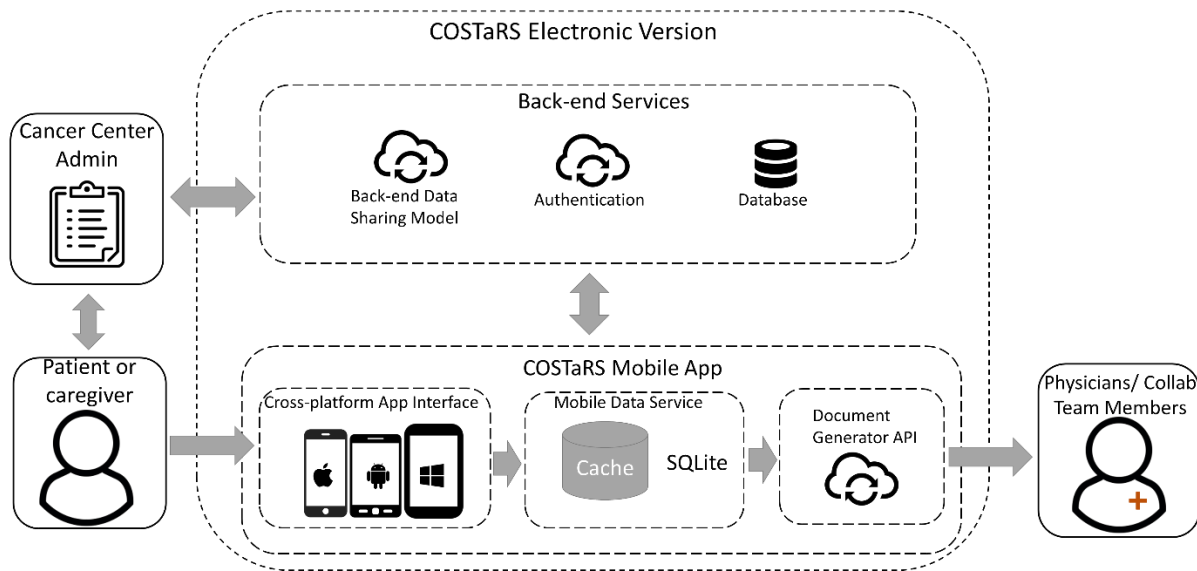


Figure 17: High-level design of COSTaRS mobile application.

The cancer center admin who is in contact with the patient and/or caregiver will provide the authentication information for the user to sign in using their smartphone. Offline data entry was a requirement, and thus, when a patient enters a symptom, the report will be saved both locally on the device and also on the server. Therefore, there is also a local database on the device storing the reports. The application communicates with the server in order to authenticate the user in the first place. Besides authentication, the server offers the data sharing model, which allows the user to retrieve the stored data on their device. Moreover, the server utilizes a document generator API in order to create a document format to be sent to the desired recipient by the user. For privacy purposes, the server collects the data anonymously, which means the information on the server that is assigned to a user is nameless and indexed.

Hybrid mobile development is among the most effective mobile development strategies (Malavolta et al. 2015). Considering the desire functions and requirements in our application, hybrid development is a cost-effective development with high-speed performance results that supports multiple platforms (Malavolta, 2016). As our development framework we have chosen Ionic which is a high-performing hybrid mobile development tool (ionic n.d.).

#### **6.4.1 - Elements of Mobile COSTaRS**

The mobile COSTaRS app follows a 3-layer architecture; presentation layer, logic layer and the data layer (Marston, 2012) (Figure 18). This design is the result of the iterative design process by following the design cycle (Hartson and Pyla, 2012). The presentation layer is responsible for handling the user interface and holding the presentation logic of the app and also the user flow. The logic layer is where the app holds the structure of the application's logic, workflow and also

logical components of the app. The data layer is designed to manage the data within the application and consists of data access and data utilities. In the upcoming section, we will create and describe each of these three layers (Figure 18).

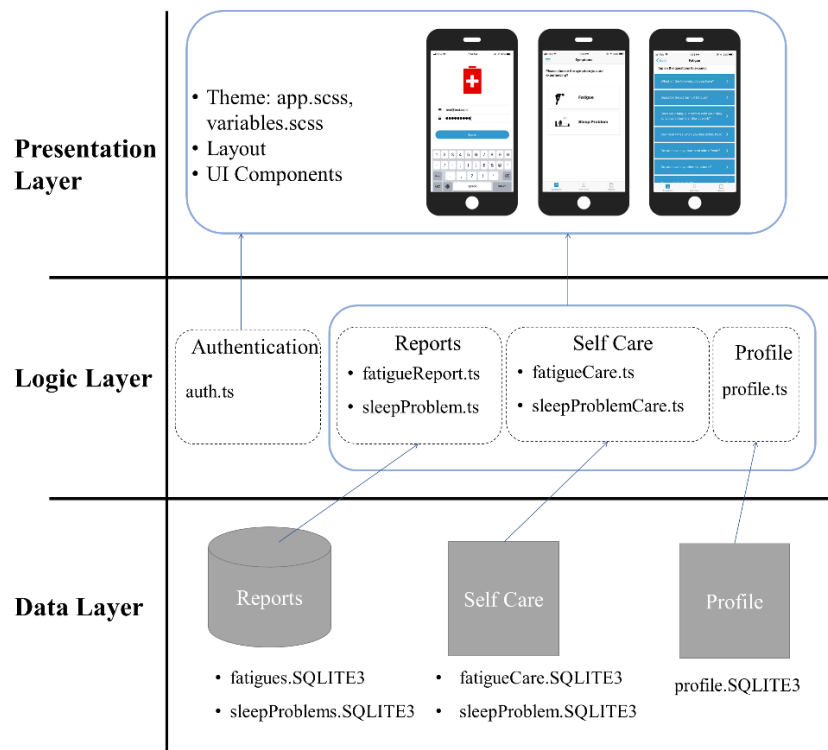


Figure 18: COSTaRS app 3-layer architecture.

## 6.5 - Presentation Layer: User Flow Diagram

To gain an understanding of the user experience from the COSTaRS app, we created flow diagrams of the application. Figure 19, shows the flow of the user interacting with COSTaRS app. This design is the result of an iterative design process by following the design cycle (Hartson and Pyla, 2012).

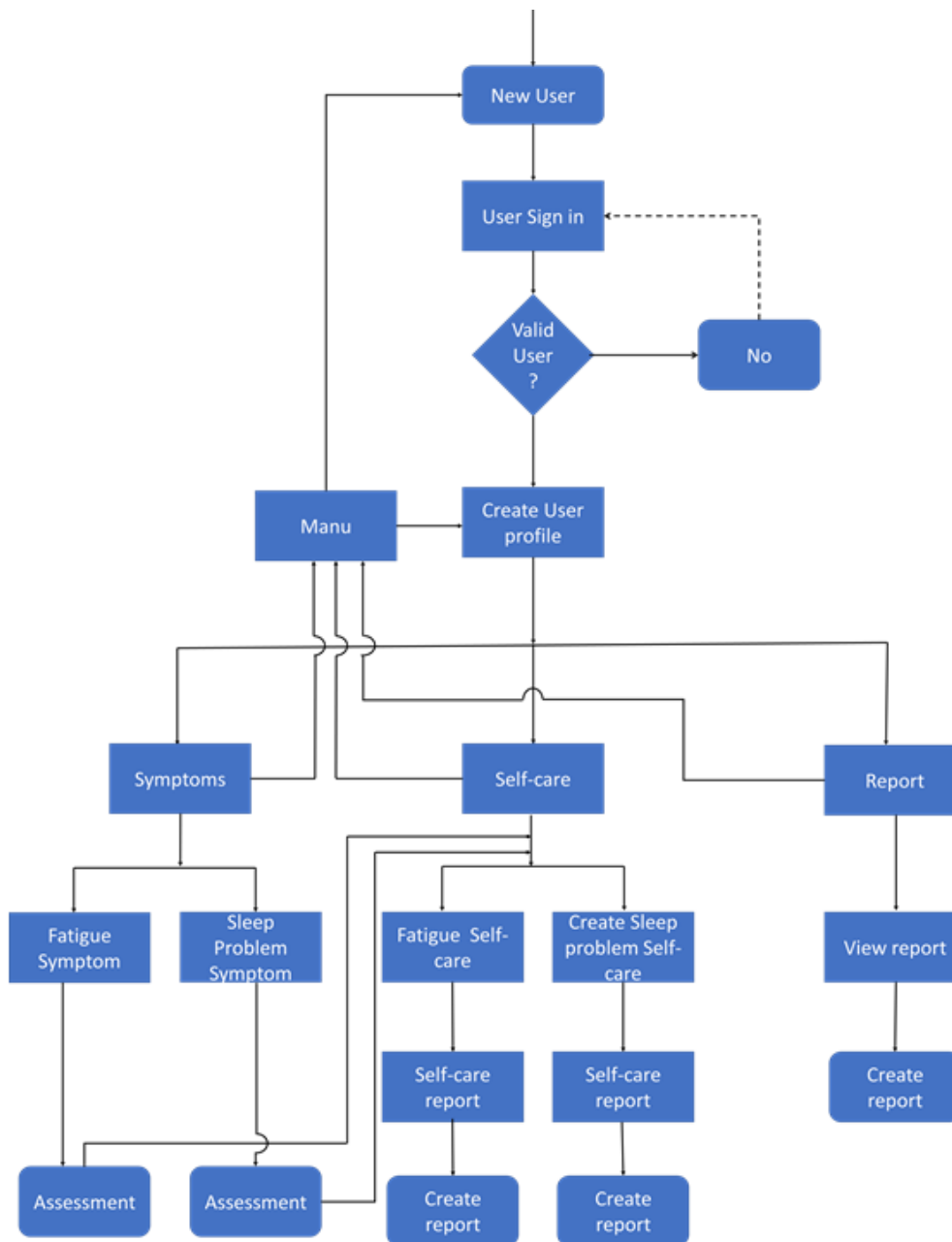


Figure 19: COSTaRS Mobile app flow chart.

As was mentioned in the previous sections, the user will be informed about the application by the cancer center and will receive the username and password in order to sign in to the application.

As the user passes the authentication, they are asked to input their information, namely, first

name, last name, date of birth and gender. By submitting their information, they will get to the main view of the app, which gives access to symptoms, self-care and reports. On the symptom section, they can choose the symptom they are experiencing and be directed to the symptom assessment and triage page of that symptom. As the user submits the symptom report, the report will be saved and categorized as mild, moderate and severe following the paper-based COSTaRS concept.

Depending on the severity of the symptom, the patient will be advised differently and directed to self-care strategies where they can learn the strategies and information regarding the management of that symptom. The user can also create their self-care strategies report where the user is asked several questions about their self-care strategies. The third section of the app, is the reporting feature, in which user can view their reports and upload the reports on the server, that can be retrieved on different devices using the same account to sign in.

## **6.6 - Presentation Layer: Interface Design**

In this study, we follow Schneiderman's design guidelines for handheld mobile devices (Gong and Tarasewich, 2004) (Figure 20). The method suggests three sets of instructions. The first set of guidelines points out that as the usage becomes more frequent, users prefer a smaller number of fast interactions. Next, suggests that there has to be informative feedback that is easy to understand by the user. Actions should be grouped in the form of process. And the user has to feel in control of steps instead of being controlled (Gong and Tarasewich 2004).

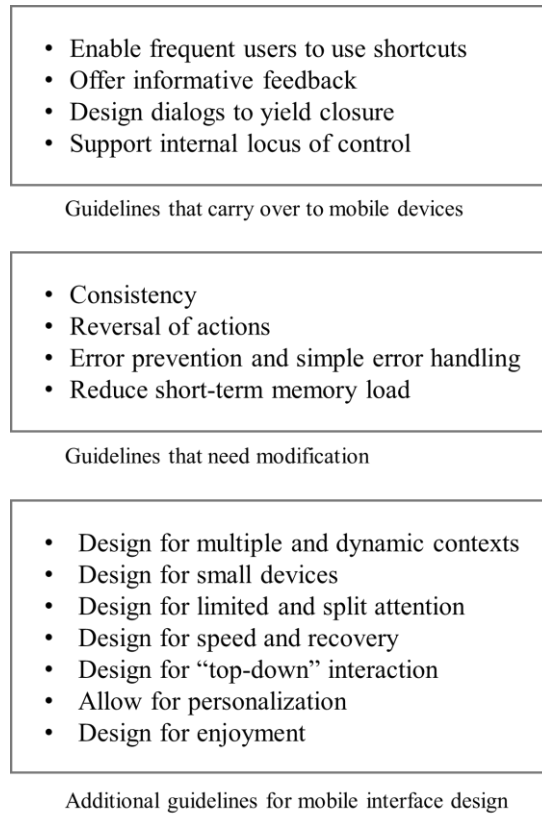


Figure 20: Three sets of Guidelines for handheld mobile device interface design (Gong and Tarasewich 2004).

The second set emphasizes consistency, which requires the app to be consistent in terms of "look and feel," UI elements, names, color schemes and dialogues (Gong and Tarasewich, 2004).

Mobile applications have to be able to operate with network connectivity as much as possible (Figure 20). Errors have to be prevented in the design and case of any error; the interface has to be able to handle the situation. Minimal user memorization should be required for performing tasks (Gong and Tarasewich, 2004).

The third set of guidelines suggests that the design should be adaptable to different contexts. Interactions are more efficient when they follow a hierarchical mechanism (Gong and Tarasewich, 2004). Users should be able to navigate through the app efficiently, and the look and

feel of the interface should be pleasing to the user. In case of our design, the UI components that are offered by the platform have been tailored for our design. Moreover, in some cases, we completely developed a UI component in the application.

### 6.5.1 - Presentation Layer: Use Case - Sign in

The first page that appears as the COSTaRS mobile app runs for the first time on the device is the sign-in page. The username (in our case is the email address) and password is provided by clinic admin to the patient. The authentication service at this point is a server-side service. Therefore, the app has to be connected to the internet for this service to be functioning. Moreover, as the app is authenticated, the user no longer requires to be connected to the internet and to sign in to use the app, unless the user logs out. Figure 21 and 22, show the sign-in page.



Figure 21: COSTaRS mobile app – logging page.

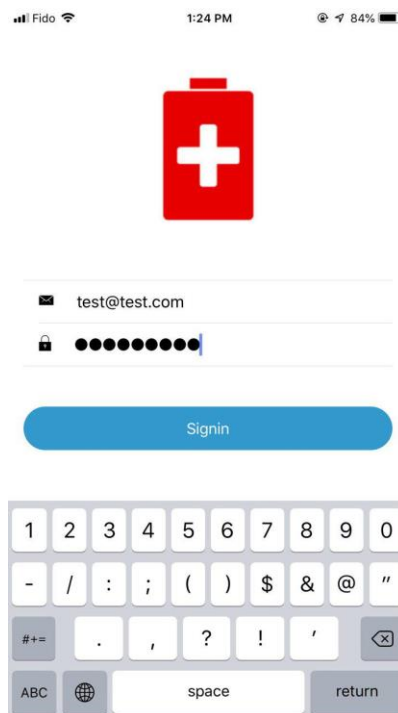


Figure 22: COSTaRS mobile app – logging page (filled).

### 6.5.2 - Presentation Layer: Use Case - Create Profile

After the authentication of the user, the first page that is presented to the user is “Create Your Profile” page where the user has to input their First name, last name, date of birth and gender. All the profile information of the user is stored within the device to protect the privacy of the users (Figure 23).



The screenshot displays a mobile application interface for creating a user profile. At the top, the status bar shows 'Fido' as the carrier, signal strength, Wi-Fi, the time '1:38 PM', and a battery level of '83%'. The app title 'Create Your Profile' is centered at the top of the form. Below the title, there are four input fields: 'First Name' with the value 'John', 'Last Name' with the value 'Doe', 'Date of Birth' with the value 'Oct 31, 1980', and 'Gender' with a dropdown menu showing 'Male'. At the bottom of the form is a prominent blue button labeled 'Create Profile'.

Figure 23: COSTaRS mobile app – create profile page.

### **6.5.3 - Presentation Layer: The Landing Page**

When the user inputs their information on the device, they will land on the main page of the app that consists of three tabs. The goal of the user is mainly to report a symptom; therefore, on the landing page, we allow the user to choose between symptoms (The design of everyday things, 2014). This design is the result of the iterative design process by following the design cycle (Hartson and Pyla, 2012). From left to right, the tabs are symptoms, self-care and report (Figure 24). The user can switch between these pages using the tabs for a dynamic and efficient interface. The same idea as the paper-based COSTaRS is being followed here, where for all the 15 practice guides this pattern is implemented. As described in the third chapter, each of the practice guides starts with an assessment of the severity of the symptom, which is the first tab on the application. The next step of the paper-based COSTaRS is the review of medication. In this design, we have brought the medication section under self-care, since as the term “self-care” suggests the plans and strategies in order to handle the symptom involves, medications. Therefore, it is justifiable to have it as a sub-section of self-care strategies. Moreover, the self-care section comes after symptom assessment, triage patient and medication review so this would be consistent with the paper-based COSTaRS practice guides. It has been pointed out that cancer patients do not necessarily change their self-care strategies due to changes in their symptom (Hasanpour-, 2016). However, self-care strategies may also be modified without the changes in symptoms, and therefore, in the mobile version, the self-care part is separated which means the user does not have to create the self-care strategies after assessment and triage sections. Users are advised to review the self-care strategies, but they do not necessarily have to make changes.

The last tab from the left is the report tab, which is also the previous section in the paper-based COSTaRS (Figure 24).

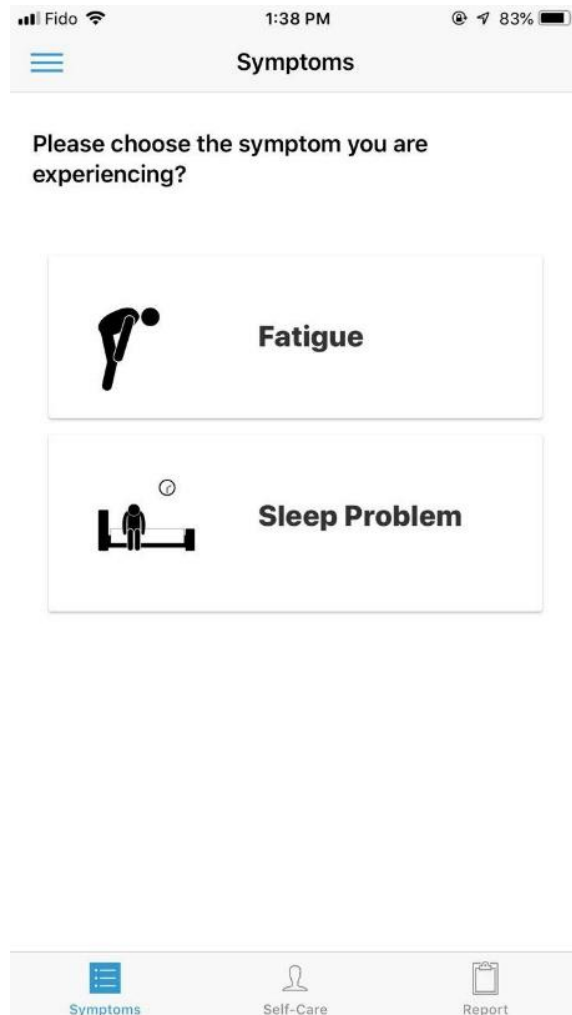


Figure 24: COSTaRS mobile app – landing page.

#### 6.5.4 - Presentation Layer: Use Case - Create Fatigue Symptom Report

When a user chooses fatigue in "Symptoms," they will be directed to a form-based page where they answer several questions. There are three types of input that they will encounter in this form. First is the range slider for the first two questions where they can express their answer in the range of 0 to 10 by moving the slider to the right and left. The second form, is a set of checkbox questions where the user can choose what applies to them or leave it empty if it is not

relevant. The third type is radio button questions where the user has to choose only one of the options (Figures 25 and 26). The radio button and range input questions are mandatory to be answered; otherwise the form gives an error of required fields and mark them by creating red borders around these questions (Figure 27). We have adapted scrolling instead of pagination for better tracking of the information. Moreover, the user can review and get back to the previous set of questions just by scrolling up (Tidwell, 2010).

Except for the range questions, there is an “Add note” function for every question where the user can add a note in case; they would like to have more explanations on the topic. By tapping on “Add note,” another page comes up that allows the user to add their notes (Tidwell, 2010). Created notes can be edited or deleted before submitting the form (Figure 28).

Figure 25: COSTaRS mobile app – fatigue report page I.

Figure 26: COSTaRS mobile app – fatigue report page II.

When the form is validated, it will be assessed by an algorithm which determines if the symptom is mild, moderate or severe and accordingly the next steps are advised to the user by a pop-up message on the screen (Figure 29).

Figure 27: COSTaRS mobile app – fatigue report page III.

Figure 28: COSTaRS mobile app – fatigue report page VI.

This function is the second part of every paper-based COSTaRS practice guide where the severity of the symptom is determined based on the input (Triage patient for symptom management based on highest severity) (Figure 29).

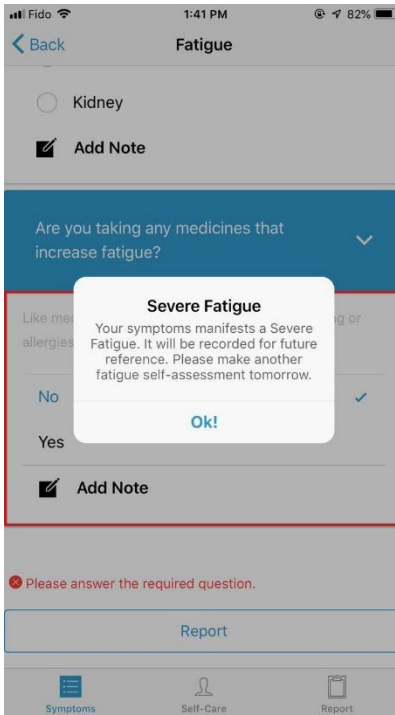


Figure 29: COSTaRS mobile app – fatigue report page V.

#### 6.5.6 - Presentation Layer: Use Case - Create Sleep Problem Symptom Report

The same design principle is applied to the sleep problem symptom page as described for fatigue. Therefore, this part will not be described in details. Figures 30 and 31, show the sleep problem report page.

**Sleep Problem**

Do you have problems with your sleep for 3 or more nights a week?

No

Yes

How worried are you about your sleep problem?

Not worried Extremely worried

Tap on the questions to expand.

Do you have difficulty falling asleep? >

Do you have difficulty staying asleep? >

Symptoms Self-Care Report

Figure 30: COSTaRS mobile app – sleep problem report page.

**Sleep Problem**

Are you taking any medicines that affect sleep? (e.g. opiates, steroids, sedatives, etc.) >

Yes

No ✓

**Mild Sleep Problem**  
Your symptoms manifests a Mild Sleep Problem. It will be recorded for future reference.  
Ok!

Do you have difficulty falling asleep? >

How are you feeling? >

Please answer the required question.

Report

Symptoms Self-Care Report

Figure 31: COSTaRS mobile app – sleep problem report page II.

### 6.5.7 - Presentation Layer: Use Case - Review Fatigue Self-care

When the report is submitted, the user will be directed to self-care page, where they can learn about the self-care strategies and plans (Figure 32). At this point, the user can input their self-care strategy by tapping on "My self-care," which can be updated later (Figure 33).

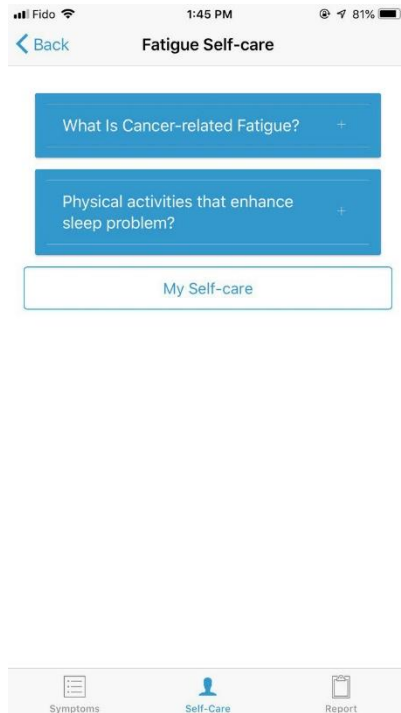


Figure 30: COSTaRS mobile app – fatigue self-care page.

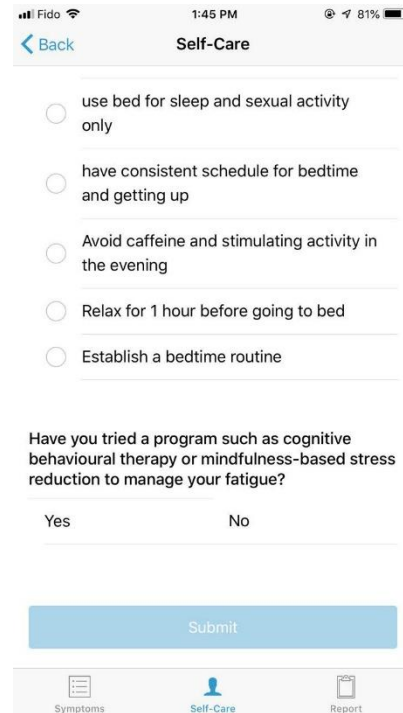


Figure 33: COSTaRS mobile app – fatigue self-care report page.

### 6.5.8 - Presentation Layer: Use Case - Review Sleep problem Self-care

The same design principals as “Review sleep problem” is applied here. Therefore, this part will not be described in details (Figure 34 and 35).

What is your goal for managing your Sleep problem?

Add your goals here...

Have you kept a sleep diary?

Yes No

Do you wake at the same time each day?

Yes No

Symptoms Self-Care Report

Figure 34: COSTaRS mobile app – sleep problem self-care page.

Have you done any of the following?

Go to bed when you are sleepy No

Limit the use of the bedroom for sleep and/or sex No

Restrict napping in the daytime No

noisy or too much light, do you use ear plugs or eye masks No

Have consistent schedule for bedtime and getting up Yes

You are exercising regularly No

What is your goal for managing your sleep problem?

Symptoms Self-Care Report

Figure 35: COSTaRS mobile app –sleep problem self-care report page.

### 6.5.9 - Presentation Layer: Use Case: View and Share Report

In this section of the app, the user can see all the created reports; the reports can be viewed by tapping on each report. The report can be converted to PDF file and be shared through email. They also have the option to delete the report.

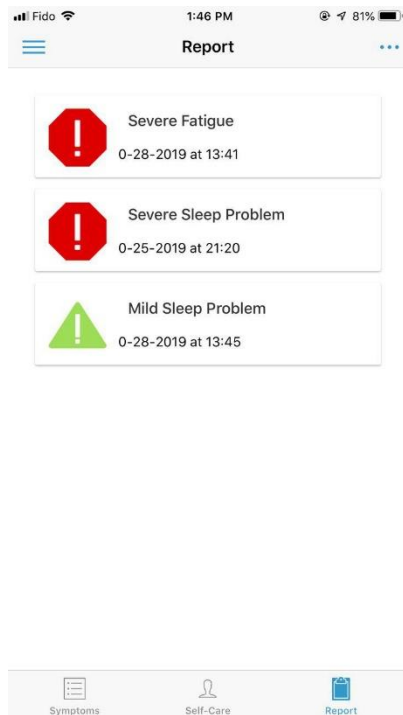


Figure 36: COSTaRS mobile app – report page.



Figure 37: COSTaRS mobile app – report view page.

Figure 36, shows an example of a list of reports where a user can see each report with the associated severity, date, time and type. When a report is selected, the user will be taken to the details of that report where they see the input they provided (Figure 37). Moreover, the user can share the report here, and also delete it. The shared report will be a PDF (Portable Document Format) file generated from the data of the report and the patient information. Figure 38, shows an example of a generated PDF file using COSTaRS app for severe fatigue.



## Severe Fatigue Report

Reported on 2018-9-10 at 11:56

Name uu uuuu

Date of birth 2008-10-31

Gender Male

How tired the patient feels on scale of 0 to 10: 6 out of 10

How worried the patient feels on scale of 0 to 10: 6 out of 10

Condition:

|                                |     |
|--------------------------------|-----|
| Shortness of breath at rest    | Yes |
| Sudden onset of severe fatigue | No  |
| Excessive need to sit or rest  | No  |
| Rapid heart rate               | No  |
| Rapid blood loss               | No  |
| Pain in the chest              | No  |

Other symptoms:

|                       |     |
|-----------------------|-----|
| Anxiety               | No  |
| appetite loss         | Yes |
| Poor intake of fluids | No  |
| Feeling depressed     | Yes |
| Pain                  | No  |
| Sleep problem         | No  |

Other health conditions that cause fatigue:

|               |     |
|---------------|-----|
| Cardiac       | No  |
| Breathing     | Yes |
| Liver changes | No  |
| Kidney        | No  |

Other health conditions:

|                     |     |
|---------------------|-----|
| Low red blood cells | No  |
| Infection           | Yes |
| Fever               | No  |

Does fatigue interfere with the patient's daily activities at home and/or at work?

Constant/ Less than two weeks

How would the patient describe the pattern of fatigue?

Constant/ Less than two weeks

Are there times when you feel exhausted?

Constant/ Less than two weeks

Do you drink alcohol?

Yes

Are you taking any medicines that increase fatigue?

Yes

Figure 31: COSTaRS mobile app – generated a PDF report

#### 6.5.10 - Presentation Layer: Use Case: Download and Upload Reports

The app can upload and download the reports. This functionality allows the user to store the reports safely and anonymously on the server, and if they sign in with another device using the same username, they can receive their reports on the other device as well (Figure 39).

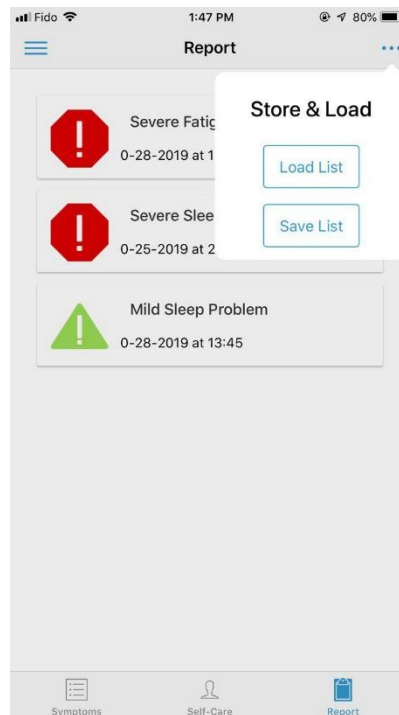


Figure 32: COSTaRS mobile app – store and load functions

#### 6.5.11 - Presentation Layer: Menu

There is a navigation menu designed, which is triggered by selecting the menu icon on the top left of the screen (Figure 40). The menu enables the user to modify their profile and also log out from the app. By having this feature, the same device can be utilized for different user accounts (Tidwell, 2010).

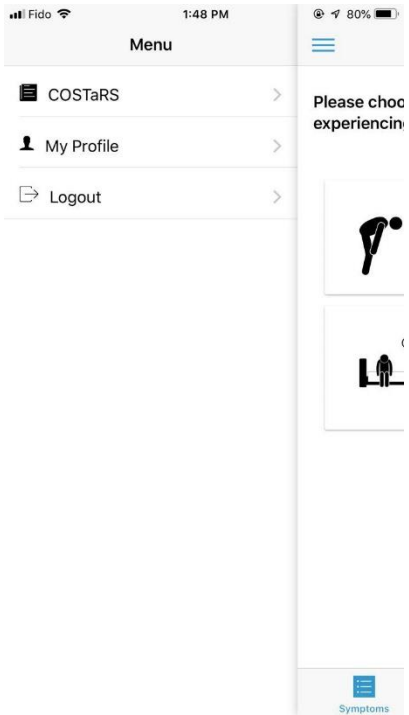


Figure 33: COSTaRS mobile app – side menu

## 6.6 - Mobile COSTaRS: Logic layer

In this part, we designed the underlying logic of the application that consists authentication, validation and logging of the application.

### 6.6.1 - Authentication

The authentication in this application is provided by Firebase (Google n.d.). This is an email and password-based authentication. Firebase provides an SDK which offers set of functions to handle authentication on the device (Google n.d.).

### 6.6.2 - App Logic

As the reports are validated, there are fed to the algorithm of the application in order to determine the severity of the symptom. In the paper-based COSTaRS, the symptom assessment section is divided into three columns. Here we follow a particular algorithm, order to make a judgement about the severity of the symptom. Moreover, the patient regularly receives weekly reminders for creating symptom reports. However, if a moderate symptom is reported, then this reminder would be in three days and case of severe symptom, the reminder would be the next day. We followed a similar triage algorithm in the mobile version (Figure 41).

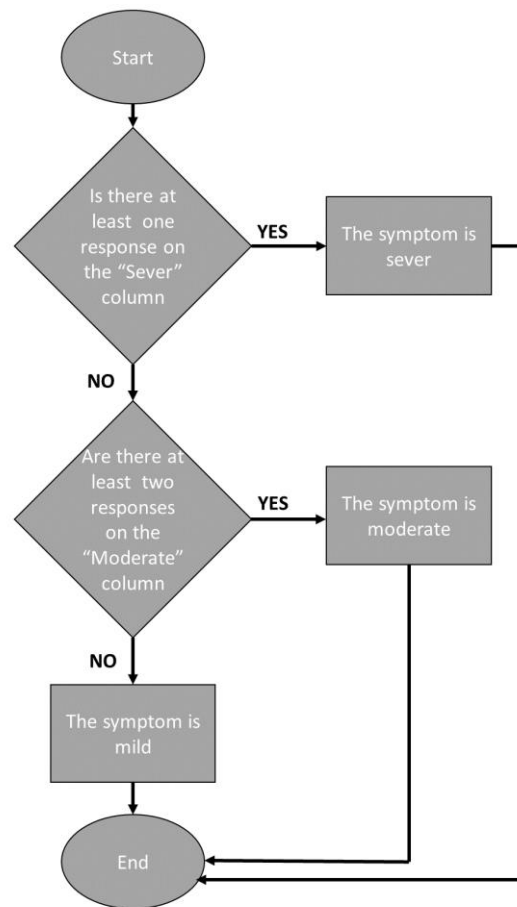


Figure 34: Triage algorithm in mobile COSTaRS

### **6.6.3 - Validation**

For symptom reports, the radio button and range slider questions must be answered; otherwise, the app does not allow the user to proceed.

## **6.7 - Mobile COSTaRS: Data Layer**

In our application, we have handled three sets of data, namely, symptom report, self-care report and user information (which is only available on the user's device). As a report is submitted in the application, a JSON object is created. This object contains all the inputted information for the report and also date and time where the report is generated. The app uses an SQLite file-based database to store the reports locally on the device which is a SQL (Structured Query Language) database engine (SQLite n.d.). The same procedure takes place with self-care strategies for each of the symptoms; however, in the case of self-care strategies, they are saved once and overwritten on later requests. Moreover, on the server, there will be an array of self-care strategies for future reference. In the report section, when reports are viewed, the user can request for the document. If there are no self-care reports for that symptom, the document will be created only with the symptom assessment section.

Every time a symptom report is created, the report will be uploaded to the server, and the same process happens for self-care strategies.

## **6.8 – Mobile COSTaRS Concepts**

In this section, we demonstrate the concepts, offered by mobile COSTaRS based on being the result of the automation process from the paper-based version or being an innovative outcome.

Table 13: Mobile COSTaRS concepts

| Concepts                                                                                                                                                                                                                                               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Automation                                                                                                                                                                                                                                             | Innovation                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| <ul style="list-style-type: none"> <li>• Electronic form for inputting the patient generated data.</li> <li>• Viewing the symptom report in an electronic format.</li> <li>• Storing the reports in a server and also local mobile devices.</li> </ul> | <ul style="list-style-type: none"> <li>• Set of UI components for compact design notion including slider range and accordion.</li> <li>• The 3-tab design which consists of symptoms, self-care and report design.</li> <li>• Constructing an independent notion for self-care reports from symptom report.</li> <li>• Enabling the user to gain access to their symptom and self-care reports and also self-care strategies using their handheld device.</li> <li>• Designing an infrastructure in clinical settings where the app blends in.</li> </ul> |

Table 13, shows the concepts of COSTaRS mobile application categorized based on the nature of the outcome.

## 6.9 - Chapter Summary

In this chapter, we explained the steps taken to create the COSTaRS mobile application. From the high-level design to app's logic and the data layer. We described the underlying arguments

for adapting different design decisions. We explain the functionalities and the features of the app. Moreover, we looked into the resulting concepts in mobile COSTaRS.

## **CHAPTER 7: EVALUATION**

In this chapter, we describe the evaluation process of the application and the usability testing that was done. This usability study was approved by the office of research ethics and integrity of the University of Ottawa under the ethics file number of H-12-18-1774.

### **7.1 - Purpose**

The main objective of this evaluation is the assessment of the in terms of usability.

Moreover, our usability study is assessing:

- The effectiveness and efficiency of the COSTaRS mobile symptom management application from usability perspective.
- How successful was the transition from the paper-based to the electronic version in terms of usability as a mobile application?

### **7.2 - Test Design**

One qualitative evaluation technique is the think-aloud protocol (Boren and Ramey, 2000). In this method, the participant expresses his/her opinion about their experience with an application while interacting with it. Also, the participant describes their reasoning for having a positive or negative point of view from each interaction with the interface, based on their experiences (Boren and Ramey, 2000). This technique was chosen for our study due to being robust, cost-efficient and productive.

In this study, we will collect the user input after they have interacted with the application (G. I. Johnson, Clegg, and Ravden, 1989). Participants are first asked to read and sign a consent form (Appendix D). In the first step, the participants will be introduced to the application and the purpose of this app, and then asked to read two scenarios (Wei and Coquereau, 2006). The scenarios are designed to represent the typical conditions of cancer patients experiencing cancer-related symptoms. In our study, the symptoms are fatigue and sleep problem.

### **7.2.1 - Design: Pre-test Descriptions**

After explaining to the participant, the purpose of the study, the mobile application, and the intended user of the app, the user is told that: “Imagine you are a caregiver of a cancer patient and you would like to use the COSTaRS mobile app to manage the symptoms of the patient. You are interviewing the patient in order to fill in the forms and describe the situation of the patient according to the questions. You will then, provide feedback to the patient according to what the app suggests” (Boren and Ramey, 2000). The participants are also asked to think loud and express their opinions while interacting with the interface.

The researcher in this study listened to the participant and took notes while the participant conducts the scenarios (Boren and Ramey, 2000). Moreover, the researcher did not give any comments or instructions to the Participant during the test sessions.

### **7.2.2 - Creating the Scenarios**

The first scenario is a cancer patient with fatigue symptoms. The scenario is designed according to the typical situation of a cancer patient experiencing fatigue symptom (Simon and Zittoun,

1999). The second scenario is intended to represent the situation of a cancer patient with sleep problems (Davidson et al. 2002) (Appendix B).

### **7.3 - Testing Process**

At the start of the testing session, a consent form was given to the participant. After explaining the process, the participant is asked if they have questions or concerns with the testing session, and if they do not, we move to the next step. The first scenario is given to the participants to follow. An iOS smartphone is given to the participant with the COSTaRS app installed on it to perform the tasks. The screen of the mobile phone will be recorded for measuring performance metrics (Roy, Pattnaik, and Mall, 2014). Upon finishing the first scenario, the second scenario is given. While the participant is using the application, we took notes of what they say about their experience. When the participant is finished with the second scenario, they were asked to fill out a questionnaire form about the experience with the application (Sauro and Lewis, 2016). The questionnaire is given to measure usability metrics. Also, there is a recorded no-voice, video of each testing session. As mentioned in the previous chapter, the intended user of the app is the patient or the caregiver. In this usability study, we are considering that the user is the caregiver since none of our participants are actual cancer patients. However, since the test is conducted to see the usability parameters, we believe the usability concepts are also valid in the case of an actual cancer patient (Seffah et al. 2006).

## **7.4 - Recruitment**

The recruitment of the participants was from Computer Science and Electrical Engineering graduate students of the University of Ottawa. These students were chosen due to the fact that the purpose of this study is to investigate the usability of the COSTaRS mobile app and students may be consumers of the healthcare system.

To recruit the participants, a message was posted on the Facebook group of the Computer Science and Electrical Engineering graduate students of the University of Ottawa. We targeted 25 participants as that number has been suggested as an ideal number of participants for a usability study (Hartson and Pyla, 2012).

## **7.5 - Demographics**

In this usability study, 26 participants were recruited in total. All the participants are graduate students from the University of Ottawa.

## **7.6 - Usability Measurements**

In this usability study, we are using QUIM (Quality in Use Integrated Measurement) as a model for usability measurements (Hasan and Al-Sarayreh, 2015). QUIM is a consolidated model that overcomes the limitations in other models by combining a variety of methods and standards to effectively measure usability. QUIM model integrates different usability factors and metrics (Seffah et al. 2006). The model suggests specific metrics for usability measurements. Table 14, shows the parameters we have adapted from QUIM model in consideration of the goals of our study.

Table 14: Usability metrics (Seffah et al. 2006)

| <b>Factors</b>       | <b>Description</b>                                                                                                                                                                      |
|----------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Efficiency</b>    | This is the ability of a software product to allow the users to spend a proper amount of effort considering the effectiveness achieved in specific use.                                 |
| <b>Effectiveness</b> | The characteristic of a software product to enable users to fulfill a certain task or set of tasks wholly and precisely.                                                                |
| <b>Satisfaction</b>  | This is the user's feeling toward using the software product.                                                                                                                           |
| <b>Learnability</b>  | The quality of being easy to learn for achieving a particular goal by using the software product.                                                                                       |
| <b>Usefulness</b>    | The capability of a software product to enable the user to solve a certain problem properly.                                                                                            |
| <b>Productivity</b>  | This is the scale of effectiveness while considering the time and effort spent on a certain task. Unlike efficiency, productivity concerns about the level of usefulness of the output. |

In this usability study, we are using self-reported metrics by designing a usability questionnaire (Sauro and Lewis, 2016). The questionnaire is designed to provide us with the results of the usability metrics in Table 13. However, in case of learnability and productivity, resulted notes from think-aloud method and screen videos were used. To create the questionnaire, we followed the Psychometric Evaluation of the Post-Study System Usability Questionnaire (PSSUQ) (Lewis, 2017) with changes in wording (Appendix A). PSSUQ is a scenario-based usability evaluation instrument which produces reliable results for evaluation of user satisfaction of the usability (Frugling and Lee, 2005). Therefore, this instrument is used in order to capture participants satisfaction scores in our study.

## 7.7 - Results Analysis

To analyze the results, first, we went through the overall feedbacks about the application. Here are the overall average scores. Figure 42, shows usability metrics that were extracted and calculated from the 26 participants. As the metrics results depict, the application received relatively high scores in terms of usability. The highest rating is for usefulness (9.22/10), and the lowest is for learnability (7.66/10). Learnability and productivity factors were resulted from the think-aloud protocol notes and screen recordings.

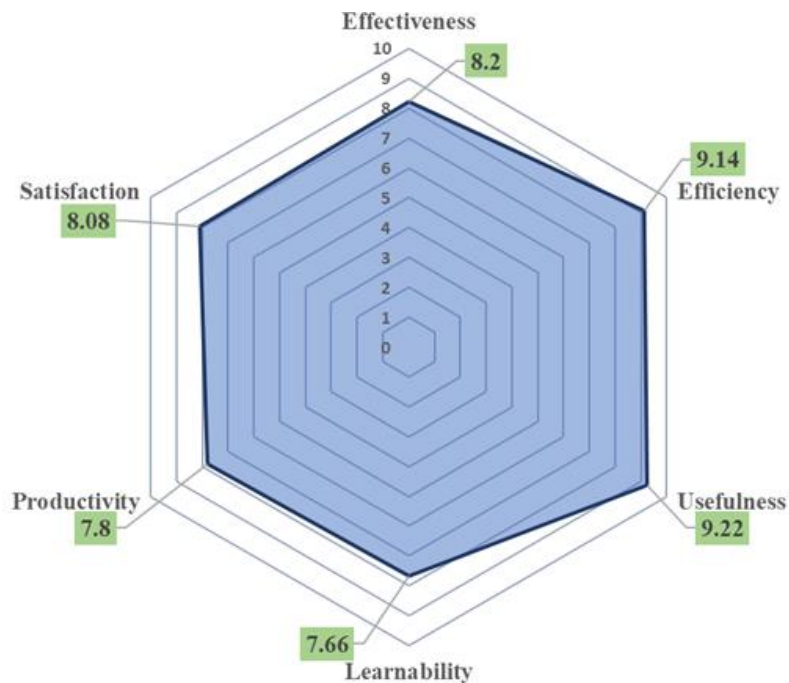


Figure 35: Usability metrics measurements for COSTaRS mobile application.

The overall advantages of the app that were mentioned by participants were the well-structured design in terms of flow of the data and the map. Moreover, the app has a compact and smooth design. For overall disadvantages, one was mentioned that the app lacks a tutorial on how to use

it to be more effective. Moreover, there were usability issues with the symptom reporting pages and self-care and report.

## 7.8 - Result Analysis – Tasks

The average score given to each task performed by the participant is depicted in Figure 43. For each task, they could choose between: not satisfied at all, slightly satisfied, neutral, very satisfied and extremely satisfied. Figure 43, shows the final results of user satisfaction.

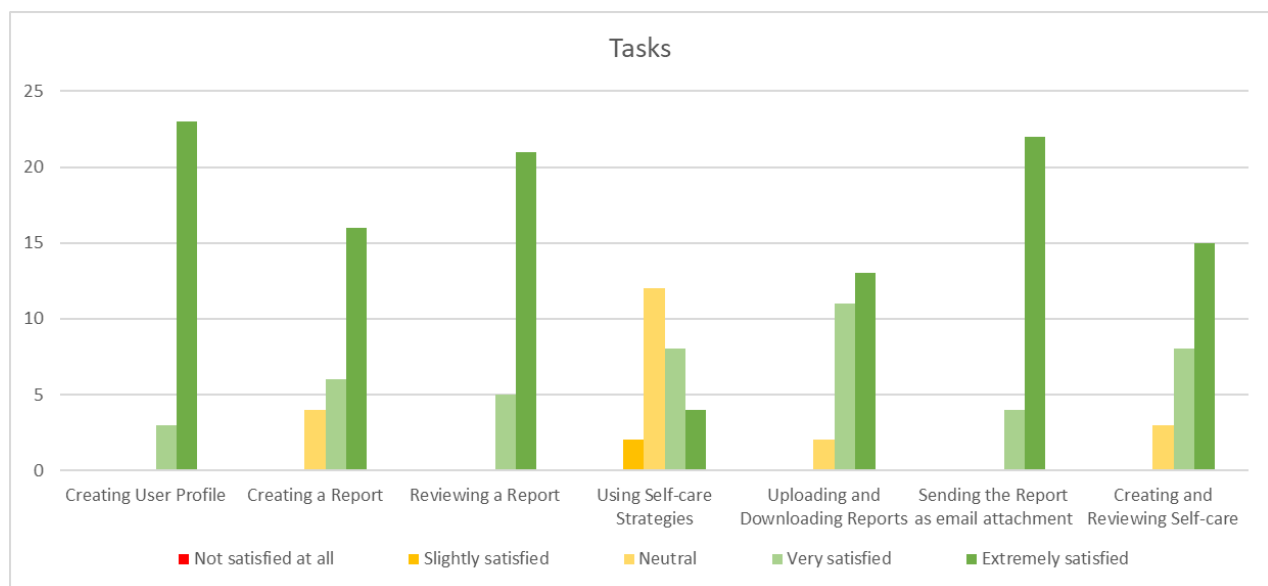


Figure 36: Comparison of satisfaction scales from different sections of COSTaRS app.

As Figure 43 shows, the app received a high level of satisfaction with all the tasks except for a moderate level of satisfaction in using self-care strategies. To analyze the cluster of user satisfaction, we will use a weighted satisfaction score scale. For each task, scores from “not satisfied at all” to “extremely satisfied” will be multiplied by 1,2,3,4 and 5 accordingly and added together. The result will be divided by five, multiplied by the number of participants:

*Satisfaction Score*

$$= \frac{1 \times \text{Not satisfied at all} + 2 \times \text{Slightly satisfied} + 3 \times \text{Neutral} + 4 \times \text{Very satisfied} + 5 \times \text{Extremely satisfied}}{5 \times \text{Number of participants}} \times 100$$

The calculation of the above-mentioned formula will output the weighted satisfaction score for each task in percentage.

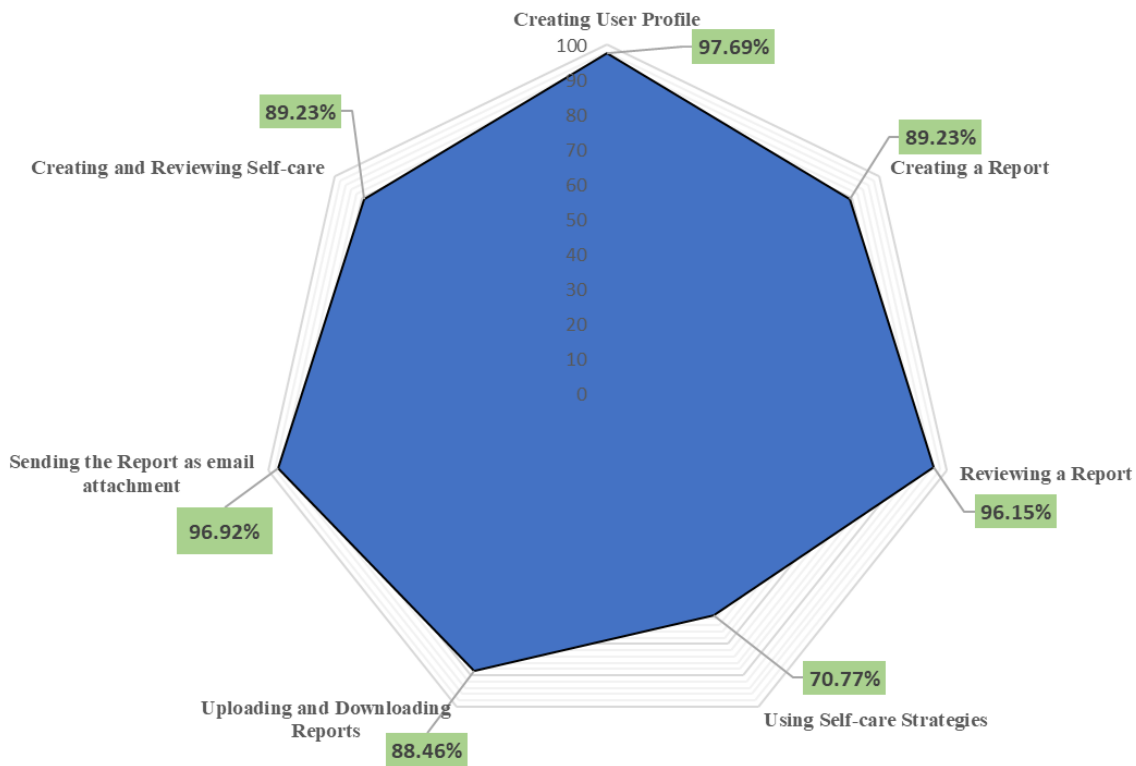


Figure 37: Weighted satisfaction scores of usability testing.

The radar chart in Figure 44, shows the results of the calculations. Using self-care strategies had the lowest satisfaction score among all the tasks. This result verifies the high usability level of COSTaRS mobile application. Next, we describe specific feedback on each of the tasks.

### **Result Analysis – Task: Creating a User Profile**

The first task the users accomplish after signing in is creating the user profile. According to the user feedback and notes on this section, there were not any significant issues reported. The user's understanding of the interface was straightforward.

### **Result Analysis – Task: Creating a Report**

The report creating task, was performed by each user twice. In the first scenario, the users created a fatigue report first. Eleven participants, found the range slider hard to adjust due to a lack indication of the value. Four participants, failed to notice or use the “Add note” function. Four participants, expressed that the check-list questions are vague in terms of being required or not. Three users found the "Add note" function existence pointless. Moreover, it was mentioned that the font sizes and spaces could be improved.

### **Result Analysis – Task: Reviewing a Report**

In the case of reviewing a report, two participants pointed out the colour theme of questions and their background have made them partially hard to read. Two participants mentioned that the app should ask for confirmation upon deleting a report. Overall, participants found this section easy to perceive.

### **Result Analysis – Task: Using Self-care Strategies**

Eleven participants, mentioned that this section was confusing and vague and also the purpose and functionality of this section is time-consuming to figure out. However, once the self-care report is recorded, the subsequent interactions with this section are easy to perform. Commonly, the participants were under the impression that this section would behave the same as a symptom report which confused the participants to some extent.

### **Result Analysis – Task: Saving and Loading the Report from the Server**

According to five participants, the choice of vocabulary does not imply what the functions actually do and the function is not easy to understand in the context. However, once they understood it the participants found this function to be useful.

### **Result Analysis – Task: Sending the Report as an Email attachment**

Two participants, suggested that the email subject and recipients are more beneficial to be inputted inside the app. Moreover, the idea of sharing the result was satisfactory to the participants.

## **7.8 - Analysis of the Issues**

In this section, we analyze the issues according to the participant's feedback (Table 15).

Table 15: Issues captured from participants for COSTaRS application

| <b>Issues<br/>code</b> | <b>Description</b> |
|------------------------|--------------------|
|------------------------|--------------------|

|    |                                                                                                                                                                  |
|----|------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| I1 | Delete report option does not confirm the delectation with the user. The user may have a second thought, or they may have mistakenly tapped the button.          |
| I2 | The “Add note” is not noticeable to the user. It was hard to be noticed by some participants.                                                                    |
| I3 | UI of checklist questions are not clear if they required or not. The user would not be sure whether a particular question is mandatory.                          |
| I4 | UI of range sliders are not easy to use. The user would be confused about the value that the slider takes as it lands on a certain value.                        |
| I5 | The self-care section is vague in terms of understanding the purpose and function. The user would be confused when trying to create a self-care strategy report. |
| I6 | The symptom form would be vague for some users in terms of vocabulary and questions.                                                                             |
| I7 | The steps in the app, namely, symptom, self-care and report would be vague to some extent for the users due to lack of instructions.                             |

All issues are associated with the UI/UX, except for lack of instructions to use the app and the contextual resources used for creating the app. The lack of instructions problem is also related to the learning curve of an app, considering that in second scenarios, the participants could easily find what they were looking for. The I6 issue, in Table 15, relates to the materials that are used to create the app, which is COSTaRS practice guides. Therefore, this issue would be out of the scope of this study.

## **7.9 – Suggested modifications**

In this section, we propose several changes to address the issues that resulted from usability testing.

**I1:** on the symptom report's detail page by selecting "Delete." A pop-up dialogue box will appear that allows the user to confirm deleting the report.

**I2:** the add note function will bring the created note to the report page so that the user can see the created note without leaving the symptom report page.

**I3:** the symptom report page informs the user whether a response is mandatory or not by changing the shape of radio button questions.

**I4:** the slider will indicate the changing of the value on top of the scale as it is dragged to the left or the right.

**I7:** the self-care informative part will be merged in the self-care report. In this case, the user would not be confused about the purpose of the self-care part.

## **7.10 – Conclusion**

In this chapter, we designed the test and described the protocol for usability testing. The results of the trial indicated a significant degree of satisfaction with some issues that needed addressing. We have revised the app to fix the issues that were in the scope of this study.

## CHAPTER 8: DISCUSSION, CONCLUSION AND FUTURE

### WORK

In this chapter, we explore the COSTaRS mobile application approach for satisfying the user requirements. We also discuss the contributions of the COSTaRS mobile application and then investigate the transition from the paper-based COSTaRS to the electronic version. We then finish with the future work and expansion of the COSTaRS mobile application.

#### 8.1 – Satisfying the Requirements

In the 5th chapter, we introduced the requirements of the COSTaRS mobile application. In this section, we describe the extent by which the COSTaRS mobile application in satisfying the defined requirements.

Table 16: Mobile COSTaRS approach for requirements

| Requirements     | Mobile COSTaRS approach                                                                                                                                                                                                                                                 |
|------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| R1, R2           | The reporting process is divided into three sections for completing the reports. The sections are based on paper-based COSTaRS, and the average time for creating a report has reduced dramatically.                                                                    |
| R2, R5, R12      | The reports are being stored on a structured server-side architecture with a standardized format. This would allow potential easier symptom clustering and tracking of the symptoms.                                                                                    |
| R6, R7, R13, R14 | The application is username and password protected. Moreover, it has to be connected to the internet for the first login. However, the app can also work offline. The privacy of the user is protected on the server-side by indexing the anonymous data on the server. |

|          |                                                                                                                                                                                                                                              |
|----------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| R16      | The add note function allows the user to input and adds descriptions beyond the determined response.                                                                                                                                         |
| R4       | The COSTaRS mobile platform allows the symptom management to be updated and expanded without having to reinvent the system or resulting in noticeable expanses due to the nature of the mobile application platform (Keng Siau et al. 2005). |
| R1, R15  | The app is evaluated in terms of being usable, and the required time for creating a report is reduced and optimized.                                                                                                                         |
| R9       | The same idea as paper-based COSTaRS followed in the development of fatigue and sleep problem reports. And content is fed from the paper-based version.                                                                                      |
| R10      | The application notifies the user upon the severity of their symptom.                                                                                                                                                                        |
| R17      | The documentation is electronic which promotes the current documentation process (Kalra, 2006).                                                                                                                                              |
| R19      | The app is capable of supporting multiple languages. Although this function is not applied yet.                                                                                                                                              |
| R3       | The app is runnable on iOS, Android and Windows smartphones and tablets.                                                                                                                                                                     |
| R11, R18 | The app allows the user to view, share the stored reports upon their request.                                                                                                                                                                |

Table 16, shows that the requirement, we defined in the case study chapter and how the COSTaRS mobile application addressed the requirements. The app was successful in satisfying the requirements categorized as medium and high priorities.

## 8.2 – Comparison with Related Applications

In this section, we compare the COSTaRS mobile application with the other mobile applications that we reviewed in this study. Table 17, shows the comparison of the applications that we

reviewed in this study. We also have the COSTaRS mobile application in the last row of the table with “CA” as the application ID.

As Table 17 shows, the COSTaRS mobile application contains all the listed features. Moreover, the application handles the symptom management process using an evidence-based approach, which is not offered by other applications.

Table 17: Comparison of COSTaRS app

| Application ID | Cross-platform | Self-triage Symptom | Allows sharing results | Offers Self-care strategies | Provides information on medication | Tracks symptoms | Tracks Medication | Tracks self-care Strategies | Used in clinical settings | Result of a study or commercial |
|----------------|----------------|---------------------|------------------------|-----------------------------|------------------------------------|-----------------|-------------------|-----------------------------|---------------------------|---------------------------------|
| C1             | Yes            | Yes                 | No                     | Yes                         | Yes                                | Yes             | Yes               | Yes                         | No                        | Commercial                      |
| C2             | Yes            | No                  | Yes                    | Yes                         | No                                 | No              | No                | No                          | No                        | Commercial                      |
| C3             | Yes            | Yes                 | Yes                    | Yes                         | No                                 | Yes             | No                | No                          | No                        | Commercial                      |
| C4             | Yes            | No                  | No                     | Yes                         | Yes                                | No              | No                | No                          | No                        | Commercial                      |
| C5             | No             | No                  | No                     | Yes                         | Yes                                | No              | No                | No                          | No                        | Commercial                      |
| C6             | No             | No                  | Yes                    | No                          | No                                 | Yes             | Yes               | No                          | No                        | Commercial                      |
| C7             | No             | Yes                 | Yes                    | Yes                         | Yes                                | Yes             | Yes               | Yes                         | No                        | Commercial                      |
| S1             | Yes            | Yes                 | No                     | No                          | No                                 | Yes             | No                | No                          | No                        | Study                           |
| S2             | Yes            | Yes                 | No                     | Yes                         | No                                 | Yes             | No                | No                          | Yes                       | Study                           |
| S3             | No             | Yes                 | No                     | No                          | No                                 | Yes             | No                | No                          | No                        | Study                           |
| S4             | No             | Yes                 | No                     | Yes                         | No                                 | Yes             | No                | No                          | Yes                       | Study                           |
| S5             | Yes            | Yes                 | No                     | No                          | Yes                                | Yes             | Yes               | No                          | No                        | Study                           |

|    |     |     |     |     |     |     |     |     |     |       |
|----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-------|
| S6 | No  | No  | Yes | Yes | Yes | No  | No  | No  | Yes | Study |
| S7 | No  | Yes | No  | Yes | No  | Yes | No  | No  | Yes | Study |
| CA | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Study |

### 8.3 – Validity Challenges and Limitations

In this section, we discuss the challenges that arose from the implementation of the mobile COSTaRS and the transition from the paper-based version. Validity indicates whether the results of the research is truthful (Golafshani, 2003).

#### 8.3.1 – Content Validity

Content validity determines the estimate of how a measurement tool properly measures an specific construct in question (Heale and Twycross, 2015). In our case, we carried out a usability study conducted on students as participants. As discussed in the previous chapter, we used QUIM model for our usability measurements which is robust and reliable. Moreover, we applied PSSUQ as our research instrument to create scenario-based questionnaires. In addition, we combined thinking aloud method with PSSUQ in order to achieve more reliable results. However, the challenge of content validity in our study, is associated with QUIM not being an optimum model and drawbacks of PSSUQ as a measurement tool.

#### 8.3.2 – Criterion Validity

Criterion validity determines the validity of the research instrument considering related instruments (Heale and Twycross 2015).

The COSTaRS mobile application may not be useful in emergencies due to its nature of being a mobile application. The patient or the caregiver would directly call an emergency number instead of using the app. By implementing the mobile version of symptom management, we may lose the advantages of having the expertise of an experienced oncology nurse in the system. An example can be in terms of the psychological knowledge of the conversation with a cancer patient and a medical expert.

### **8.3.3 – Construct Validity**

Construct validity determines the accuracy of the testing, which verifies the results (Heale and Twycross 2015). The content of the COSTaRS mobile application in terms of wording and questions is captured from the paper-based version. Moreover, the services that are offered by mobile COSTaRS are relevant to the paper-based COSTaRS. The mobile application provides self-care strategy information and also creates symptom reports and although the type of the data and information are digital, the content is equivalent to what is on the paper form. Therefore, the accuracy of the symptom management results is dependent on the quality of the content of the paper-based version. However, since we have transformed the COSTaRS paper-based guide into a mobile application, the accuracy of the results will not be completely equivalent.

## **8.4 - Conclusion**

We have created a user-friendly mobile application which not only contains the benefits of the paper-based COSTaRS symptom management guides, but we also added innovation to a number of the features in the paper-based COSTaRS guides. This innovative approach can increase the

efficiency of the symptom management process. Although the implementation of COSTaRS mobile application may have several challenges, the benefits of the app outweigh any potential problem in terms of usability. The results of this study, depict the extent that the mobile application can improve the current COSTaRS symptom management process. The research questions in this study are as follow:

1. *“How can the current paper-based COSTaRS (pan-Canadian Oncology Symptom Triage and Remote Support) symptom management system be improved by developing the mobile version of COSTaRS for patients and caregivers?”.*
2. *“How to develop an innovative practice-based mobile application for symptom management with high level of usability?”.*

We used the resources and materials of paper-based COSTaRS in order to create the mobile version. The resulting product was a mobile version with high level of usability that created an electronic practice-based symptom management tool with the potential to be used in clinical settings. The mobile app offered innovations in the symptom management process, and it is also capable of producing electronic records for an improved symptom management process.

Moreover, in comparison with the paper-based version of COSTaRS, the data is stored faster, more secure, cost-efficient and easier to manipulate. Besides, the COSTaRS mobile application provides informative materials for the user, which can improve the handling of the symptoms. The COSTaRS mobile application, creates a flexible platform for the facilitated implementation of changes in symptom management, and adding various features like multiple languages.

## 8.5 - Future Work

The COSTaRS mobile application introduces new approaches for research in mobile application development in symptom management for cancer treatment-related patients. Here we discuss some of the potential works going forward:

1. The development of analysis tools, by utilizing the data created with the COSTaRS app for symptom clustering, symptom tracking and decision-support.
2. The standardized electronic data, allows the integration of different e-health records. The patient record, can be converted to be adopted in a variety of electronic healthcare data systems.
3. Expanding the app to support the demonstration of changes in symptom and behavioural tracking of the patient.
4. Developing a desktop version of COSTaRS for nurses, patients and caregivers.
5. Developing a mobile version of COSTaRS designed for nurses to improve remote symptom management.

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## Appendix A: Questionnaire

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### **COSTaRS Application feedback questionnaire**

**Participant No.**

1. How easy is it to use and perform tasks using COSTaRS app on scale of 0 to 10 where 0 is the hardest and 10 is the easiest?
2. Does the application allow the users to perform the tasks efficiently in terms of being quickly performed on scale of 0 to 10 where 0 is not efficient and 10 is complete efficient?
3. How much the app accomplished in terms of the objective of the study explained by the usability test conductor on scale of 0 to 10 where 0 is least accomplished and 10 is most accomplished?
4. Was the interface easy to understand on scale of 0 to 10 where 0 is not easy and 10 is completely easy?

5. How much mental effort does the app required in order to understand the context on scale of 0 to 10 where 0 is most mental effort and 10 is the least mental effort?

6. Please rate each of these tasks in terms of being easy to use and understand and use:

a. Creating user profile:

| Not at all<br>satisfied | Slightly<br>satisfied | Neutral | Very<br>satisfied | Extremely<br>satisfied |
|-------------------------|-----------------------|---------|-------------------|------------------------|
|                         |                       |         |                   |                        |

b. Creating a report:

| Not at all<br>satisfied | Slightly<br>satisfied | Neutral | Very<br>satisfied | Extremely<br>satisfied |
|-------------------------|-----------------------|---------|-------------------|------------------------|
|                         |                       |         |                   |                        |

c. Reviewing a report:

|                         |                       |         |                   |                        |
|-------------------------|-----------------------|---------|-------------------|------------------------|
| Not at all<br>satisfied | Slightly<br>satisfied | Neutral | Very<br>satisfied | Extremely<br>satisfied |
|                         |                       |         |                   |                        |

d. Using self-care strategies:

|                         |                       |         |                   |                        |
|-------------------------|-----------------------|---------|-------------------|------------------------|
| Not at all<br>satisfied | Slightly<br>satisfied | Neutral | Very<br>satisfied | Extremely<br>satisfied |
|                         |                       |         |                   |                        |

e. Saving and loading the report form server:

|                         |                       |         |                   |                        |
|-------------------------|-----------------------|---------|-------------------|------------------------|
| Not at all<br>satisfied | Slightly<br>satisfied | Neutral | Very<br>satisfied | Extremely<br>satisfied |
|                         |                       |         |                   |                        |

f. Sending the report as email attachment:

|                         |                       |         |                   |                        |
|-------------------------|-----------------------|---------|-------------------|------------------------|
| Not at all<br>satisfied | Slightly<br>satisfied | Neutral | Very<br>satisfied | Extremely<br>satisfied |
|                         |                       |         |                   |                        |

|  |  |  |  |  |
|--|--|--|--|--|
|  |  |  |  |  |
|--|--|--|--|--|

g. Creating and reviewing self-care strategies:

| Not at all<br>satisfied | Slightly<br>satisfied | Neutral | Very<br>satisfied | Extremely<br>satisfied |
|-------------------------|-----------------------|---------|-------------------|------------------------|
|                         |                       |         |                   |                        |

7. Is there a functionality in the app that you find pointless or irrelevant, if yes, explain why?

8. How satisfy are you with your experience using the app on the scale of 0 to 10 where 0 is not satisfied at all and 10 is complexly satisfied.

9. Would you have any suggestions for improving the app?

## Appendix B: Scenarios

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### Scenario A: Fatigue Symptoms

Jane Griffin is a 56-year woman, suffering from breast cancer. She is going through chemo and radiotherapy. Recently she has been experiencing a severe tiredness. We are using COSTaRS mobile app in order to manage her symptom.

Please log in to the app using:

Email:           **test@test.com**

Password:       **12345678**

Please input the patient's information (first and last name, date of birth and gender).

#### Step 1: Symptom triage and assessment

Please input her **fatigue symptoms** according to the following interview:

**How tired are you feeling on scale of 0 to 10?**

7

**How worried are you about your fatigue on scale of 0 to 10?**

6

**Which of the following do you have?**

I start to get so tired suddenly where I need lay or sit down and rest for a while doing the household chores.

**Describe the pattern of fatigue?**

Continuously, I felt tired during last week.

**Does your fatigue interfere with your daily activities at home and/or at work?**

Yes, it does, I need to push myself to do a usual activity.

**Are there times when you feel exhausted?**

Yes, continuously

**Do you have any treatment side effects?**

None of the symptoms

**Do you have any other symptoms?**

Painful chronic headaches and anxiety

**Do you drink alcohol?**

No

**Do you have other health conditions?**

I have heart disease.

**Are you taking any medicines that increase fatigue?**

Yes, blood pressure medications

## **Step 2: self-care strategies**

Please review the provided content for fatigue self-care strategies and input her self-care strategies and plans for handling **fatigue**. Create her self-care strategy according to the following responses.

**What is your goal for managing your fatigue?**

Resting and taking vitamins

**Do you think you are eating/drinking enough to meet your body's energy needs?**

Yes

**Have you tried activities such as read, games, music, garden, experiences in nature?**

Yes

**Do you participate in any support groups and/or have family/friends you can rely on for support?**

No

**Have you tried activities to make you more relaxed (e.g. relaxation therapy, deep breathing, guided imagery, or massage therapy)?**

Yes

**Have you done any of the following to improve the quality of your sleep?**

I have consistent schedule for bedtime and getting up and I also avoid caffeine.

**Have you tried a program such as cognitive behavioral therapy or mindfulness-based stress reduction to manage your fatigue?**

No

### **Step 3: Reports**

1. Please save the created report.
2. View the report and create the document and email the pdf file to: [test@test.com](mailto:test@test.com).
3. Delete the report.
4. Now recover the deleted report by using the “load list”.

## **Scenario B: Sleep Problem Symptoms**

John Doe is a 64-year man, suffering from Genitourinary cancer. he is going through chemotherapy. Recently he has been experiencing sleep problem. We are using COSTaRS mobile app in order to manage his symptom.

Please change the patient's information (first and last name, date of birth and gender).

### **Step 1: Symptom triage and assessment**

Please input her **sleep problem symptoms** according to the following interview:

**Do you have problems with your sleep for 3 or more nights a week?**

No

**How worried are you about your sleep problem on scale of 0 to 10?**

6

**Do you have difficulty falling asleep?**

More than 3 days per week

**Are you having difficulty falling asleep more than 30 minutes every night?**

Yes

**Do you have difficulty staying asleep?**

More than 3 days per week

**Are you having difficulty staying asleep more than 30 minutes every night?**

Yes

**Early morning waking when not desired?**

No

**How long have these sleep problems been present?**

Less than 1 month

**Did the onset of this problem occur with another issue?**

Yes, with nausea and vomiting

**Are you taking any medicines that affect sleep? (e.g. opiates, steroids, sedatives, etc.)**

No

**Do you have other sleep disorders?**

No

**Which condition that applies to you?**

Anxiety

**Step 2: self-care strategies**

Please review the provided content for sleep problem self-care strategies and input his self-care strategies and plans for handling **sleep problem**. Create her self-care strategy according to the following responses.

**What is your goal for managing your Sleep problem?**

Taking lorazepam

**Have you kept a sleep diary?**

No

**Do you wake at the same time each day?**

No

**Do you get exposed to light soon after waking?**

No

**Do you take time to clear your head early in the evening (problem solve, write down plan)?**

Yes

**Do you have a 90-minute buffer zone before intended bedtime (e.g., read, watch TV, crossword puzzle, relax, listen to music, yoga, deep breathing, meditation, guided imagery)?**

Yes

**If you can't fall asleep within 20-30 minutes, do you get out of bed and return to bed when you are sleepy?**

No

**Have you done any of the following?**

Have consistent schedule for bedtime and getting up

### **Step 3: Reports**

1. Please save the created report.
2. View the report and create the document and email the pdf file to: [test@test.com](mailto:test@test.com).
3. Delete the report.
4. Now recover the deleted report by using the "load list".

## Appendix C: Recruitment

---

Hello,

We are testing a new mobile application for cancer-treatment related symptom management.

The mobile application allows the user to input their symptoms and store them as reports which can be accessed later and emailed as document. You will be asked to create an account in the app, make reports and also email the reports. Moreover, you will be asked to provide feedback regarding your experience with the app.

This study is being conducted by Reza Eynakchi, Reza Eynakchi, Faculty of Engineering, School of Electrical Engineering and Computer Science, University of Ottawa, under the supervision of Dr. Craig Kuziemy, Telfer School of Management, University of Ottawa.

You will participate in one, 60-minute evaluation session at the uOttawa faculty of engineering. During the session, you will be asked to use the COSTaRS Mobile Application and perform a set of defined tasks. The mobile application screen will be recorded while the app is running. After completing the tasks, you will also be asked to filled out a usability feedback form regarding your experience with the app

To volunteer for this study, or for more information, please contact Reza Eynachi \*\*\*\*\*@\*\*\*\*\*.\*\*).

Thank you for considering this request.

Reza Eynakchi

## Appendix D: Consent Form

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uOttawa

Université d'Ottawa

Faculté de génie

École de science informatique  
et de génie électrique

University of Ottawa

Faculty of Engineering

School of Electrical Engineering  
and Computer Science

**Title of the study:** Evaluation of The COSTaRS Mobile Application

**Name of researcher:** Reza Eynakchi (MSc candidate) under supervision of  
Prof. Craig Kuziemytsky;

**Invitation to Participate:** I am invited to participate in the “COSTaRS Mobile Application Usability Testing” research study. This study evaluates usability of a new patient centered mobile application.

**Purpose of the Study:** The purpose of the study is to evaluate the usability of the new COSTaRS mobile app. The COSTaRS mobile application allows the user to input their cancer treatment-related symptoms, create reports, also learn about selfcare strategies for each set of symptoms. In addition, users can save/load the reports from the server and review the history of created reports.



Moreover, the user can also email the report to healthcare providers to enable collaboration across the patients and healthcare providers. This study is being conducted as part of Master's thesis.

**Participation:** My participation will involve one, 60-minute session at the uOttawa faculty of engineering (STE building, the exact dates will be informed by email). During the session, I will be asked to use the COSTaRS Mobile Application and perform a set of defined tasks. The mobile application screen will be recoded while the app is running. After completing the tasks, I will also be asked to filled out a usability feedback form regarding my experience with the app.

**Risks:** My participation does not entail any risks beyond regular use of a mobile app.

**Benefits:** Learning about the testing process for mobile applications and how a usability study test can be designed and implemented for a specific app.

**Confidentiality and anonymity:** The information that is collected will remain confidential. My screen video recording will be used only for evaluating usability of the app. My data will be stored electronically on the secure laptop, and the data will be accessible only by the researcher and his supervisor. The

consent forms will be saved as physical documents in a locked cabinet in prof. Craig Kuziemy's office (DMS 6116) at the Telfer school, University of Ottawa. The video is anonymously and securely stored only in the researcher's laptop.

**Anonymity:** The data will be identified by a participant number, to maintain anonymity. The participant's name and contact will be saved and protected separately in the master identifying file which will be kept on the secured laptop and file. The results will be published in journal or conference publications as anonymized group data; therefore, there will be no name and email in the publications.

**Conservation of data:** Electronic data - Data collected in the mobile phone and laptop, which both are secured by a strong password. Hard copy data - All the hard copy data will be saved as physical documents in a locked cabinet in prof. Craig Kuziemy's office (DMS 6116) at the Telfer school, University of Ottawa. The anonymous indexed recordings are first saved on the secured, password-protected local memory of the smartphone being used in this study, then the recordings will be moved to a secured laptop and will be securely and unrecoverable deleted from the smartphone's memory. The recordings on the laptop will be password-encrypted and the laptop is also protected by a passphrase. The length of the data conservation will be 10 years.

**Voluntary Participation:** I am under no obligation to participate and if I choose to participate, I can withdraw from the study at any time and/or refuse to answer any questions, without suffering any negative consequences. If I choose to withdraw, all data gathered will be destroyed and will not be used.

**Recording:** The screen of the smartphone while using the app, will be recorded as a video only while the COSTaRS app is being used. The final result is an no sound video of the screen of the smartphone while the app is being used. This video is recorded to be used in the usability assessment of the COSTaRS app. The video is anonymously stored.

**Acceptance:** I, \_\_\_\_\_, agree to participate in the above research study conducted by Reza Eynakchi, Faculty of Engineering, School of Electrical Engineering and Computer Science, University of Ottawa, which research is under the supervision of Prof. Craig Kuziemytsky.

The project is funded by a Discovery Grant from the Natural Sciences and Engineering Research Council of Canada.

If I have any questions about the study, I may contact the researcher or his supervisor.

Contact information:

Researcher: Reza Eynakchi

Email: [\\*\\*\\*\\*\\*@\\*\\*\\*\\*\\*.\\*\\*\\*](mailto:*****@*****.***)

Telephone: \*\*\*\_\*\*\*\_\*\*\*\*

Office: DMS 6142, Telfer School of Management, University of Ottawa, 55 Laurier  
Avenue East Ottawa, Ontario K1N 6N5

Supervisor: Dr. Craig Kuziemsky

Email: [\\*\\*\\*\\*\\*@\\*\\*\\*\\*\\*.\\*\\*\\*](mailto:*****@*****.***)

Telephone: \*\*\*\_\*\*\*\_\*\*\*\*

Office: DMS 6116, Telfer School of Management, University of Ottawa, 55 Laurier  
Avenue East Ottawa, Ontario K1N 6N5

If I have any questions regarding the ethical conduct of this study, I may contact the Protocol Officer for Ethics in Research, University of Ottawa, Tabaret Hall, 550 Cumberland Street, Room 154, Ottawa, ON K1N 6N5  
Tel.: (613) 562-5387  
Email: [ethics@uottawa.ca](mailto:ethics@uottawa.ca)

Participant's signature:

Date:

Researcher's signature:

Date: