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# Design and Evaluation of a Multidisciplinary Cancer Conferencing Platform

*Master's Thesis in the Master Degree Program, Biomedical Engineering*

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CHALMERS UNIVERSITY OF TECHNOLOGY
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# Abstract

The ever-increasing complexity of medical sciences and growing demand to improve care quality has led to a new paradigm for medical practices. This new model proposes coordinated engagement of various medical practices in the process of care delivery. The proposed teamwork approach is of great importance in case of chronic conditions, such as cancer whose complexity and long lasting course of treatment impose huge burden on the healthcare systems. These factors, coupled with economic pressures to consolidate and centralize medical practices are driving the development of systems that can optimize access to specialized diagnostic services.

Considering the extent to which various specialized medical practices, such as pathology and radiology, have gone digital, current study focuses on the design and evaluation of a web-based medical application to improve access, quality, knowledge transfer, and cost-effectiveness. It aims at facilitating information exchange between members from multiple medical disciplines in cancer care team. Comprehensive literature review and empirical data gathering were conducted to analyze and identify challenges in current multidisciplinary cancer conferences.

Following national standards and Health Level 7 (HL7) message development framework has led to an object-oriented framework for design of the system. This approach supports required interoperability when interacting with external information systems. Unified Modeling Language is used to describe, analyze, and document existing use case scenarios around the intended multi-care case conferencing platform.

An adapted version of DeLone and McLean Information Success Model is proposed to evaluate the application at three different levels of technical, semantic, and effectiveness. Evidence from previous studies has shown the effectiveness of this approach to examine whether system benefits are realized and to track key system functionalities as an evaluation tool to flag issues.

# Acknowledgments

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# Table of Contents

# Acronyms

| Acronym | Meaning |
|---|---|
| CA | Certificate Authority |
| CCO | Cancer Care Ontario |
| CHI | Canada Health Infoway |
| CPD | Continuing Professional Development |
| CT | Computed Tomography |
| D&M | Delone and Mclean |
| DICOM | Digital Imaging and Communication in Medicine |
| EHR | Electronic Health Record |
| EMA | European Medicine Agencies |
| FDA | Food and Drug Administration |
| HIAL | Health Information Access Layer |
| HIT | Health Information Technology |
| HIS | Health Information System |
| HL7 | Health Level 7 |
| ICT | Information and Communication Technology |
| iEHRS | Interoperable Electronic Health Record Solution |
| MCC | Multidisciplinary Cancer Conference |
| MR | Magnetic Resonance |
| MEDLINE | Medical Literature Analysis and Retrieval System Online |
| NHS | National Health Services |
| NM | Nuclear Medicine |
| OO | Object-Oreinted |
| OTN | Ontario Telemedicine Network |
| PACS | Picture Archiving and Communication System |
| PKI | Public Key Infrastructure |
| PoS | Point of Service |
| PhRMA | Pharmaceutical Research and Manufactures of America |
| S/MIME | Secure/Multipurpose Internet Mail Extensions |
| SNOMED CT | Systematized Nomenclature of Medicine -- Clinical Terms |
| SOP | Service Object Pair |
| UHN | University Health Network |
| WHO | World Health Organization |
| WSI | Whole Slide Imaging |

# Chapter I – Introduction

# Background

In the last decade, common global trend towards improving quality of care and increasing patient safety through more personalized treatment and evidence-based medical practice has made health care industry subject to fundamental changes in the way it delivers various services. Care delivery has moved from an isolated, individualized process towards a highly dynamic practice, which requires collaboration between different specialties. This teamwork approach is especially of great importance in case of chronic diseases, such as diabetes, heart diseases, arthritis, inflammatory bowel disease, and cancer (1). The complexity of these conditions requires involvement of several disciplines through their long course of treatment. It also imposes huge burden on the healthcare systems around the globe in terms of healthcare expenditures and the amount of required resources and competence to obtain optimal treatment (2).

Traditionally, the process of care in oncology comprises screening, diagnosis, treatment (surgery, chemotherapy and radiotherapy), and follow-up. Throughout this process, interventions from various medical disciplines are often necessary. In three recent comprehensive studies (3-5) on the interfaces between different care providers along cancer care continuum, the authors investigate the challenges and opportunities to improve the efficiency and effectiveness of care delivery process. Their findings show that to achieve optimal care for cancer patients requires four factors to be realized:

1. Providers should collaborate with each other.
2. Care should be provided in the most optimal sequence.
3. Processes of care should be integrated in a way that ensure connection between providers and at the same time retain their autonomy and unique role.
4. Relationship between patient and care providers should be maintained.

In addition, survivorship plans, which include rehabilitation, supportive care, and follow-up plans, have been recently included in quality improvement initiatives in healthcare. This shift towards providing long-term support to help patients reintegrate with the society necessitates a clear definition of the respective roles of different care providers and at the same time seamless communication across the entire continuum of care (5, 6). Although there is still paucity of research in this field, efforts are underway to establish new standards and guidelines that support cancer survivorship; such an extensive process increases complexity (1, 7). Evaluation of the current state reveals the extensive amount of work required in terms of political, financial, and technical matters.

## Multidisciplinary Cancer Conference

To date, various shared care models have been proposed to increase inter-professional collaboration and achieve shared decision-making in the field of health care. Among them, Multidisciplinary Cancer Conferences (MCCs) have shown the greatest promise in maximizing communication and collaboration between different specialties throughout the entire care continuum (3-5, 8). These conferences are

defined as regularly scheduled meetings where each individual patient case is prospectively reviewed by a multidisciplinary team comprised of medical oncologists, radiation oncologists, surgeons/surgical oncologists, pathologists, radiologists, nurses, nutritionist and social workers. The primary goal is to ensure that all appropriate tests, treatment options, and recommendations are considered for each individual patient (9).

Since its introduction, MCCs have been gaining more and more interest and are recently considered as the most standard method of dealing with cancer cases in many countries. Evaluations of this method of care delivery have brought evidence that interdisciplinary approach is attributed with enhanced clinical decision making, patient/clinical staff experience, and clinical outcomes.

## International Experience

Many countries around the globe including Australia, the United States, the United Kingdom, and some other EU countries have recognized the effectiveness of multidisciplinary care in treatment of cancer (7, 8). Several studies including the two very recent by Wheless et al (10) and Freeman et al (11) reflect on the effectiveness of multidisciplinary approach on the treatment of patients with head and neck, and thoracic malignancies, respectively. The experience of Wheless and his colleagues with 120 consecutive head and neck cases presented at multidisciplinary boards reveals how shared approach affects the diagnosis and/or treatment plans in 45.3% of cases. The latter study on 535 patients with thoracic malignancies also shows encouraging results in terms of complete staging of disease, adherence to national guidelines, and timeliness of receiving treatment when each case is evaluated in a multidisciplinary setting. Published results of another study by Kupard et al at the University of North Carolina (12) also points out the positive clinical impact on patients with urologic malignancies. From economical perspective, Stalfors and his colleagues in Sweden (13) showed, when accompanied by telemedicine capabilities quality care can be delivered in lower prices.

Besides all positive impacts of MCCs, there are also reports showing interference in clinical daily practice caused by team meetings. In several studies including the one, the authors investigated the impact of the introduction of this new approach on the workflow of two main contributors, radiology and pathology practices. They revealed that inherent, active contribution of these two clinical streams to multiple meetings has increased daily practice workload up to 20%. This is mainly attributed to the time it takes for preparation and pre-meeting review of radiological and pathological materials (14).

Despite the geographical and system diversity within these countries, reflection on their experience with this new approach in medical practice reveals some of its key structural and functional components. In the UK, National Health Services (NHS) identified specifications for multidisciplinary teams working in cancer care in the Manual of Cancer Services Standards in 2004 (15). Simon van Belle (16) describes how important legal foundations are to mandate reorganization of oncology in a way that supports multidisciplinary care. In a more recent study by Prades and Borras (17), they reviewed the implementation of multidisciplinary cancer care within Spain's decentralized healthcare system. They described responsibilities of various stakeholders from therapeutic to managerial roles. They also identified critical factors for handling huge cultural change in clinical practice when introducing new

collaborative paradigm. In 2008, the reported results of a 2-year pilot study on a multi-institutional online tumor conference in Germany by Chekerov et al (18), indicated the potential benefits of using a web-based approach to facilitate participation. Although their proposed software application only provides audiovisual communication through a web server, where participants can log in, their successful experience of virtually conducting the meeting can be considered as the first step towards applying IT solution into this practice.

Recently, the notion that multidisciplinary cancer conferences have been accepted by many countries as a new standard of care is becoming more prevalent. Many theoretical studies and few reports on actual implementation have also suggested benefits of its usage, including reliable data collection, evidence-based clinical decision-makings, better adherence to clinical guidelines, increased patient access to clinical trials, enhanced coordination and cost-effectiveness of hospital services, reduced wait times, improved both patient and care provider experience, and inclined quality of life. However, there is still paucity of actual evidence that supports the role of this approach in cancer management. (4, 7, 10, 12, 19).

## Current Situation in Canada

In Canada, due to geographical diversity, provision of multidisciplinary care, which requires involvement of large number of stakeholders, is a complex process. Challenges exist in terms of access, cost, and coordination to achieve the most effective long-term treatment for cancer patients. Only in Ontario, where the 12.4 million inhabitants spread across more than one million square kilometers, more than 70% of cancer patients receive treatment in community settings with varying amount of resources and provider experience (9). The emphasis of the Ontario Excellent Care for All Act, 2010, on the quality and value of patient experience through evidence-based practice, has necessitated the existence of a solution capable of addressing human resource and case-costing constraints while supporting health equity, sub-specialization, service excellence, and research in cancer care continuum.

Recognizing the ever-increasing demand for timely and appropriate interaction among numerous stakeholders, Canada Health Infoway, an independent not-for-profit corporation, was formed to foster the development and implementation of electronic health record systems. Together with its partners, they identified the following five priorities for healthcare in Canada until 2015 (20):

1. Finalize the work underway in Electronic Health Record (EHR) (Figure 1), Telehealth and Public Health Surveillance
2. Implement Electronic Medical Record (EMR) systems in physician offices and Provider Order Entry systems in hospitals
3. Set up Wait Time Management Systems
4. Facilitate self-care management by empowering patients with access to their own health information
5. Integrate Chronic Disease Management systems

Despite positive international reports on the perceived benefits of Multidisciplinary Cancer Conferences (MCC), it has been only 5 years since cancer agency in Ontario established guidelines and mandated

implementation of MCCs (21). According to the recent study by Wright et al on the prevalence of MCCs in Ontario, (9), lack of administrative support and issues around scheduling the meetings are the most important limiting factors. In a more recent study by Look Hong and their colleagues (21), analysis of data collected from four hospital sites also revealed a number of factors, including administrative, structural, functional, and site-specific attributes that influenced the value of MCCs. Despite paucity of published literature on the work that has been done in Canada, the above studies clearly show that the current ad hoc process of data collection, exchange, and documentation for the purpose of synchronous and asynchronous case review is laborious. It not only hinders the primary function of MCCs, but also makes the secondary objectives, e.g. contribution to research, care quality improvement, and patient engagement hard to achieve.

The current shortcomings with respect to MCCs in cancer care are summarized in Table 1.

**Table 1 - Shortcomings with current use of MCCs in cancer treatment**

| Pre-meeting | Meeting | Post-meeting |
|---|---|---|
| Lack of administrative support | Frustration caused by navigating through large numbers of windows on the screen | Difficulties providing and documenting clear follow-up plans |
| Lack of appropriate scheduling solution | Lack of integration between clinical data sources | Lack of robust database for secondary user |
| Cumbersome data collection | Hybrid environment | |
| Excessive amount of time required for preparing presentation materials | | |

# Process Improvement

Recent technologic advances introduced new innovative methods and modalities that could potentially lead to improved diagnosis and treatment of various diseases. Among them is the existence of broadband internet connection, videoconferencing, and commercial hardware solutions that have enabled digitization of different aspects of care process including radiology and pathology practices. Despite full digitization of radiology, pathology practice is only just beginning to move towards widespread adoption of digital technology for diagnostic purposes. However, the encouraging results of well-designed validation studies on the integration of the state of the art technologies, such as Whole Slide Imaging (WSI), in pathology daily practice have brought hopes for the realization of digital transformation in closer future.

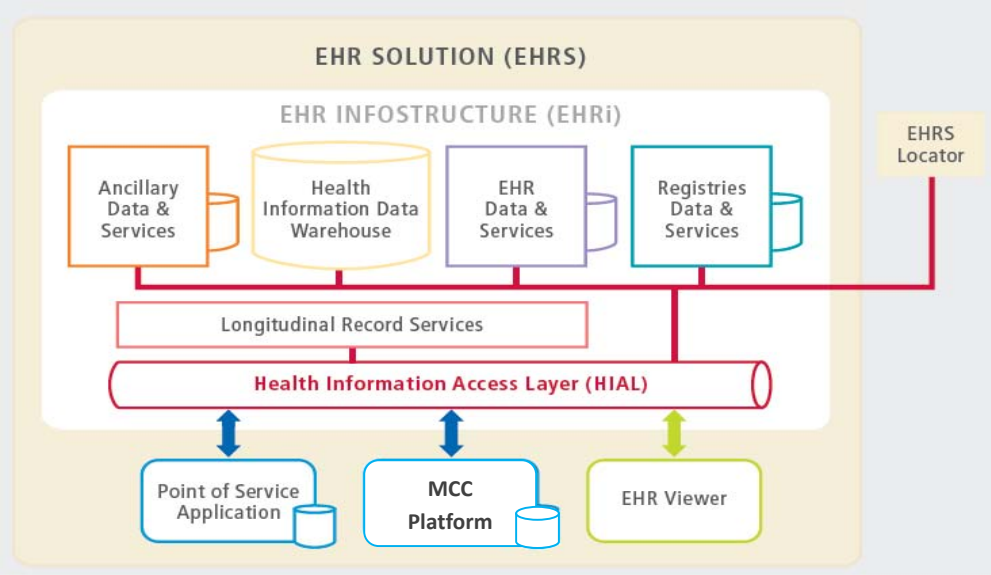
Likewise other healthcare or economic sectors, MCCs could also take advantage of the opportunities that IT brings to improve interdisciplinary care process, function, and outcome. With elimination of technology barriers, it is now possible to combine multidisciplinary integrated care delivery with affordable, reliable, and secure IT solutions to improve access, quality, knowledge transfer and cost

effectiveness. This can also address human resources and case costing constraints while supporting health equity, sub-specialization, service excellence and research.

## Purpose of This Project

This project aims to design and evaluate a computerized web-based platform to address current operational and organizational issues within the process of Multidisciplinary Cancer Conferencing in Ontario. To the best of my knowledge, there has been no documented effort to develop such a software platform. The proposed system will leverage latest IT solutions and provincial infrastructure to support information exchange and communication among clinical team members. The ultimate goal for this is to position the intended platform, as Point of Service (PoS) application within Canadian Electronic Health Record Solution (EHRS), as implementation of pan-Canadian EHR proceeds (Figure 1). This will lead to significant extension to its functionality. The standards based approach for the design and considering the high-level design requirements for interoperable EHRS provided by Canada Health Infoway and its jurisdictional partners ensures that the system will be aligned with both Canadian clinical requirement and international standards.

**Figure 1 - Infoway EHR Solution. Adopted from Canada Health Infoway's Executive Overview, (22)**




The system will provide means for integrating clinical data with scheduling, communication, and telehealth in order to facilitate both synchronous and asynchronous case review. Enabling patients to be directly involved in their case management through a patient portal is also considered as an important step towards including patients' perspective in the initial discussion and encouraging self-efficacy. Another important feature of such a system is providing means of formal integration of the MCCs' data element, with individual patient record. This data will be useful for future quality assurance activities. In addition, this project aims to address current needs to maintain expertise within healthcare sector

through introduction of innovative solutions that support continuity of educational activities and provide new educational materials.

Initial part of the project covers the first step towards designing the proposed system. This essential first step provides us with detailed information that can be used as blueprints for future implementation. At this phase of software development process, blueprinting ensures that business functionality is complete and correct, and end-user demands are met. It also supports future needs for scalability, robustness, security, extendibility, and other characteristics, which are difficult and expensive to achieve once the code is implemented.

The best way to visualize the design and check it against requirements before starting the implementation is using modeling techniques. Models not only bring us the big picture of the system by hiding or masking details, but also let us focus on different aspects of the prototype (23, 24). Throughout an iterative and knowledge discovery process, it is tried to identify and model users, use cases, and their association. Based on this information, a comprehensive use case model is developed. The process of software development always begins with designing the whole system.

Evaluation element of the present study focuses on providing a framework for future assessment of the system. In this section, it is tried to form the ground for the assessment of the proposed informatics products through identifying the best definition for success. Accordingly, measures and metrics that best fit within the MCC-context will be selected. This framework helps future steps of evaluation that include data gathering and analysis.

# Chapter II - Methodology

The following chapter is dedicated to elaboration of the approach used for the design and data gathering. This includes description and motivation for important choices made throughout the study.

## Literature Review

In order to obtain deep understanding of the purpose and functions of MCCs, identify current challenges and the best possible solution to address them, a comprehensive literature review was conducted. The literature can be divided into four categories including

1. reports on both national and international experience on the use of multidisciplinary approach in treatment of chronic diseases
2. available national standards for holding multidisciplinary meetings
3. standard healthcare data formats and architecture
4. modeling and software development methods

Data gathered from the literature is used to support findings from my own observations. It also helps make decisions about the best possible approach for the design and analysis of the intended system.

Literature studied comprises books, articles, published conference papers, reports and Internet pages. These sources are mainly found through academic databases, such as PubMED, MEDLINE, Science Direct, and Wiley, accessed through the University of Toronto Library website. Certain keywords, including *cancer, multidisciplinary, tumor board, practice guideline, and health informatics*, were used in different combinations as a first filter. The ultimate decision about the inclusion of the resource was made based on the title or abstract.

Citations are also used as a source for finding additional references.

## Environmental Scan

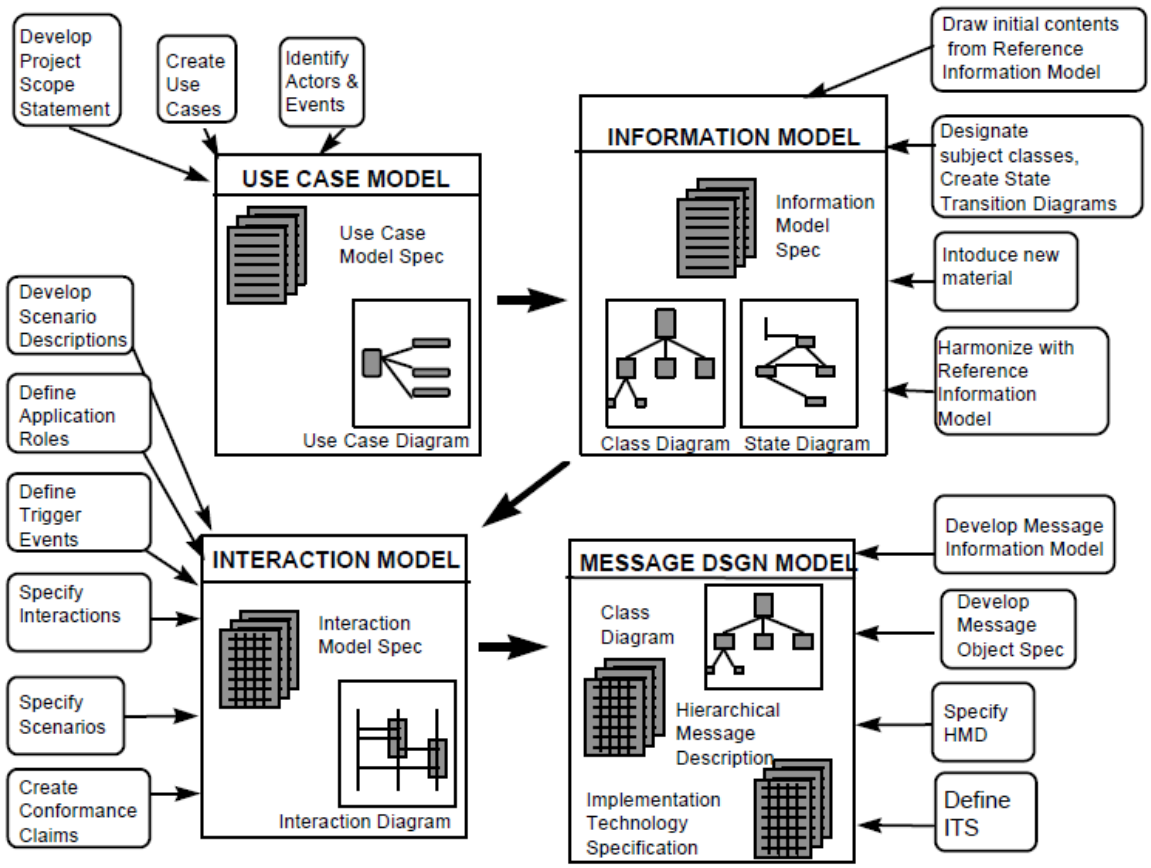
To learn about the process of MCCs from perspective of meeting attendees and, thus, better understand the workflow, 8 tumor boards were attended. These include 4 genitourinary and 3 gastrointestinal-colorectal rounds at University Health Network and 1 breast cancer tumor board at Mount Sinai Hospital. In addition, informal discussion with the meeting's chair and coordinator, and various specialists was performed.

This first-hand information, supported by the evidence from literature, is used throughout the study in order to make decisions about the various aspects and features of the system

## Design Method

Understanding the ever-increasing demand for interoperability of various information systems in healthcare domain, HL7 provides a methodology for development of HL7 messages that carry information between applications. The latest version of HL7 Message Development Framework (HL7 V3) proposes creating models and graphs during different stages of design. Considering the current best practice in software development, particularly the object-oriented methodologies, it identifies the following four types of models in order to fully visualize the system (Figure 2).

**Figure 2 - Four types of Model for Visualizing the Whole System. Adopted from Beeler et al** (25)




- *Use Case Model* – By definition, a *Use* Case is an interaction between the system and an *Actor (User)* that causes the system to fulfill a responsibility and, as a result, to produce a product of value for the *Actor* (26). Therefore, use cases can be considered as real world scenarios for system performance. Analysis of use cases extends the high-level scope statement of the project and provides detailed view of the application to the environment in which it runs. It also identifies various parties acting in specific healthcare domain and their expected product of value from the system. In case of HL7 use cases, the focus is on the need for exchange of

information between various independent systems within healthcare. The formal result of the iterative process of use case analysis will be documented in Use Case Model and defines system boundaries and responsibilities.

- *Information Model* - It provides a general overview of the information domain of the system under development. This model is obtained after identifying static structures (people, places, roles, things, events, and their relationships), information content, and dynamic behaviors. It ensures connectivity of data semantics and lexicality transferred within HL7 messages. Therefore, in case of our computing platform, which requires data transfer between different systems, architectures, and languages, meaningful information can be carried in the field of HL7 messages.
- *Interaction Model – It defines* dynamic picture of the system can be represented by the interaction model. Based on the results of two previous modeling procedures, the model identifies the information flow between various parties through exchange of HL7 messages.

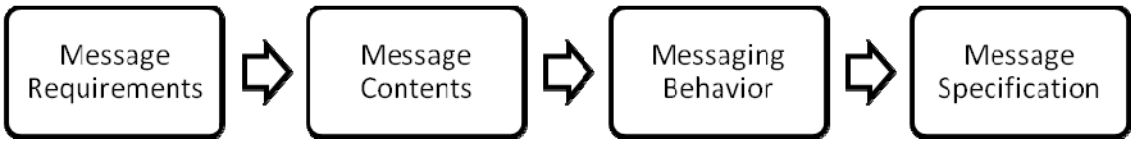
Following the steps identified in this framework leads to standardized information, message structures and business transactions to support interoperability and exchange of information in and out of the EHR. This message-oriented model of communication lets the interacting systems understand the data in an unambiguous and uniform manner. This framework follows a typical development life cycle (Figure 3) and comprises of the following three highly iterative phases: Requirements, Analysis, and Implementation (25).

**Figure 3 - Typical Software Development Life Cycle**


The proposed methodology for the design of the Multi-Care Case Conferencing Platform is based on the HL7 V3. This methodology complies with the guidelines proposed by Infoway's Blueprint to document clinical business requirements for the purpose of design of EHR's conceptual and technical architecture (22). The main advantage of using this version of HL7 messaging standard over the previous ones is the extension of the design to the level that supports larger context of "system conformance". Having complete information about both message content and system conformance has led to considerable decrease in site-specificity issues when it comes to interfacing or integrating different information systems. Additionally, its object-oriented nature allows us to combine data structures with functions and, thus, build reusable objects. It also supports unique privacy and security requirements when it comes to exchange of EHR data at the point of service.

According to the Figure 4, the whole process is divided into four stages (25):

**Figure 4 - Four steps for HL7 Message Development**




1. Message Requirements: defines the scope of the system through specification of users and system responsibilities.
2. Message Contents: indentifies data carried within each message.
3. *Messaging Behavior*: focuses on interactions that support system's functionality. These interactions identify situations in which messages will be needed. Following indicate triggers for information exchange.
4. Message Specification: precisely defines HL7 messages based on the results of the past three stages.

Following each stage, different aspects of the proposed system, including its function, static structure, and dynamic behavior, will be captured and documented within a model or several associated groups of models.

To describe the system, Unified Modeling Language (UML) is utilized. The UML is a standardized modeling language that helps in describing and designing software systems, particularly the ones built using the Object-Oriented (OO) method, regardless of the methodology used to gather and analyze the requirements. It includes a set of graphical notations to visualize static structure, dynamic behavior, and aspects of interaction within the system (23, 24). Its visual representation of different aspects of an artifact being developed, are useful to understand, design, modify, and share the design for future implementation.

# Chapter III - Modeling

## Use Case Model

The development phase of our intended MCC platform starts with building a comprehensive use case model. Through this highly iterative, architectural, and knowledge discovery process of actor and user identification, documentation, and association, we will be able to understand 1) why the system is being developed; 2) what it is expected to do for the users; and 3) how the users are going to use it to facilitate their practice. According to HL7 standard, each iteration of the process should follow the following steps:

1. Project Scope Development
2. Actors Identification
3. Use Case Identification and Documentation
4. Actors and Use cases Association

Following these steps helps us define system boundaries and responsibilities, which is of vital importance to avoid being trapped in scope creep. Besides yielding a clear definition to the project scope, it naturally provides us with a framework for testing the system and at the same time system's user documentation.

Since use case analysis is a top-down process, we first start by defining a general high-level overview of the system. As the analysis proceeds, more facts and details about the users and their expectations from the system will be revealed. Based on these information, we can modify and break down the whole system into smaller subsystems each of which having its own actors and responsibilities. In order to fulfill the ultimate goal of the whole system, proper communication between the defined subsystems is vital.

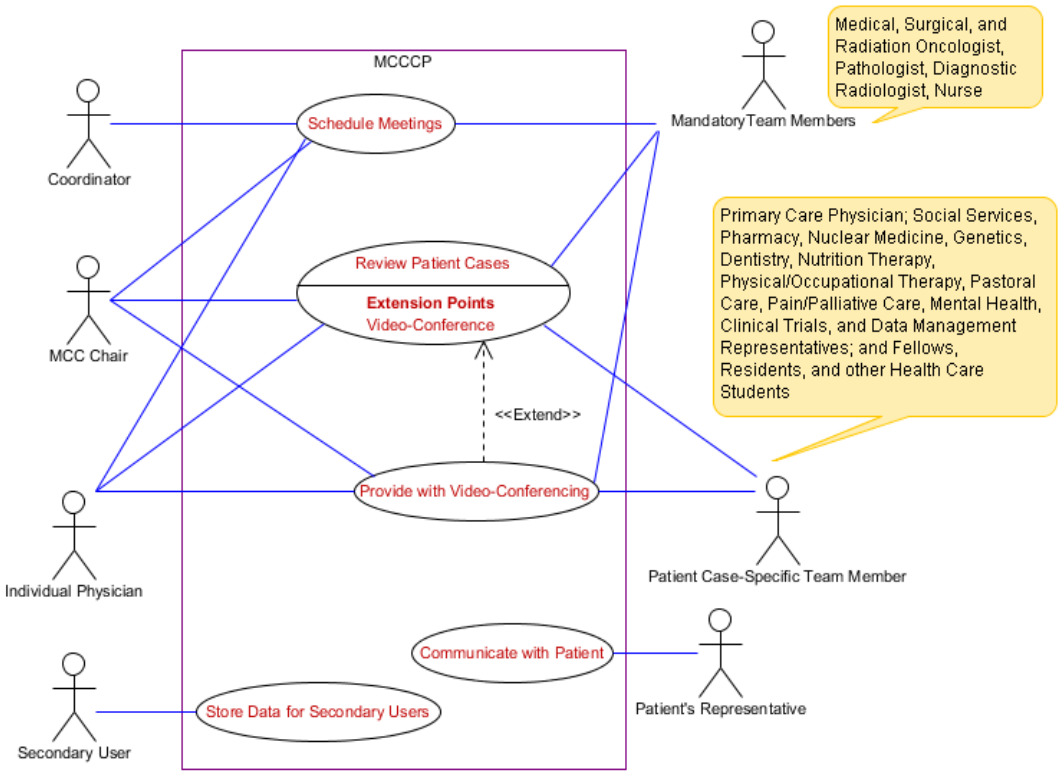
In healthcare, where multiple systems from various vendors, each with their own set of standards for data collection, presentation, analysis, and transmission, exist, communication between existing systems is even more crucial. Decomposition should be continued to the level, where HL7 messaging subsystems within various physical healthcare information systems become apparent. At this level, use cases are only initiated with only one actor, called sending application role. Thus, the structure and content of required messages that must be transferred between various systems can be precisely defined.

### Root Use Case

The most high-level overview of the system is depicted (Figure 5) based on the project scope statement, which is "*development of a scalable and generalizable software platform to support multidisciplinary conferencing for complex cases and to engage patients in their own case management locally and across Ontario*". Since all the functionalities of this area of healthcare should be supported by this computing platform, we refer to the available standards for MCCs and environmental scan to capture the minimum requirements. According to a special report published by Cancer Care Ontario (CCO) on MCC Standards,

the mandatory team members of such conferences comprised of a designated chair, a coordinator, and representatives from medical oncology, radiation oncology, surgery/surgical oncologists, pathology, diagnostic radiology, and nursing (9). CCO also provided disease site attendance criteria, which specifies additional specialties to maximize benefits that a certain patient types/cases can get from the meetings (27) . At this stage, identification of users who are lying outside the system leads to define system boundaries. In order to prevent the graphical representation of the high-level overview being filled with multiple actors of this level, three abstract actors (Mandatory Clinical Team Members, Patient Specific Case Team Member, and Secondary User) are introduced. For the root use case, project scope statement is considered for its documentation.

**Figure 5 - Root use case**




In order to achieve more clear description of the sub-systems involved in realization of the above five responsibilities, the next step is decomposition of each use case into more intermediate-level ones. This architectural process leads to identification of individual building blocks of the whole system. As we move down the hierarchy, application roles, which are non-human actors, will gradually take the place of real actors. This process is mainly done based on the available standards and real user's experience and opinions on how the whole process should be managed in real world.

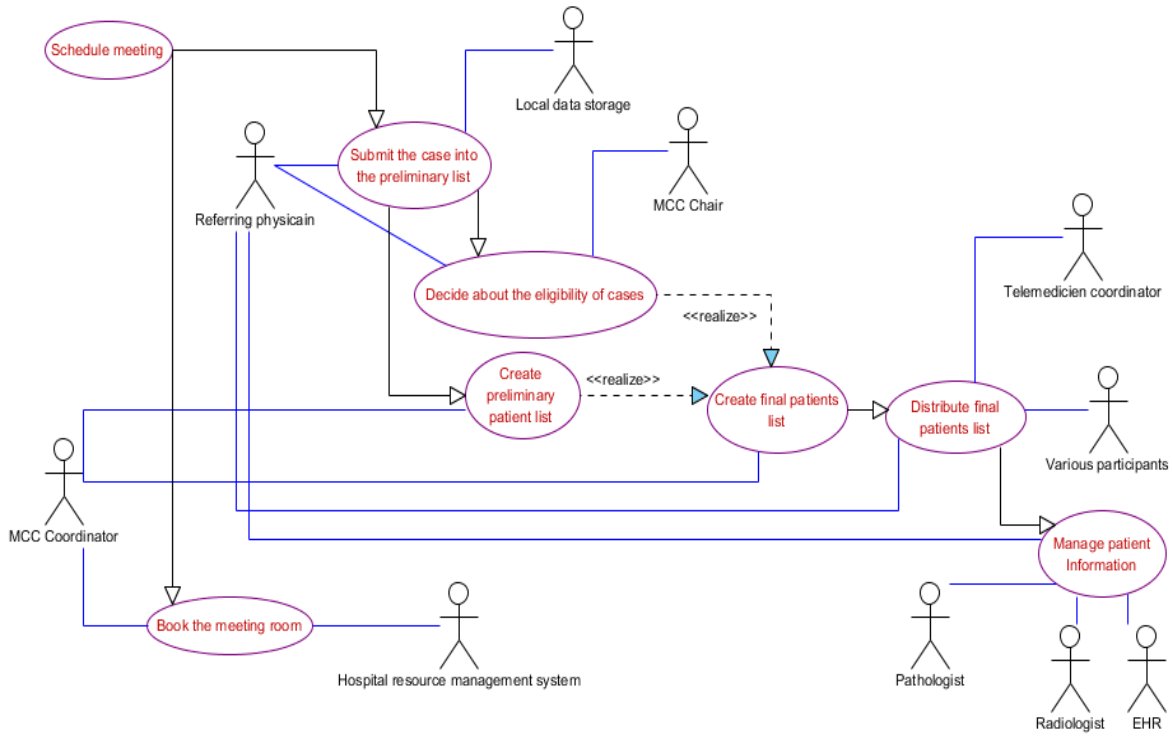
## Schedule Meeting

Based on preliminary environmental studies and MCC Standards (9), to schedule meetings, the intended system has to take the responsibility for the following four tasks.

1. Create the list of patient cases
2. Ensure all relevant up-to-date patient information is submitted
3. Book the meeting room
4. Notify all core and patient-specific members

Accordingly, the "Schedule Meeting" use case can be decomposed further into lower level use cases (Figure 6).

**Figure 6 - Schedule meeting use case**




The scenario for this decomposition starts with submission of patient cases for being reviewed in a meeting. The standards for MCC (9) indicates that it is the responsibility of individual physicians to forward all MCC cases, including new, recurrent, or metastatic cancer cases from inpatient or ambulatory patients. The referring physician should clearly identify the reason for the referral. The referrals can be filed on a local storage. Once the deadline for case submission is passed, MCC coordinator forms the preliminary patient list to be reviewed by the meeting chair and referring physician. Then, depending on the amount of time available the MCC, they will make the decision about whether each case can/should be presented at a particular meeting. Identifying the criteria that make each case eligible for being discussed in a meeting is of great importance to speed up the decision-process. Complicated cases will necessarily require more time and should be identified in advance to

facilitate a streamlined order of presentation (ie: the most complicated go first so that the quality of the discussion is not compromised by time pressure). Existence of a pre-structured referral form not only avoids confusion about required information for making the referral but also facilitates the process of decision making about the eligibility of cases for being discussed in the meeting. It should clearly indicate the reason behind consultation request. Tables 2 and 3 describe decomposition of "Schedule meeting" model use case.

In order to not compromise timely patient care for urgent cases, some sort of backup option such as an email discussion among the MCC members is also considered in the standards.

In case of having remote consultation, telemedicine coordinator should also be informed about the place and time of the meeting in order to establish connection between participating sites.

**Table 2 - Actors in the presented model for schedule meeting use case**

| **Actors in: Model for schedule meeting use case** |
|---|
| Actor: **EHR**<br>System takes care of patient clinical information. |
| Actor: **Hospital resource management system**<br>The system used by the institute to manage its physical resources such as meeting rooms. |
| Actor: **Local data storage**<br>System that stores the record of submitted cases for consultation. |
| Actor: **MCC chair**<br>The individual who is responsible for the actual running of the meeting. |
| Actor: **MCC coordinator**<br>The individual who is responsible to schedule the meetings and make sure all relevant patient data is available before each meeting. |
| Actor: **Pathologist**<br>The Individual in charge of giving/presenting/discussing consult on the pathologic findings. |
| Actor: **Radiologist**<br>The Individual in charge of giving/presenting/discussing consult on the radiologic findings. |
| Actor: **Referring physician**<br>Person who makes the referral. |
| Actor: **Telemedicine coordinator**<br>The individual in charge of establishing and maintain connection between remote parties participating in a meeting. |
| Actor: **Various participants**<br>Persons whose expertise is required to give consult for the patient case. |

**Table 3 - Use cases in the presented model for schedule meeting use case**

| Use cases in: Model for schedule meeting use case |
|---|
| Use case: **Book the meeting room**<br>The physical location of the meeting should be booked in advance.<br><br>Is child of: **Schedule meeting**<br><br>Involves actions by: **MCC coordinator**<br>Involves actions by: **Hospital resource management system** |
| Use case: **Create final patient list**<br>Once the MCC chair and referring physician agreed on the eligibility of the patient case to be discussed at the meeting, MCC coordinator creates a list of patients. The list can be considered as a shared document to be filled out by the participants. This way responsible individuals can work simultaneously on each referral and the coordinator can monitor the progress of information gathering to make sure all relevant patient data is available prior to each meeting.<br><br>Is parent of : **Send the list to the participants**<br><br>Involves actions by: **MCC coordinator** |
| Use case: **Create preliminary patient list**<br>Once the deadline for case submission is passed, the coordinator creates preliminary case list. The list will be used by individuals in charge of making decision about the cases being discussed.<br><br>Is child of: **Submit the case into preliminary patient list**<br><br>Is parent of: **Create final patient list**<br><br>Involves actions by: **MCC coordinator** |
| Use case: **Decide about the eligibility of cases**<br>Based on the information provided in the preliminary list, responsible individuals identify appropriate cases for being discussed.<br><br>Is parent of: **Create final patient list**<br><br>Involves actions by: **MCC chair**<br>Involves actions by: **Referring physician** |
| Use case: **Distribute final patient list**<br>Final list should be distributed among key participants for reviewing the case and gathering relevant information.<br><br>Is child of: **Decide about the eligibility of cases**<br>Is child of: **Create preliminary patient list with triaged order of presentation based on perceived complexity**<br><br>Is parent of: **Manage patient information**<br><br>Involves actions by: **Referring physician**<br>Involves actions by: **Telemedicine coordinator**<br>Involves actions by: **Various participants** |

| Use cases in: Model for schedule meeting use case | |
|---|---|
| Use case: **Manage patient information** | Once the final patient list is distributed, it is the responsibility of the assigned key participants to look for appropriate clinical evidence.<br><br>Is child of: **Distribute final patient list**<br><br>Involves actions by: **EHR**<br>Involves actions by: **Pathologist**<br>Involves actions by: **Radiologist**<br>Involves actions by: **Referring physician** |
| Use case: **Submit the case into preliminary patient list** | In order to refer a case, the referring physician should submit the case to a preliminary patient list. At this stage, a clear reason for making the referral and a brief clinical information should be provided for making decision about the eligibility of the case to be discussed.<br><br>Is child of: **Schedule meeting**<br><br>Is parent of: **Create preliminary patient list**<br><br>Involves actions by: **Referring physician**<br>Involves actions by: **Local data storage** |

## Manage Patient Information

Once consults are scheduled, assigned physicians seek relevant evidence to provide recommendations and treatment options. During the environmental scan, it was observed that having a mechanism to integrate different data elements while preserving autonomy of each individual physician in gathering relevant data would be of great importance. It enables monitoring the progress in data gathering to ensure that all data elements are available prior to the meeting. On the other hand, integration of each patient's data in a single package improves the quality of presentation as it avoids cumbersome navigation between them during the limited meeting time.

These needs promote the idea of having a collaborative tool, which users can use to generate case reports. The idea comes from cloud computing concept in which applications and data are provide and managed by a cloud server. Therefore, a shared digital report package for each case can be formed and stored in a cloud configuration to allow multiple-users to work on a patient case simultaneously while contributing to generate the report. Besides providing real-time collaboration among users, this approach can provide several other services that are of great use in MCC context, including:

- ***Notification***: Notifications can be sent, via email for example, to MCC coordinator when users change the shared documents. Thus, MCC coordinator, who is in charge of ensuring all relevant data is obtained, can easily monitor the process.
- ***Access control***: Providing secure authentication method can protect the report against unauthorized access.

- ***Mobilization***: Networked access to the report via any using a computer, smart phone, or any other devices with network capability provides freedom to the users as they can work from anywhere with a network connected mobile device.

As illustrated in Figure 7, once eligibility for consultation is approved, the referring physician, a pathologist, and a radiologist will be assigned to gather required information for each case, including patient clinical history, pathology slides (that must be reviewed and selectively converted into digital images) , and radiology images.

Regardless of the type of information, the whole process of gathering patient information always begins with authenticating the authorization of the user. Following verification of user's authority over data, the actual information can be gathered by communication with shared data repositories.

Authentication of the user can be seen as the first point of contact with a PoS. To accommodate increasing demand for privacy and security of health information, HL7 v3 recommends using more advanced technologies to authenticate requests for the provided services (25).

**Figure 7 - Manage patient information use case**

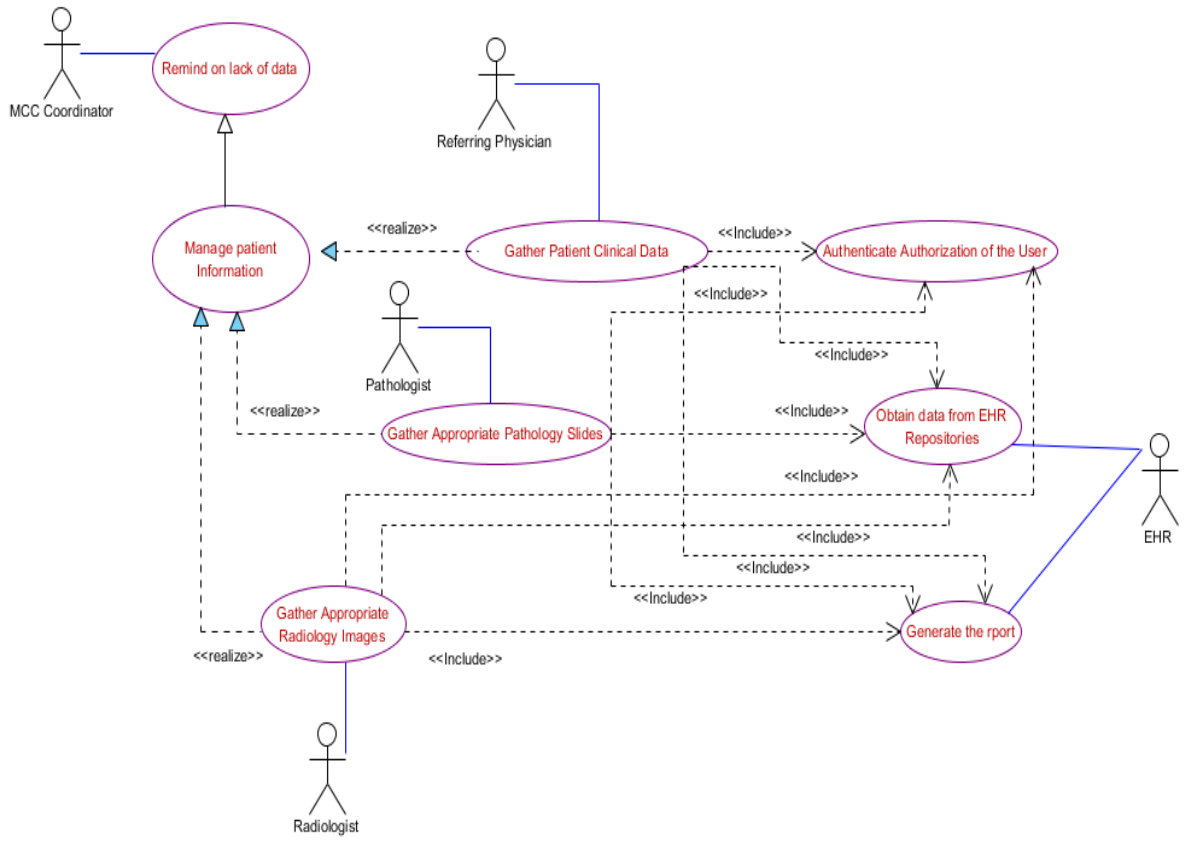


**Table 4 - Actors in the presented model for manage patient information use case**

| Actors in: Model for manage patient information use case |
|---|
| Actor: **EHR**<br>The system takes care of patient clinical information. |
| Actor: **MCC coordinator**<br>The individual in charge of tracking the process of patient information gathering. |
| Actor: **Pathologist**<br>The person in charge of gathering and reviewing relevant pathology slides. |
| Actor: **Radiologist**<br>The person in charge of gathering and reviewing relevant radiology images. |
| Actor: **Referring physician**<br>The individual who makes the referral. |

**Table 5 - Use cases in the presented model for manage patient information use case**

| Use cases in: Model for manage patient information |
|---|
| Use case: **Authenticate authorization of the user**<br>The identity of the user should be confirmed before being able to use the system.<br><br>Is child of: **Gather patient's clinical data**<br>Is child of: **Gather appropriate pathology slides**<br>Is child of: **Gather appropriate radiology images** |
| Use case: **Gather appropriate pathology slides**<br>Assigned pathologist looks for relevant pathology slides containing evidence to provide consultation. The slides are then reviewed to select those required for digitization to address issues raised by the referring physician.<br><br>Is child of: **Manage patient information**<br><br>Is parent of: **Authenticate authorization of the user**<br>Is parent of: **Obtain data from EHR repositories**<br>Is parent of: **Generate the report**<br><br>Involves actions by: **Pathologist** |
| Use case: **Gather appropriate radiology images**<br>Assigned radiologist looks for relevant radiology images containing evidence to provide consultation.<br><br>Is child of: **Manage patient information**<br><br>Is parent of: **Authenticate authorization of the user**<br>Is parent of: **Obtain data from EHR repositories**<br>Is parent of: **Generate the report**<br><br>Involves actions by: **Radiologist** |

| Use cases in: Model for manage patient information |
|---|
| Use case: **Gather patient's clinical data**<br>Referring physician seeks for relevant patient personal and clinical information such as LAB results<br><br>Is child of: **Manage patient information**<br><br>Is parent of: **Authenticate authorization of the user**<br>Is parent of: **Obtain data from EHR repositories**<br>Is parent of: **Generate the report**<br><br>Involves actions by: **Referring physician** |
| Use case: **Generate the report**<br>The obtained information from data repositories will be utilized to report on the findings<br><br>Is child of: **Gather patient's clinical data**<br>Is child of: **Gather appropriate pathology slides**<br>Is child of: **Gather appropriate radiology images**<br><br>Involves actions by: **EHR** |
| Use case: **Manage patient information**<br>The healthcare provider (tumor board team) keeps track of patient information in order to consistently link all health and healthcare service related information for a person.<br><br>Is parent of : **Remind on lack of data**<br>Is parent of : **Gather patient's clinical data**<br>Is parent of : **Gather appropriate pathology slides**<br>Is parent of : **Gather appropriate radiology images** |
| Use case: **Obtain data from EHR repositories**<br>Once the authorization of user is proven, desired patient information is sought for in the existing health data repositories.<br><br>Is child of: **Gather patient's clinical data**<br>Is child of: **Gather appropriate pathology slides**<br>Is child of: **Gather appropriate radiology images**<br><br>Involves actions by: **EHR** |
| Use case: **Remind on lack of data**<br>During the time when responsible physicians are gathering relevant up-to-date patient information, the system should notify about any changes or missing information.<br><br>Is a child of: **Manage patient information**<br><br>Involves actions by: **MCC coordinator** |

## Gather Patient Information

Utilizing such a software platform to manage patient information in the context of MCC relies on the assumption that patient related data is available in digital format. Unlike radiology, this is currently not the case for most pathology departments in Ontario/Canada. Glass slides for a given case must be reviewed by a pathologist to select specific slides for conversion into digital images. With the existence of various clinical information systems and their different components that cover informatics requirements of different sectors within a hospital, such as administrative, financial, and clinical, we can assume that clinical information, for the most part, is available at the hospital level in Canada. Upon implementation of a pan-Canadian EHR, local digital data can be shared among the health centers regardless of their physical location.

As demonstrated in Figure 7, two thirds of the whole process of managing patient information responsibility is related to imaging needs (radiology images which already exist and pathology glass slides which must be reviewed and digitized). In case of MCCs, clinical images are utilized to provide visual evidence about clinical findings in terms of diagnosis, etiology, and mechanism of disease at cellular level including structural changes and their manifestation. The way this information is gathered and presented during the meeting is important for the effectiveness of the shared decision-making process. This is not only because it can improve clinical workflow, but also due to its ability to enhance the overall experience of tumor boards by empowering the participant with real time flexibility in responding to the questions and comments and increasing satisfaction of all participants (28). Understanding these needs is essential to identify functions that our intended software platform is going to support.

For the purpose of MCC, supporting visual materials comprise medical images, obtained from various medical-image acquisition modalities such as Computed Tomography (CT), Magnetic Resonance (MR), ultrasound, and Nuclear Medicine (NM) imaging, as well as pathology slides (29). According to the published standards (9), a radiologist and a pathologist will be assigned to gather imaging data and report on the findings once decision about appropriateness of each consults is made.

The whole story of obtaining medical images begins with the question of “whether digital replica of radiology images and pathology slides are available”. It has been more than two decades since radiology has first experienced a huge change in its day-to-day practice by introduction of digital radiology. Despite the existence of many challenges in the beginning, as technology has evolved and standards have been established, digital radiology has been introducing new capabilities and become the standard approach for medical imaging workflow in many countries. Since the standardization of Picture Archiving and Communication System (PACS) that facilitates storage, retrieval, and access to medical images, radiology practice has been reliant on digital capabilities so much that return to the pre-digital era is not imaginable for imaging specialists.

As with digital radiology, it is now believed that transformation to soft copy reading environments is possible for pathology practice as well. From different proposed methods to digitize pathology practice, such as static, and dynamic robotic microscopy and WSI, the latter has shown good promise to realize

the transformation. Although tumor boards would seem like an obvious application for WSI technology (WSI is in fact being used for this purpose in many centers), but there is a paucity of literature on the subject. Spinosa (28) provided a comprehensive overview of a pilot project looking at the effectiveness of using WSI for tumor boards at Scripps La Jolla Memorial Hospital in San Diego, CA. This study demonstrates benefits such as increased efficiency for pathologists when preparing cases for presentation, improved quality in terms of information that is presented to clinical colleagues and increased satisfaction on the part of all who attend these meetings. Dr. Evans and colleagues at the University Health Network in Toronto have also used WSI for primary diagnoses since 2006. The encouraging results of their experience has led to recent expansion of the project to provide primary frozen section support to a hospital 643 kilometers north of Toronto. Based on their experience, availability of digital pathology slides at least at the provincial scale could be feasible (30). Once guidelines on monitor resolution, image quality, and DICOM standards (Supplement145 “Whole Slide Microscope Image Information Object Definition and Service/Object Pair Classes”) to create interoperability between WSI platforms, compression (JPEG2000) and retention of digital slides used for diagnostic purposes are established, it is expected that pathological information will be pushed into EHR and shared across different entities (31). Thus, likewise other domain specific repositories such as PACS, MCC application can retrieve pathological information from EHR.

Assuming virtual slides are available, which is true at least at local settings, “Obtain data from EHR Repository” use case can be decomposed as shows in Figure 8. Decomposition at this level is based on the DICOM’s structure for searching and retrieving data. Detailed description of each component can be found in Table 6 and Table 7.

**Figure 8 - Obtain data from EHR**

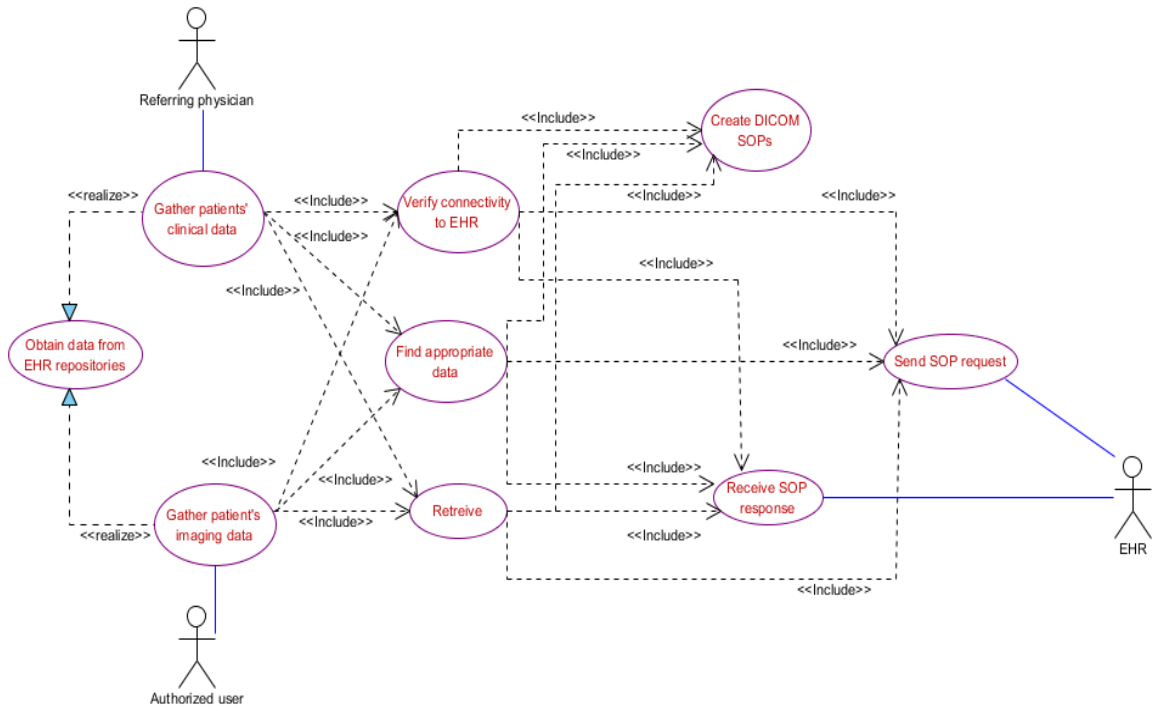


**Table 6 - Actor in the presented model for obtain data from EHR**

| Actors in: Model for obtain data from EHR use case |
|---|
| Actor: **Authorized user**<br>Individuals responsible for gathering relevant patient information, including a radiologist and a pathologist. |
| Actor: **EHR**<br>The system takes care of patient clinical information. |
| Actor: **Referring physician**<br>The individual who makes the referral. |

**Table 7 - Use cases in the presented model for obtain data from EHR**

| Use cases in: Model for obtain data from EHR use case |
|---|
| Use case: **Create DICOM SOPs**<br>Create queries to find the existing matches in EHR data repositories<br><br>Is child of: **Obtain data from EHR repositories** |
| Use case: **Find appropriate data**<br>Based on the response of EHR, the user should select the most appropriate data for each case.<br><br>Is child of: **Obtain data from EHR repositories**<br><br>Is parent of: **Create DICOM SOPs**<br>Is parent of: **Send SOP request**<br>Is parent of: **Receive SOP response** |
| Use case: **Gather patient clinical data**<br>Gather patient clinical data, including clinical history, medication history, etc.<br><br>Is a child of: **Obtain data from EHR repositories**<br><br>Is parent of: **Verify EHR connectivity**<br>Is parent of: **Find appropriate data**<br>Is parent of: **Retrieve** |
| Use case: **Gather patient imaging data**<br>Gather patient relevant radiology and/or pathology information.<br><br>Is child of: **Obtain data from EHR repositories**<br><br>Is parent of: **Verify EHR connectivity**<br>Is parent of: **Find appropriate data**<br>Is parent of: **Retrieve** |
| Use case: **Obtain data from EHR data repositories**<br>Healthcare professionals responsible for discussing the case are in charge of obtaining relevant patient data from EHR data repositories. The data falls into two categories: clinical and imaging data. |

| Use cases in: Model for obtain data from EHR use case |
|---|
| Is parent of : **Gather patient's clinical data**<br>Is parent of : **Gather patient's imaging data** |
| Use case: **Receive SOP response**<br>Receive the response from EHR.<br><br>Is child of: **Obtain data from EHR repositories** |
| Use case: **Retrieve data**<br>Save a local copy of the data to be added to MCC report.<br><br>Is child of: **Obtain data from EHR repositories**<br><br>Is parent of: **Create DICOM SOPs**<br>Is parent of: **Send SOP request**<br>Is parent of: **Receive SOP response** |
| Use case: **Send SOP request**<br>Send the prepared query to EHR.<br><br>Is child of: **Obtain data from EHR repositories** |
| Use case: **Verify EHR connectivity**<br>Establish network connectivity between PoS application and EHR.<br><br>Is child of: **Obtain data from EHR repositories**<br><br>Is parent of: **Create DICOM SOPs**<br>Is parent of: **Send SOP request**<br>Is parent of: **Receive SOP response** |

According to the Canadian blueprint for an interoperable EHR framework, HIAL will serve as a gateway that integrates PoS applications with the other components of information management structure (22). Its common services layer comprises functions, such as user authentication, that address privacy and security requirements (32).

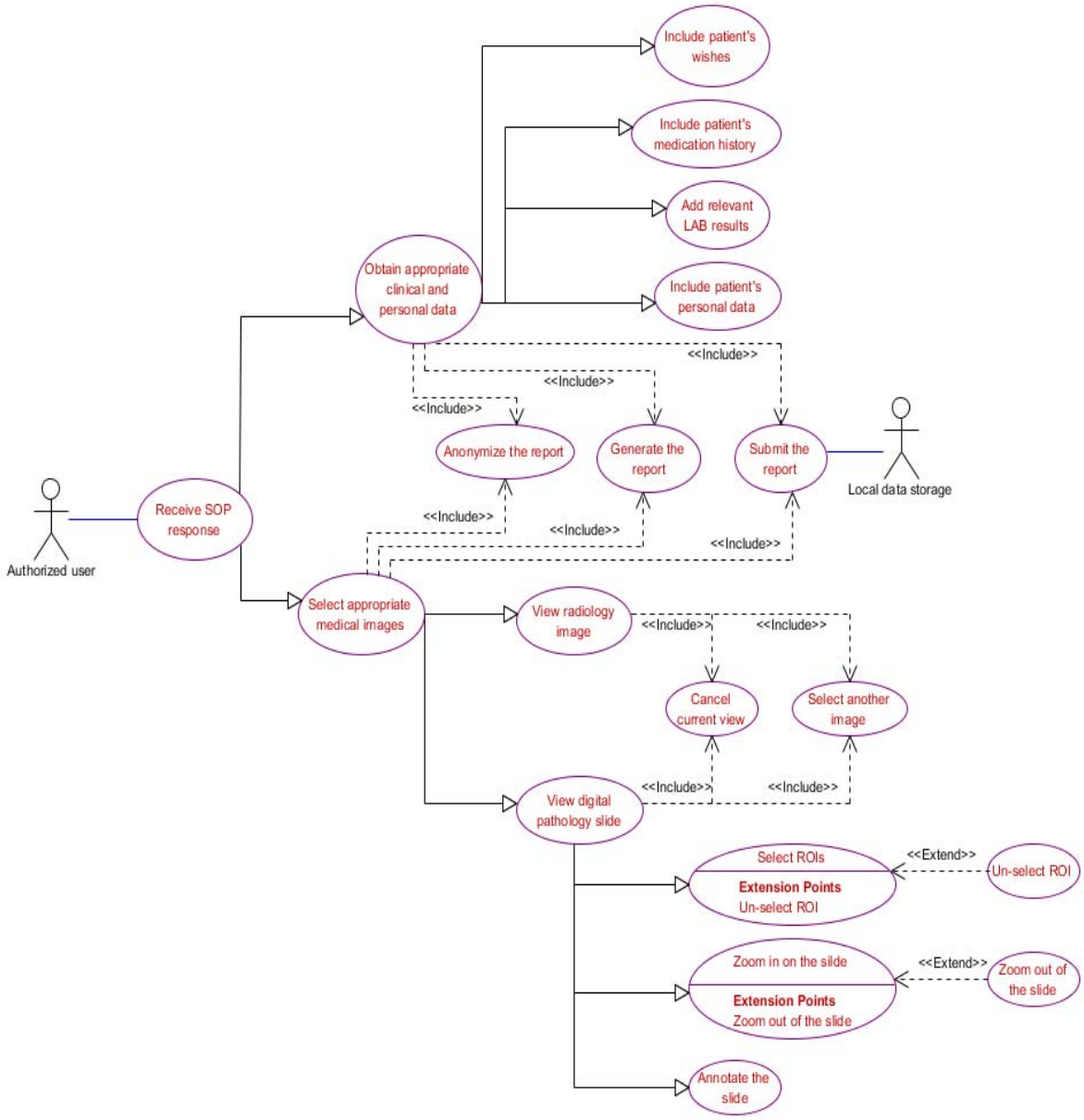
Once the authorized user is connected to the EHR, he/she looks for desired information by preparing queries to find the existing matches in EHR data repositories. The result of the search will be sent back to the physician. After the related data is chosen from EHR response, further processes can take place to gather necessary information for the MCC. Standard message definitions, such as DICOM and HL7, are required for interoperability.

DICOM services facilitate querying and retrievals. Based on the data type, required SOPs can be selected from the list of standard DICOM SOPs. Providing instances of these SOP classes with appropriate data object elements via a DICOM interface will fulfill the requirements illustrated in.

## Generate Specialized Report

According to Figure 9, once data is retrieved from EHR, the application provides appropriate means for reading and interpreting the content. For textual information, such as laboratory results, data content of the messages will be in accordance with HL7 Reference Information Model (RIM) to ensure interoperability between this application and EHR. In case of medical visual data, such as various radiology images and pathology slides, it is transferred in DICOM format. Therefore, the software should provide specific file viewer capable of showing highly precise medical images with their respective attributes, such as colors, width, height, size of detected objects within the image, and etc.

**Figure 9 - Receive SOP response**



In both cases, the application should be able to meet security requirements, such as anonymization, that protects confidentiality of information in public domains (29). Although this service is planned to be provided by HIAL, local de-identification of data can be implemented within the platform to ensure security of data during the time that national EHR is not in hand. Anonymization software should look for confidential data at two levels (22, 29):

1. Confidential attributes within the standard DICOM data dictionary: There are 18 DICOM tags identified as confidential in Health Insurance Portability and Accountability Act. Maintaining a list of these attributes within the anonymization software package and replacing their values with meaningless values in a unique and consistent way is a method used by DICOM anonymization software to keep patient's data confidential.
2. Confidential information embedded in the actual data: Due to proprietary nature of such information, the success of the method used to remove information automatically depends on the layout used by imaging device to generate medical images.

**Table 8 - Actors in the presented model for receive SOP response**

| **Actors in: Model for receive SOP response use case** |
|---|
| Actor: **Authorized user**<br>Individual responsible to obtain data (referring physician, radiologist, pathologist, etc). |
| Actor: **Local data storage**<br>Local storage responsible to store presentation materials and MCC reports. |

**Table 9 - Use cases in the presented model for receive SOP response**

| **Use cases in: Model for receive SOP response use case** |
|---|
| Use case: **Add relevant LAB result**<br>Referring physician is in charge of gathering relevant LAB results that help to make the best decision about patient's case.<br><br>Is child of: **Obtain appropriate clinical and personal data** |
| Use case: **Annotate the slide**<br>For the purpose of report generation, the pathologist should be able to annotate slide to clarify the findings and to address all concerns/questions raised by the referring physician.<br><br>Is child of: **View digital pathology slides** |
| Use case: **Cancel current view**<br>If an image is selected by mistake, it must be deleted.<br><br>Is child of: **View radiology images** |
| Use case: **Generate the report**<br>Clinical findings should be imported into a predefined form. |

| Use cases in: Model for receive SOP response use case |
|---|
| Is child of: **Obtain appropriate clinical and personal data**<br>Is child of: **View radiology image**<br>Is child of: **View digital pathology slides** |
| Use case: **Include patient's medication history**<br>Information about drugs taken by each patient and possible allergies should be available.<br><br>Is child of: Obtain appropriate clinical and personal data |
| Use case: **Include patient's personal data**<br>Referring physician should look for personal and health related information about the patient, including hospital discharge summaries, whether patient smokes, the effects of patient's condition on his personal life, etc.<br><br>Is child of: **Obtain appropriate clinical and personal data** |
| Use case: **Include patient's wishes**<br>In order to maintain patient's autonomy, patients' wishes should be considered while providing consults.<br><br>Is child of: **Obtain appropriate clinical and personal data** |
| Use case: **Obtain appropriate clinical and personal data**<br>The most relevant and up to date clinical data should be selected from the search result.<br><br>Is a child of: **Receive SOP response**<br><br>Is a parent of: **Include patient wishes**<br>Is a parent of: **Include patient medication history**<br>Is a parent of: **Add relevant LAB results**<br>Is a parent of: **Include patient personal data**<br>Is a parent of: **Generate the report**<br>Is a parent of: **Submit the report** |
| Use case: **Receive SOP response**<br>Interpret the data received form EHR.<br><br>Is parent of : **Obtain appropriate clinical and personal data**<br>Is parent of : **Select appropriate medical images**<br><br>Involves actions by: **Authorized user** |
| Use case: **Select another image**<br>If an image is selected by mistake, it should be able to select another one.<br><br>Is child of: **View radiology image** |
| Use case: **Select appropriate medical images**<br>The images providing important clinical finding should be selected from the available medical imaging examinations<br><br>Is child of: **Receive SOP response** |

| Use cases in: Model for receive SOP response use case |
|---|
| Is a parent of: **View radiology images**<br>Is a parent of: **View pathology slides** |
| Use case: **Select ROIs**<br>In case of pathology slide, the pathologist should be able to select ROIs of the slide for further examinations and including them in the final report.<br><br>Is child of: **View digital pathology slides**<br><br>Changes ROI :fm: **Inactive** :to: **Selected** |
| Use case: **Submit the report**<br>Once the user is done with his/her part, he/she should be able to submit it.<br><br>Is child of: **Obtain appropriate clinical and personal data**<br>Is child of: **View radiology image**<br>Is child of: **View digital pathology slides**<br><br>Involves actions by: **Authorized user** |
| Use case: **View digital pathology slides**<br>Before selection, pathology slides should be viewed to confirm their relevance in terms of extracting the required information.<br><br>Is child of: **Select appropriate medical images**<br><br>Is parent of: **Cancel current view**<br>Is parent of: **Select another image**<br>Is parent of: **Generate the report**<br>Is parent of: **Submit the report**<br>Is parent of: **Select ROI**<br>Is parent of: **Zoom in on the slide**<br>Is parent of: **Annotate the slide** |
| Use case: **View radiology images**<br>Before selection, radiology images should be viewed to make sure about their relevance and extract the information.<br><br>Is child of: Select **appropriate medical images**<br><br>Is parent of: **Cancel current view**<br>Is parent of: **Select another image**<br>Is parent of: **Generate the report**<br>Is parent of: **Submit the report** |
| Use case: **Un-select ROIs**<br>If a region n a slide is selected by mistake, it must be un-selected<br><br>Is child of: **View digital pathology slides**<br><br>Changes ROI :fm: **Selected** :to: **Inactive** |
| Use case: **Zoom in on the slide**<br>Digital slide viewer should provide the pathologist with proper means that replicates functions of a zooming and focusing functions of alight microscope. |

| Use cases in: Model for receive SOP response use case |
| --- |
| Is child of: **View digital pathology slides**<br><br>Changes Slide :fm: **Inactive** :to: **Zoomed in** |
| Use case: **Zoom out of the slide**<br>If the slide is zoomed in by mistake, it must be zoomed out.<br><br>Is child of: **View digital pathology slides**<br><br>Changes Slide :fm: **Zoomed in** :to: **Inactive** |

Besides visual capabilities, the intended software platform should also include a package that assists users with preparing materials to be presented in the meeting and previewing the final report (29). It should equip the user with various tools for editing and extraction of ROIs from medical images. These tools may include magnifier, region selection, and text inclusion. A template for Multidisciplinary Cancer Conference (MCC) record, found in appendix B, is provided by CCO. Depending on the type and site of disease, this template can be subject to further revisions to include required site-specific information. For instance, in multidisciplinary head and neck meetings, a diagrammatic representation of the complex three-dimensional anatomical site that shows the levels and type of metastatic lymph nodes is of great help to perform accurate measurements and present the result at the time of meeting (33).

From both literature review and environmental scan, it was observed that the specialized reports, prepared by individuals in charge on clinical evidence from the available patient's health information, are among the core elements of MCC. These are the main source of information that ultimately serves as the basis for the shared decision. The inherent characteristic of cancer, which makes its diagnosis and treatment activities to be spread across diverse settings, requires uniform documentation in order to foster communication among health care facilities. Despite the necessity of being comprehensive, clear, and accurate, considerable variability in the format and content of these reports seems to have negative effects on the whole experience of collaborative work. The way they are prepared and their content affect not only the quality of MCCs but also the daily workflow of key participants. With the current attempt to promote MCC's functionality using the intended digital platform, it will be possible to integrate a standardized mechanism to capture clinical evidence and generate synoptic reports digitally.

Electronic synoptic reporting, an accurate, pre-formatted, standardized digital reporting scheme, is now considered as one of the most effective tools to address problems associated with incomplete free-text reports, particularly in cancer care. Identification of a core set of elements to be reported in this structured method facilitates report generation through prioritizing diagnostically valuable information. Therefore, it ensures that specialists' view on patient's condition is being carried through care continuum without causing confusion by providing unnecessary information or missing important data. On the other hand, availability of such a core data set will guarantees usefulness and consistency in the content of reports and provides opportunities for data comparison that would be useful in clinical, educational, and research activities. Utilizing this method of capturing diagnostic as well as prognostic information has also several other advantages including minimized typographical and transcription

errors, aligned with patient initiatives, and possibility to store reports in a data repository (34). In terms of financial matters, the new reporting method leads to considerable cost saving by eliminating dictating, handling and mailing of reports (35).

In the case of pathology, where so many fields including the type, size, stage of the tumor, plus the status of lymph nodes and descriptors of the cancer should be covered in pathology report, existence of an electronic synoptic reporting is vital. This information set should include all evidence-based positive and negative parameters that would be considered important in terms determining prognosis and formulating an optimal treatment plan for individual cancer patients. Over the past few years, there has been a continuous collaboration among pathologists, researchers, and informatics experts to come up with an effective and efficient virtual method in the form of templates, checklists, and tables to make the pathology reports more useful (36). Being supported by Canada Health Infoway, there has been good progress in the development of content and informatics standards with the aim of implementing synoptic reporting for specific cancer surgeries in Canada. The effort has led to introduction of electronic synoptic cancer surgery reporting to number of specialized centers in Alberta, Ontario, Manitoba, Quebec and Nova Scotia. Considering Canada's leading position in implementing such an innovative reporting mechanism, it is thought that integration of electronic synoptic reporting with the intended platform will help widespread adoption the new reporting system (34, 35).

## Review Patient Case

At the time of each meeting, the prepaid specialized report on each case serves as the presentation material. Each case usually begins with brief explanation of clinical findings by referring physician or his/her delegate in order to let participants know about the most up-to-date relevant data. Following this introduction, the designated radiologists and pathologists (or their representatives) will present findings on the available radiology images and pathology slides. Once all case-specific information is presented, further required actions will be discussed among the participants. The result, including additional investigations, treatment recommendation, and required examinations, will then be recorded in accordance with guidelines and in suitable formats (Appendix B). Following MCC Chair's approval, an official copy of the consensus recommendation on each case will be forwarded to the referring physician to be discussed with patient. Figure 10 along with Table 10 and Table 11 illustrates the model proposed for the activities during the meetings.

### *Integration of different data types*

During the first period of environmental scan, it was observed that appropriate radiology images are accessed via PACS at the time of discussion. This requires some time for the images to be searched, found. The result is then displayed in a separate DICOM viewer window. At one session, access to CT images was denied due to licensing errors. It caused considerable delay in the discussion of subsequent cases. The approach has led to several difficulties, including poor time management, lack of consistency between presented materials, and excessive work for preparation of research and educational materials.

Lack of proper linkage between different data types for each case is another problem with current method of case presentation. It affects pace and flow of the meetings. Bringing all patient information together, including medical images and clinical history, into a single, so-called, case-specific package is an alternative that can address these issues around actual run of the meetings. Being supported by a usable interface to navigate through different components and offline accessibility during the meeting are two important factors of such case-specific packages. This approach also enhances the comprehensiveness and validity of the report for future activities.

**Figure 10 - Review patient case**

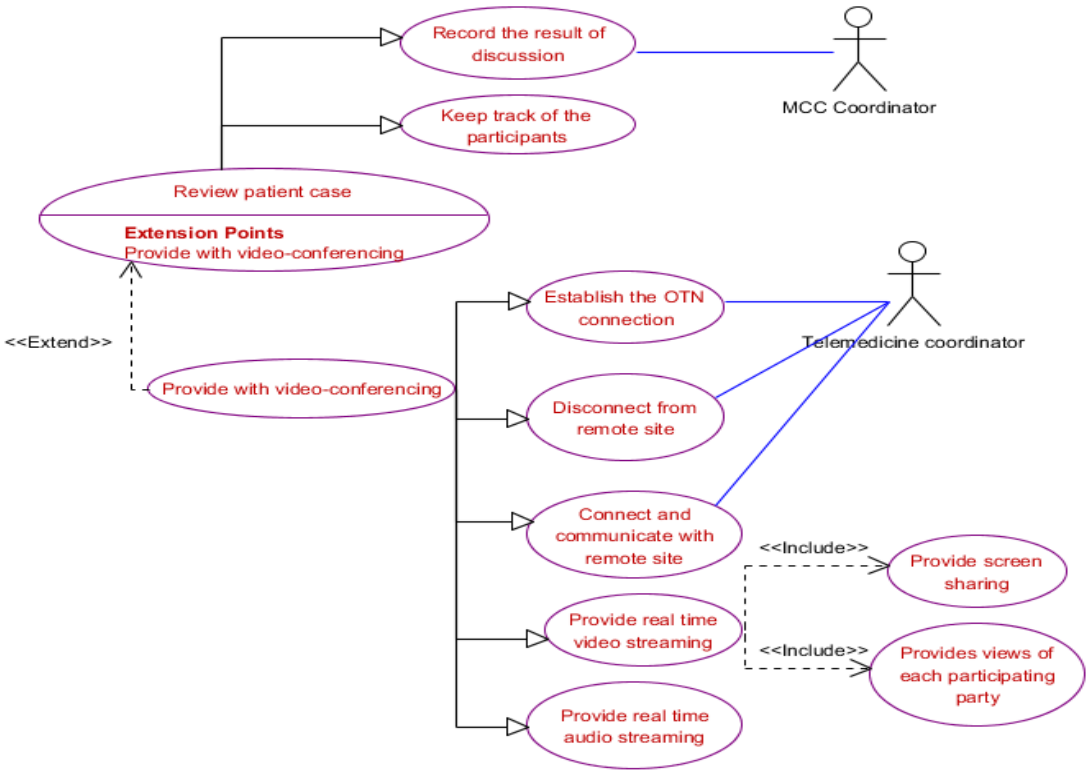



**Table 10 - Actors in the presented model for review patient case**

| **Actors in: Model for review patient's case use case** |
|---|
| Actor: **MCC Coordinator**<br>The person responsible for recording MCC results and keeps track of participants. |
| Actor: **Telemedicine coordinator**<br>The person responsible for establishing videoconference connectivity between participants. |

**Table 11 - Use cases in the presented model for review patient case**

| **Use cases in: Model for review patient's case use case** |
|---|
| Use case: **Connect and communicate with remote site**<br>Once the OTN connection is established<br><br>Is child of: **Provide with videoconferencing**<br><br>Involves actions by: **Telemedicine coordinator** |
| Use case: **Disconnect from remote site**<br>Disconnect the sites at the end of each remote consultation.<br><br>Is child of: **Provide with videoconferencing**<br><br>Involves actions by**: Telemedicine coordinator** |
| Use case: **Establish the OTN connection**<br>Secure and reliable two-way videoconferencing will be provided through OTN.<br><br>Is child of: **Provide with videoconferencing**<br><br>Involves actions by: **Telemedicine coordinator** |
| Use case: **Keep track of participants**<br>A list showing the presence of key participants should be made for the purpose of granting CPD and encouraging participation.<br><br>Is child of: **Review patient's case** |
| Use case: **Provide with videoconferencing**<br>In some cases, referral is made from outside of the hospital. When that happens, remote site should be able to participate via videoconferencing.<br><br>Is child of: **Review patient's case**<br><br>Is parent of: **Establish the OTN connection**<br>Is parent of: **Connect and communicate with remote site**<br>Is parent of: **Provide real time video streaming**<br>Is parent of: **Provide real time audio streaming**<br>Is parent of: **Disconnect from remote site** |
| Use case: **Provide real time audio streaming**<br>Transmit audio data between participating parties.<br><br>Is child of: **Provide with videoconferencing** |
| Use case: **Provide real time video streaming**<br>Video streaming includes sending and receiving of both presentation materials and different parties involved in the discussion.<br><br>Is child of: **Provide with videoconferencing** |
| Use case: **Record the result of discussion**<br>The result of discussion should be recorded as part of the MCC report to be communicated with referring physician or pushed to EHR. |

| Use cases in: Model for review patient's case use case |
|---|
| Is a child of: **Review patient's case**<br><br>Involves actions by: **MCC Coordinator** |
| Use case: **Review patient's case**<br>Being referred by physician, each case will be discussed in pre-scheduled meeting.<br><br>Is parent of : **Record the result of discussion**<br>Is parent of : **Keep track of participants**<br>Is parent of: **Provide with videoconferencing** |

### *Continuing Medical Education*

The increasing demand for the healthcare providers to maintain their level of competence and knowledge about the most recent clinical findings, a new set of standards have been developed to foster learning activities. The inherent highly interactive environment and freedom in selection of teaching materials from real patient cases have made tumor boards an ideal place to achieve this educational initiative (37). Considering the critical role that participants play in the effectiveness of the tumor boards, CCO mandates the recording of attendance as a criterion to grant Continuing Professional Development credit (CPD) (9). This approach not only maintains the effectiveness of meetings but also keeps the participants up to date. Considering this need, the proposed software platform should provide means to keep track of participants. Currently, this is usually done by distributing a paper sign-in sheet among the participant. Based on the findings from site visits at the period for environmental scan it is observed that this method can cause some distraction among the participants, especially if senior participants are not sitting next to each other in the room. At least in local settings, such as UHN where smart-phones are being utilized for communication purposes among clinical staff, these devices can be used to improve this functionality. The proposed solution requires a unique code for each multidisciplinary meeting. This code can be revealed during the meeting by having them displayed on the screen. Sending this code along with participant's unique identifier via a text message to the intended application, attendees' presence can be verified and their information can be extracted and imported into the electronic sing-in sheet. All that is required for this purpose is to establish connection to the SMS gateway of the wireless service provider.

In addition to consult recommendations and participants record, MCC standards (9) requires the coordinator to keep track of minimum data requirement, such as number of consult requests, number of discussed cases at the MCC. Availability of this information helps to promote future consultations through better scheduling and organization of the meetings.

### *Telemedicine*

Telemedicine, refers to the application of ICT in the field of healthcare to facilitate consultations and at some points care delivery, is now taking advantage of technologic advances to transfer multi-media medical information. Reviewing its success in various fields including teleradiology, teledermatology,

teleendoscopy (38), and more recently telepathology imply the effect of human-factor elements in its success. In two articles by Robertson et al (1) and Li et al (39), several workplace related issues along with social and technical issues that affect communication process in distributed settings is discussed. According to them, having an effective video-mediated multidisciplinary meeting requires not only appropriate technologies in hand but also configurations in organizational protocols and interpersonal relationships. This includes various aspects of the conversational process such as ability to see remote people regardless of the stage of case discussion and availability of tools that enhance interaction that could be interrupted in the new virtual environment. Considering these social factors in the selection of the appropriate technologic solutions plays an important role to achieve the desired outcome.

Since the ultimate goal of such a computerized platform is to support the ever-increasing demand for proper communication process in healthcare, and thus reduce medical errors, it must have the ability to facilitate the collaborative work in both co-located and distributed settings. The latter has been gaining more attention as economical and human resource constraints are driving the shift towards centralized healthcare solutions. Thus, depending on the physical site, where senior participants are, it should be able to extend the functionality of the meeting by providing means for teleconferencing. Several studies have been conducted to indentify the most effective setting for distributed multidisciplinary meetings.

The Ontario Telemdicine Network (OTN), an independent, not-for-profit organization created in 2006 and funded by the government of Ontario, is among the largest telemedicine networks in the world. The aim has been to promote telemedicine all across Ontario. Part of this extensive effort is providing secure, reliable, and real time two-way videoconferencing to support telemedicine activities, distance education, and professional meetings. Utilizing the available infrastructure, OTN can establish a videoconference network between participating parties.

According to the guidelines provided by CCO for Virtual MCCs (40), at the point of service extension to establish audio-visual network connectivity, it is the responsibility of the telemedicine coordinator to ensure OTN connectivity and let the partner sites to communicate.

## Generate MCC Report

According to the standards, it is the responsibility of referring physicians to communicate treatment options with patients and making the ultimate treatment decision together with them (9). Just like the hardcopy of the MCC report, where signature provides proof of the information and its authenticity, the digital version requires some sort of proof for the authenticity of the document before it can be sent to the referring physician. In addition, keeping the report as part of EHR and other future activities, such as research and quality assurance, requires a mechanism to securely validate the report's content. Considering the demand for authentication of the MCC report, a use case model is defined as illustrated in Figure 11 and described in Table 12 and Table 13.

So far, several sectors within the society, including pharmaceutical community, software distribution and finance have succeeded in their digital business transformation. Their experience for such a transition in the routine workflow indicates the necessity of having a mechanism to replicate the function of wet signature in the digital world.

**Figure 11 - Model for report generation**

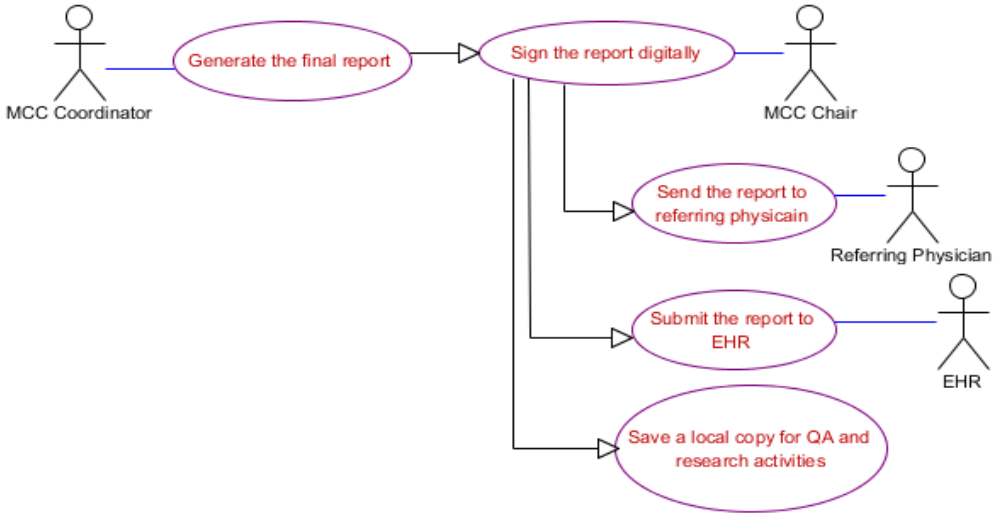



**Table 12 - Actors in the presented model for report generation**

| **Actors in: Model for report generation's use case** |
|---|
| Actor: **EHR**<br>The system that stores the reports of each individual case. |
| Actor: **MCC Chair**<br>The person in charge of verifying the result of consultation and sign the final report. |
| Actor: **MCC Coordinator**<br>The person responsible for summarizing the consensus result and the follow up plan. |
| Actor: **Referring physician**<br>The person responsible for communicating the result of consultation with the patient. |

**Table 13 - Use case in the presented model for report generation**

| **Use cases in: Model for report generation's use case** |
|---|
| Use case: **Generate the final report**<br>During the meeting, the result of discussion about each individual case, including recommended treatment, required examination, trial eligibility, and follow up plans, is recorded.<br><br>Is parent of : **Sign the report digitally**<br><br>Involves actions by**: MCC coordinator** |
| Use case: **Save a local copy for QA and research activities**<br>As part of quality assurance initiatives, the reports are subject to investigation to make sure the decisions are made based on the available best practice. Also rare cases can be considered for research activities. |

| Use cases in: Model for report generation's use case |
|---|
| Is a child of: **Sign the report digitally** |
| Use case: **Send the report to the referring physician**<br>For the result of meeting be discussed with patient, the signed report should be sent to the referring physician.<br><br>Is child of: **Sign the report digitally**<br><br>Involves actions by**: Referring physician** |
| Use case: **Sign the report digitally**<br>Once the coordinator generates the report, it should be verified by the meeting chair before it can be transmitted to the referring physician or pushed to the EHR. Verification will be done digitally through the digital signature service provided.<br><br>Is a child of: **Generate the final report**<br><br>Is parent of: **Send the report to the referring physician**<br>**Submit the report to EHR**<br>**Save a local copy for QA, research, and other secondary applications**<br><br>Involves actions by**: MCC chair** |

### *Digital Signature*

Digital signature, first introduced in 1976, is a mathematical approach that enables replication of wet signature functionalities, information approval and authentication, in virtual manner. The concept of digital signature has applications in the areas where paper-based workflow is going to be replaced by digital alternatives. Now that technological advances allow taking the concept of the conventional paper based signature into the digital realm, documents stored in electronic format can be digitally signed before being transmitted in a computer network. This method of authentication has been used in other sectors to secure message communication, and detect and avoid counterfeit and tampering. Their experience shows that successful introduction of digital identities requires appropriate standards, legislations, and technologies capable of delivering unique and globally valid electronic identity credentials for legally enforceable and regulatory–compliant digital signatures.

As part of Canada's attempt to realize secure digital transformation of its healthcare system several advanced security features such as time stamping, notarization, strong guarantee data integrity, and non-repudiation has been proposed within the Canadian EHR solution framework. According to the framework, digital signature is proposed as a part of the ten named components of privacy and security service type within the HIAL in an attempt to standardize the way identity is determined and documents can be digitally signed and provide mutual trust between the owner of the certificate and the party who receives the signed document. As a result, the many information systems involved in the modern healthcare environment will be able to communicate efficiently and securely (22, 41, 42). For digital signatures to be applicable in daily healthcare activities, it is required to have following properties:

1. ***Uniqueness***: It is the core characteristic of the concept of signature. It ensures that individuals can be uniquely distinguished from one another based on their unique digital identities.
2. ***Persistence***: It points out to the demand for verifying signatures at any time in the future. It is of particular importance for health records as they may be kept for long time
3. ***Portability***: Meeting interoperability requirements to ensure receiving parties can use digital signature to authenticate the document.
4. ***Independent verifiability***: It refers to the requirement for the verification process to be platform and vendor independent.
5. ***Integrity***: Protecting message content from being manipulated after it is signed.
6. ***Non-repudiation***: This property refers to the ability to protect signed documents from possible future disclaimer. Although this feature may not seem to be of high priority for our intended platform, the more digital flow of information in healthcare the more important the role of digital signature for authentication and workflow management.

Utilizing a digital signature scheme can help various entities working in a collaborative environment, such as healthcare sector, to communicate with each other electronically in an efficient and trustful manner. Among its numerous advantages are facilitating document management, improving interoperability, and promoting trust while mitigating potential legal, regulatory and other business risks. It not only speeds all approval processes, including report generation, but also eliminates paper handling and paper-retention and their associated time, errors, costs, and environmental issues. In addition, the digital process facilitates audit activities through electronic retrieval of the signed documents. The main characteristics that make us believe a digital signature is necessary for communication in context of chronic disease management are as follows:

1. Encrypting the information about the identity of the signer provides a secure way to verify identities in electronic transaction. It also limits the access to confidential patient information that is in line with security and privacy requirements (29).
2. Due to its inherent collision resistance, modifying a digitally signed document is computationally infeasible. This feature results in signature invalidation in case of manipulating digitally signed documents. Thus, the viewer of the document can be notified easily if any inadvertent or intentional change has happened, as the signature is not verified. As the result, both sender and receiver can make sure that the report cannot be changed once it is signed digitally (41).
3. Being legally enforceable, non-repudiable and instantly auditable is another important characteristic of digital signatures that supports the required security for healthcare applications (41).

Based on the formal definition, a digital signature scheme comprised of the following five elements (41):

1. A finite set of message or a document to be signed ($\mathcal{P}$).
2. A finite set of possible signatures ($\mathcal{A}$).
3. A finite set of keys that will be used for both signing and verification ($\mathcal{K}$).

4. A signing algorithm, $\mathsf{sig}_K \in \mathcal{S}$, which takes the message and user's private key to create the signature.
5. A verification algorithm, $\mathsf{ver}_K \in \mathcal{V}$, which verifies signer's identity based on the provided message and its purported signature. This is done by comparing two elements of a signed message $(x, y)$, with $x \in \mathcal{P}$ and $y \in \mathcal{A}$, in order to check if $y = \mathsf{sig}_K(x)$.

*Certificate Authority*

The cryptographic approach mentioned in the previous section to sign and verify an electronic document digitally, is based on asymmetric public key / private key algorithms to transform message into a format that can be read only by the intended receiver. The idea behind this model of cryptography is to make it computationally impossible to find a decryption rule for a given encryption algorithm. In order to indentify the various entities involved in the transaction, a unique pair of public/private key, where the public key is available to the world while the private key is only known by the use, should be assigned to each party involved in the communication. This approach for implementation of digital signature requires a mechanism that ensures the uniqueness of the pair associated with each individual. For this purpose, there need to be an operational Public Key Infrastructure (PKI) in place that addresses issues around the authenticity of public keys (41, 43). Adams and Lloyd (44) define PKI as; "the basis of pervasive security infrastructure whose services are implemented and delivered using public key concepts and techniques".

Digital certificate, whereby an electronic document is signed by a globally trusted third party, is a solution for establishing a unique binding between a pair of keys and an identity. It confirms the ownership of the public key, contained in the certificate, by the person, organization, or entity noted in the certificate. They form the basis for secure and scalable PKI that can be used as authentication tools for public keys. PKI has many components to create, manage, distribute, use, store, update, recover, and revoke digital certificates. Certificate Authority (CA) is trusted entity within each PKI that controls and manages the issuing of the certificates. Being signed by CA, the other parties can rely on digital certificates to make sure that signature is valid. (41)

Once the appropriate legal and technical infrastructure to provide such a service is in place, CA can process users' requests for the certificate. After approval of user's identity, CA generates and signs the certificate that contains applicant's verification key. The verified key is used as part of the algorithm to sign the document. The receiver of the signed document will then use this certificate to authenticate message content and the signature.

In order to encourage the use of digital identity and to establish and manage digital signature, there are non-profit associations and companies, such as SAFE-BioPharma Association and VeriSign, providing the essential infrastructure for such credentialing services. Supported by the Pharmaceutical Research and Manufacturers of America (PhRMA) and major pharmaceutical companies, SAFE-BioPharma is mainly involved with creation and managing standards, legal policies, and technology needed to incorporate digital identities and digital signatures into pharmaceutical, biotech, and healthcare industries in an international level. Its Close collaboration with healthcare and regulatory agencies such as Food and

Drug Administration (FDA) and the European Medicine Agencies (EMA) ensure that provided standards services meet the requirements established by regulatory bodies. Providing support for the PKI digital signature standards required for SAFE transactions by various widely used document formats avoids extra cost associated with purchasing any additional hardware or software. It also prevents all the resistance by the mostly nontechnical users to the integration of the new digital authentication process as the new application is fully integrated with their routine workflow, which they are accustomed to. It also addresses the interoperability issues with the diverse preexisting PKIs.

### *Hash Function*

For a message, in this case a MCC report, to be digitally signed, there are various signature schemes with different security levels. Just like any other cryptosystem, a clear definition of the required type of security is necessary to come up with the most secure solution for our intended system. Almost all signature schemes begin with transforming the message of an arbitrary length to a file of specified size (message digest) via a cryptographic hash function. Hash functions are used for data integrity in conjunction with digital signature schemes. The result of this transformation can be considered as a unique identifier of a message to be sent and, thus, determines if there has been any manipulation to the message. Then the resulting message digest, as a representative of the message, is signed in place of the original message. Since signature generation is relatively slow for many schemes, signing message digest requires less computational time due to limited length of hash value as compared to the original message. In addition, it eliminates the need for splitting the message into smaller blocks and the security risks associated with reordering of multiple signed blocks. It also addresses issues around compatibility with signature's operation domain as hash function converts an arbitrary input into the appropriate file format.

In order to meet security requirements of the intended application, this transformation should satisfy certain properties, including (41):

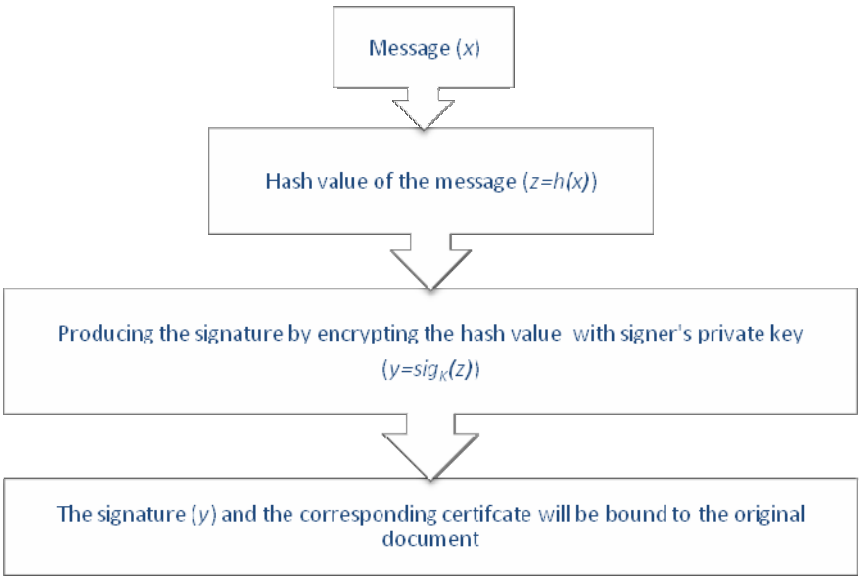
1. If it is not infeasible, it should be difficult to find the original data from a given hash value.
2. If it is not infeasible, it should be difficult to find a message with same hash value as a known message.
3. If it is not infeasible, it should be difficult to find different messages with same hash values.

### *Process flow*

Once an operational PKI is in place, it allows various applications to be built on top of it, which in turn provide various PKI-enabled services such as secure communication, Secure/Multipurpose Internet Mail Extensions (S/MIME), access control, and privacy architecture. Despite issues around the deployment of PKIs in large-scale environments, such as decision making about developing, maintaining, and regulatory roles and standardization issues, the required infrastructure for is expected to be available to support such services. This mandates the developers to come up with PKI-compatible applications to not only brings legitimacy to the new digital work environment, trusted exchange of confidential information, and avoid forgery but at the same time promote the deployment of the PKI as more applications are available utilizing capabilities of PKIs (41).

As illustrated in Figure 12, the process of signing a digital document starts by assembling the electronic document, such as a MCC report, e-prescription, or an HL7 message, via a POS application. Then, the a local cryptographic application interface will be called by the POS application to sign the electronic document in a way that complies with the standards for digital signatures. Once the hash value is calculated, the signature scheme will use this hash value along with signer's private key to form the signature. The signature and the sender's certificate will then be attached to the original data (42).

**Figure 12 - Signing algorithm**




The security of such a cryptosystem depends mainly on keeping individuals' private keys secret. There are several solutions to achieve the desired level of security in this regard. One alternative is to store private key on a smart card, which can be activated by user's PIN. This requires the hash value of the message to be sent to the smart card for being encrypted by the stored private key. Providing two-factor authentication will lead to more security as compare to single-factor authentication of storing private keys on users' computers. Despite the fact that all these security accessories make the IT systems secure, the desired security level never comes without paying the price. The user convenience has never grown together with security of the system and in fact, it is getting worse. We all know the hassle of carrying accessories such as USB sticks, smartcards, or smart card readers. It also often happens that user does not have those accessories around when he/she really needs them. These problems together with financial issues, raise as the size of enterprise using such accessories for identity management gets large, drives the effort to find alternatives by concentrating on the products that the users on a daily basis. The aim has been to make practice convenient, simple, and easy to use regardless of the computer platform.

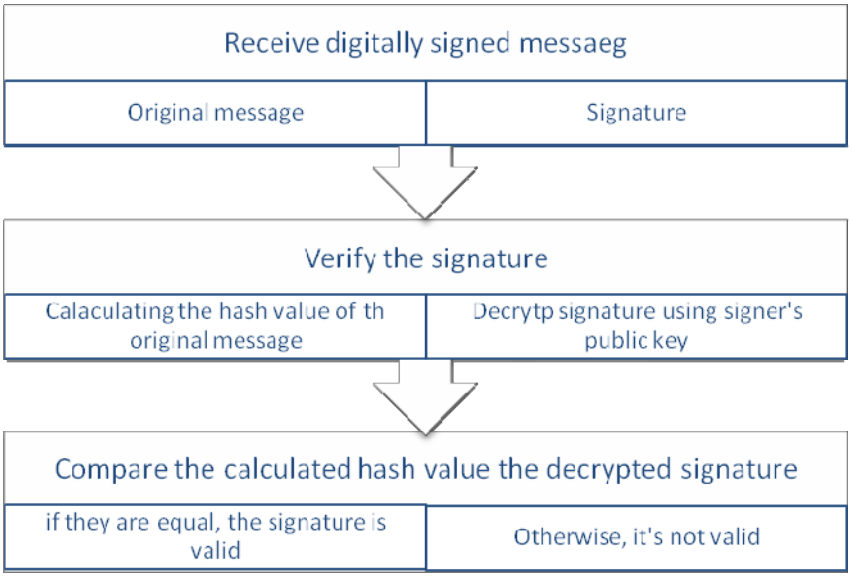
Since the advent of the first generation of smart phones in 1993, their adoption rate has experienced accelerated rate. The ever-increasing demand for more advanced functionalities from the market has been driving the attempt to introduce products with more computational power, more user-friendly interface and larger screens. At the moment, technology used to produce such devices has advanced to the level that supports both hardware and software requirements for introduction of new applications in identity management such as digital signatures. It is now believed that putting all the functionalities of security accessories into a smart phone can completely virtualize a physical smartcard and a smartcard reader. They not only provide the identification capabilities of smart cards but also add even more by increasing security level of the IT system and enhance the security interface.

Considering the current use of smart phones by medical staff at least in local settings, such as UHN, it is thought that integrating this potential function of smart phones with our intended software platform has several advantages in terms of user convenience, cost savings, and security requirements. As the medical staff carries these devices all the time, using smart phone can address portability issues. In addition, integrated wireless capabilities of smart phones, such as Bluetooth and WiFi, let the user to have better access to what he/she wants to do. If they are away from their computers, they still can use the same security for the smart phone itself. Thus, three-dimensional independency of the token, the computer platform, and of the actual smartcard could be provided.

The reinvention of smartcard and smartcard readers has also various advantages for the entire enterprise in terms of cost saving. As the size of enterprise gets large, it becomes more important to save money on all the impacts of identity management system. Utilizing the existing IT infrastructure, there will be a lot of cost saving on one side on hardware and the other because there is no need to spend money on smartcard and smartcard reader.

Once the receiver of the document, in this cases the referring physician or the EHR system, receives the signed document, authentication process will be followed as illustrated in Figure 13. The user invokes local cryptographic application to authenticate a signed e-document and confirm that the digital signature has not been tampered. To do this, hash value of the original documents will be computed. Having the signature decrypted by sender's public key, available in the sender's certificate, it will be compared with the computed hash value. Depending on the result of comparison, receiver will decide on the validity of signed document. It is also the responsibility of the receiver to make sure that the digital certificate is still valid by invoking cryptographic software that either checks a certificate revocation list or that relies on an online certificate status checking protocol to ensure that the certificate has not been revoked by the certificate issuer (42).

**Figure 13 - Verification algorithm**




Although it is currently not mandatory to push the results of multidisciplinary meetings into EHR, having this data as part of patients' health record is of great value for future applications, such as research, quality assurance, and follow-up activities. Existence of database to record the result of discussions officially increases transparency of care process to both patients and healthcare sector. Thus, not only the consultation process can be traced in the future but also enables patients to be involved with management of their own situation. As a result, together with the referring physician, they will be able to come up with the solution that best fits each individual case.

Once the decision is made, this information identifies next steps in diagnosis and treatment, and appointments can be easily set up accordingly. Therefore, coordination, integration, and continuity of care will be ensured and at the same time frustrating confusion about the follow-up care for both patients and healthcare providers will be avoided. Appendix B includes the template provided by CCO to be used for generating the report.

## Patient Empowerment

Ethical issues are increasingly becoming major concerns in medical practice and there has been a lot of debate on the key ethical principle of patient's autonomy and engagement throughout care continuum. From clinical perspective, recent findings about correlation between patient anxiety and dysregulation in glandular secretions imply the importance of informing the patients about the progress of consultation during the interval between referral submission and consensus result (45, 46). There are different attitudes towards obtaining information about the disease among cancer patients. Depending on personal characteristic, some patients simply feel more comfortable to be given information about their conditions and follow expert opinions whilst others curiously want to know about their own disease and possible treatment options and thus have full control over all medical decision-making (47).

It was in 1970s when the idea of encouraging patients to participate actively in the process of healthcare delivery was first introduced (48). Since then, the subject of patient empowerment and the application of innovative technologies in this matter have been growing in popularity. Although more investigation is required, active participation of well-informed patients in the management of their own disease while being supported by healthcare providers is now recognized as the enabler for the patients to take a better care of their condition (47). This fact is reflected in the description of patient empowerment by World Health Organization (WHO) as "a prerequisite of health", and "a proactive partnership and a patient self-care strategy to improve health outcomes and quality of life among chronically ill" (48). The work done by Harris and Veinot in 2004 (49) to determine the main driving factors for realization of such an idea in real life healthcare delivery reveals the following as the main contributors:

1. Emergence of new disease and social conditions has led to significant changes in the traditional support network of the individuals from their family and neighborhood to be more reliant on peers guidance. The result of such a transformation is reflected in the current social movement towards establishing self-help/mutual help and the growing number of patient organizations.
2. Prevalence of the consumerism concept has brought the notions of rights and power. This transformation from playing the role of a passive patient to be an active consumer, seeking for healthcare services, has led to introduction of new patient's bill of rights including the right to give informed consent based on a clear knowledge and understanding of the facts, implications, and future consequences of an action.
3. Constraints on healthcare expenditures can be considered as the driving factor for shifting much of healthcare providers' responsibilities to the patients' side. Reflection of this factor in daily medical practice can be seen in tendency towards encouraging patients suffering from chronic condition, even in the most serious chronic conditions, to take the responsibility of self-managing their illness.
4. Although access to internet is by no means universal, internet has shown undeniable impact on patient-physician relationship. Eliminating the existing knowledge asymmetries that have historically affected this relationship helps patients gain control over their disease management. On the other hand, this technology forms the basis of the ever-increasing virtual communities and support groups. These resources have not only provided users with 24/7 access to information and emotional support, but also promoted the concept of mutual aid by letting the patients produce health information and share their experience.
5. Emergence of the information societies and the effect of new and innovative technologies on our contemporary life style around the globe have resulted the value to be put in information goods and services that facilitate its production, distribution and processing rather than material goods.

There are many discussions in the literature on the most comprehensive definition of the term "Patient Empowerment" and the best method to realize and measure it. So far, no agreement has been achieved on a model that facilitates the whole process. With the latest technologic advances in IT, internet is now believed to provide many opportunities to improve health outcomes, educate patients, and change wrong common behaviors. Although there is lack of scientific evidence on the prevalence of using

internet and other media to obtain health-related information, a recent study by Atkinson et al in the United States reports that more than half of all internet users utilize Web to look for health-related information (50). This large potential application of internet has caused a lot of work underway to investigate the ever-increasing capacity and contribution of the internet to health information dissemination among the users. In an evaluation of the effectiveness of large number of Web-based interventions for chronic conditions, such as diabetes, arthritis, depression, and infertility, Samoocha et al found some evidence that such methods can be helpful to enhance patient involvement.

Despite the usefulness of such interventions to promote general awareness about health-related issues and how to deal with them, lack of central control over data published on many online and offline resources has put serious questions about reliability, credibility and liability of the information for each case. This not only makes the search a frustrating activity for the patients, but may also lead to severe emotional and physical drawbacks. This is the fact that has been experienced by many patients after their diagnosis with cancer. The personal experience of Mr. Doug Gosling, who has been involved as a patient advocate and an active volunteer in healthcare community since his diagnosis with cancer, clearly indicates the lack of coordination and consistency in the availability of information to the patients. His speech during one the *Health Services Research Seminars* at the *Department of Health Policy, Management and Evaluation, University of Toronto* (51), revealed the important role of correct information in bringing back confidence to newly diagnosed patients. According to him, learning about the disease gives patients some control over it, which help them better deal with the consequences of their condition in their daily life. Another important advantage is the ability to discuss and understand diagnoses, test results and alternatives and thus, make wise decisions in collaboration with their medical team. He also elaborated how valuable this information is to gain the support from family and friends as they become familiar with his situation and the consequences. The proposed platform will give patients who desire comprehensive information about their care access to the reports they need.

Considering all the above globally recognized facts about the importance of patient engagement in the process of care, we think that having a Web-based patient portal would be a very useful tool for cancer care management. In case of our intended MCC platform, the patient portal is assumed to enable patients monitoring the progress of the referrals, access to educational resources, and know about the future steps in the care continuum, including all the contact information for future visits. This goal can be achieved by integration of an EHR viewer that supports the above-mentioned functionalities.

The importance of the above-mentioned aspects of patient involvement in the whole process has made us propose a patient portal through which patients' role in their own case management can be maximized. Figure 14 along with Table 14 and Table 15 describe proposed model of this system's responsibility.

**Figure 14 - Model for patient empowerment**

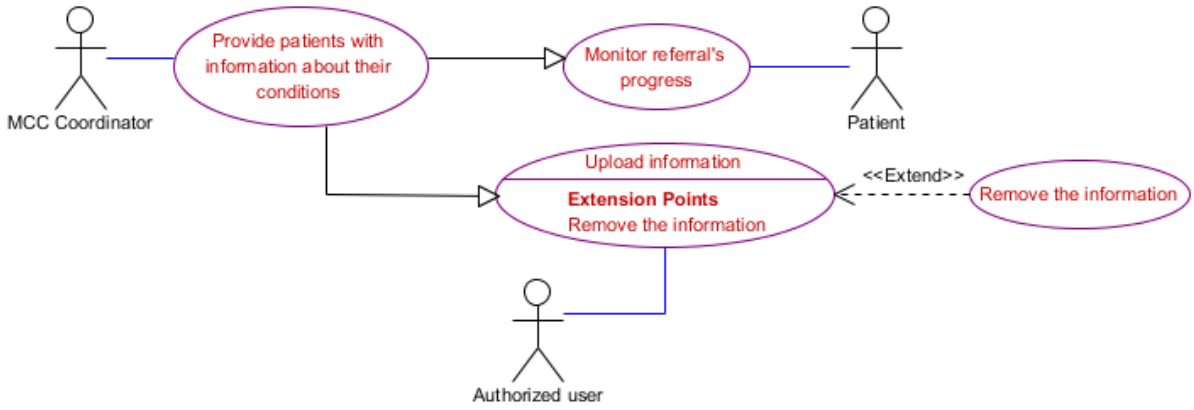



**Table 14 - Actors in the presented model for patient empowerment**

| Actors in: Model for patient empowerment's use case |
|---|
| Actor: **Authorized user**<br>The individual responsible for uploading the information about different diseases, including their origin, mechanism, diagnostic and treatment options, health and social effects, and the existing health centers. |
| Actor: **MCC coordinator**<br>The person responsible for scheduling the meetings. |
| Actor: **Patient**<br>The person whose case has been discussed in a meeting. |

**Table 15 - Use cases in the presented model for patient empowerment**

| Use cases in: Model for patient empowerment's use case |
|---|
| Use case: **Monitor referral's progress**<br>When a case is going to be discussed in a meeting, the patient will be given access to the patient portal in order to let him monitor the referral's progress and provide reliable medical information.<br><br>Is a child of: **Provide patients with information about their conditions**<br><br>Involves actions by**: Patient** |
| Use case: **Provide patients with information about their conditions**<br>The model defines the system responsibility to support patient empowerment.<br><br>Is parent of : **Monitor referral's progress**<br>Is parent of : **Upload Information**<br><br>Involves actions by**: MCC coordinator** |

| Use cases in: Model for patient empowerment's use case |
|---|
| Use case: **Remove the information**<br>Since the provided information is subject to change, it is necessary to update the information at some point.<br><br>Is child of: **Provide patients with information about their conditions**<br><br>Changes Information :fm: **Uploaded** :to: **Inactive** |
| Use case: **Upload Information**<br>Non-patient data should be uploaded and updated.<br><br>Is child of: **Provide patients with information about their conditions**<br><br>Changes Information :fm: **Inactive** :to: **Uploaded**<br><br>Involves actions by**: Authorized user** |

## Teaching Material Preparation

Recently, educational programs are considered as one of the most important activities within any residency program. Current discussions on the public's attitudes towards quality in healthcare have shown a growing demand for systems that can efficiently assess diagnostic competence of medical students as well as clinical staff. Introduction of new innovative computational platforms to healthcare practice, such as digital radiology and digital pathology, in the recent past years has brought new opportunities to improve educational activities within this sector. Being available in digital format enables the medical students, residents, and clinical staff to have better access to the most up to date research activities and challenging clinical cases. This new approach to medical education has been shown to improving teaching efficiency and increase pedagogic versatility.

Since the shift towards providing integrated and multidisciplinary care, especially to cancer patients, extensive experience in multidisciplinary care management has been very important. Considering the role that MCCs can play in providing such experience and promoting the quality of teaching experience, residents are expected to participate in MCCs relevant to their clinical rotations. Therefore, they experience the work in a collaborative environment during their residency program. Due to wide variety of cases discussed in the meetings, participants get the chance to face rare and challenging cases and learn the best method to tackle such cases. Having a mechanism to extract such cases of great teaching value and use them as teaching materials in medical curriculum seems to contribute to maintain and improve expertise within healthcare.

Integration of IT solutions with multidisciplinary routine workflow is thought to increase educational capacity of within the practice of medicine. Digital transformation of medical practice has eliminated the many hassles, such as limited access to teaching materials, increasing cost of maintaining analog sources, and inefficiencies of pedagogic approach associated with educational activities in pre-digital era. Especially in radiology and pathology, that visual presentation of images during lectures is of vital

importance. The results of several studies on the effectiveness of using digital technology in medical curriculums around the world (52-60) reveal the fact that both educators and students, involved in the studies, prefer virtual teaching environments. Importantly, this modality facilitates independent study outside of structured or formal teaching sessions.

Considering the demand for sustainable expertise within the healthcare sector and potential interest in MCC to improve medical curriculum, it is believed that the intended informatics platform can provide appropriate means to prepare materials for future educational activities. As illustrated in Figure 15, it begins with selecting appropriate cases along with clinical relevant information. In order to follow that the exact medico-legal guidelines governing the use of patient clinical data, the system should provide additional tools, such as anonymization, to make sure that confidentiality of patient data is preserved. Thus, anonymized patient data, including radiology images and pathology slides, can be distributed publically for any practical purpose such as educational and research activities.

**Figure 15 - Model for preparing teaching materials**

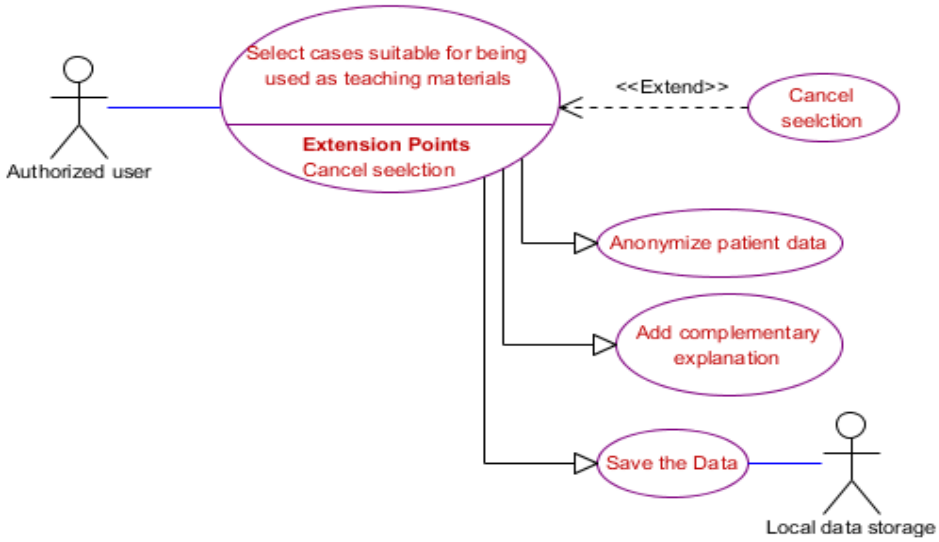



**Table 16 - Actors in the presented model for preparing teaching materials**

| **Actors in: Model for preparing teaching materials use case** |
|---|
| Actor: **Authorized user**<br>The person in charge of selecting appropriate cases to be taught. |
| Actor: **Local data storage**<br>The system that stores prepared data. |

**Table 17 - Use cases in the presented model for preparing teaching materials**

| **Use cases in: Model for preparing teaching materials use case** |
|---|
| Use case: **Add complementary explanation**<br>Once a case is selected to used as a teaching source, detailed analysis of the findings should be added to the digital file.<br><br>Is child of: **Select cases suitable for being used as teaching materials** |
| Use case: **Anonymize patient data**<br>To meet the ethical requirements and maintain confidentiality of patient data, the system should make sure that all patient data is completely anonymized.<br><br>Is a child of: **Select cases suitable for being used as teaching materials** |
| Use case: **Save the data**<br>Once the work is done, the data will be store on local storage.<br><br>Is a child of: **Select cases suitable for being used as teaching materials**<br><br>Involves actions by**: Local Data Storage** |
| Use case: **Select cases suitable for being used as teaching materials**<br>Once the case is discussed at the meeting, the responsible patient can used it a source of information for medical curriculum.<br><br>Is parent of : **Anonymize patient data**<br>Is parent of : **Add complementary explanation**<br>Is parent of : **Save the data**<br><br>Changes Case :fm: **Inactive**: to: **selected**<br><br>Involves actions by**: Authorized user** |

# Chapter IV - Evaluation

This chapter describes formulation of an evaluation framework for the MCC platform.

## What is HIS Evaluation?

Evaluation can be defined as a theoretical informed approach to measure merit, worth, significance, and quality characteristics of a product or a program. Consequently, a clear definition of it would depend on the theory, approach, purpose, and the specific context in which these measures are to be assessed (61). According to Ammenwerth et al (61), HIS (Health Information System) evaluation can be described as

*"the act of measuring or exploring attributes of a HIS (in planning, development, implementation, or operation), the result of which informs a decision to be made concerning that system in a specific context"*

Such an evaluation work seeks to answer why (objective of evaluation), what (focus of evaluation), how (methods of evaluation), who (stakeholders whose views on the system are going to be assessed), and when (the stage of the system development) questions about various technological, human, and organizational aspects of introducing new health information system (62).

Although evaluation is sometimes considered as a post-implementation activity conducted mainly for monitoring and accountability purposes, feedback gained from evaluation at all phases of design, development, and implementation of a system can provide valuable knowledge of how to maximize desired outcomes (63, 64). The goal of such a continuous activity is to provide a robust evidence-based model to (65):

1. identify and rectify a system's shortcomings;
2. understand and promote system functionalities;
3. evaluate user satisfaction;
4. promote organizational learning, development, and change;

## Types of Evaluation

Evaluation process can be classified into three categories as follows (64):

- ***process*** is a program long activity, from very early stage of planning to the end of delivery. It focuses on the appropriateness of the methods, and assess level of implementation of various planned activities of the program;
- ***impact*** is undertaken after implementation to assess immediate program effects. It keeps track of program objectives to see whether and to what extent they are achieved. Among the immediate effects are changes in service delivery, individual and organizational behaviors;
- ***outcome*** measures long-term effects of the program. Its counterfactual nature makes it different from outcome monitoring as data analysis aims at attributing captured effects to the

intervention. The goal is to investigate how the new intervention affects the clients and their circumstances. In case of healthcare related projects, it assesses whether the treatment experience or change in the delivery of care has been a factor in causing this change. The outcome indicators may be selected to track changes in mortality/morbidity/survival rates, health and well-being attributes, and improvements in terms of patient safety and health equity.

## Why Evaluate HIS?

Recently, care delivery process has been largely influenced by the adoption of HIS, ranging from simple transaction processing to complex clinical decision support systems (66). They are believed to provide major improvements in terms of productivity, care coordination, health outcomes, patient safety, care access, and cost saving. However, given the unpredictable characteristics of information systems (66), and dynamic nature of implementation process that requires changes in individual and collective behavior of various interdependent health system departments, successful introduction of healthcare IT-enabled solutions have turned into a wicked problem. Often, complex interdependencies between technical and organizational factors causes an effort to address an issue create other problems.

Experiences from failures in implementation and deployment of healthcare IT-enabled tools imply that emphasis on utilizing highly advanced technologies has often resulted in final products that are costly and outstrips human factors considerations. Thus, they may cause risks of disruption in daily clinical practice that ultimately leads to clinically adverse events (63). Without strong evidence from the previous studies, researcher, system designers and developers can never know which approaches are most effective and why certain approaches did not succeed (67).

Increasing number of medical information resources in the recent years, has resulted in emergence of new research area in academia. In order to unveil principles of this new field of study, continuous assessment of the structure, function, and impact of health-IT tools is a necessity.

In addition, evaluation studies have promotional affects in the sense that assures users that new informatics intervention is safe and benefit organizations and individuals through improved outcome-, workflow-, and cost-, effectiveness.

Thus, introduction of new information systems to a complex healthcare organization requires careful investigation of its potential impacts on various interrelated technological, human, and organizational aspects (68). Development of a method that utilizes context-specific measures to comprehensively assess the success of a HIS provides system designers and developers with robust evidence and knowledge for further refinements of the system. It also helps to justify the current digital move in healthcare and encourage potential users to embrace IT solutions (69). In addition, it ensures projects' outcomes would comply with defined standards and criteria, thereby justifying the sponsors' investment.

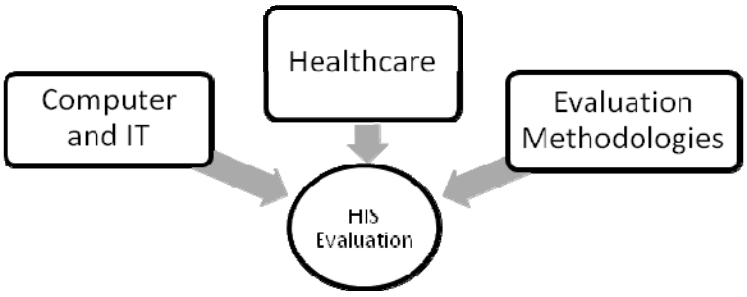
Due to inherent dynamic nature of informatics system development and implementation projects, the level of evaluation and thus the method applied varies depending on the stage of the standard software

development life cycle. This mandates a conceptual framework that guides the researchers and evaluators through the stepwise evaluation process.

## How to Evaluate HIS?

As the phrase *"Health Information System Evaluation"* implies, evaluation studies in the context of health informatics have to deal with inputs from three complex areas of healthcare (at both individual and organizational scale), computer and IT, and evaluation methodologies (Figure 16).

**Figure 16 - Complexity of HIS Evaluation**




Thus any evaluation attempt requires detailed plans to deal with

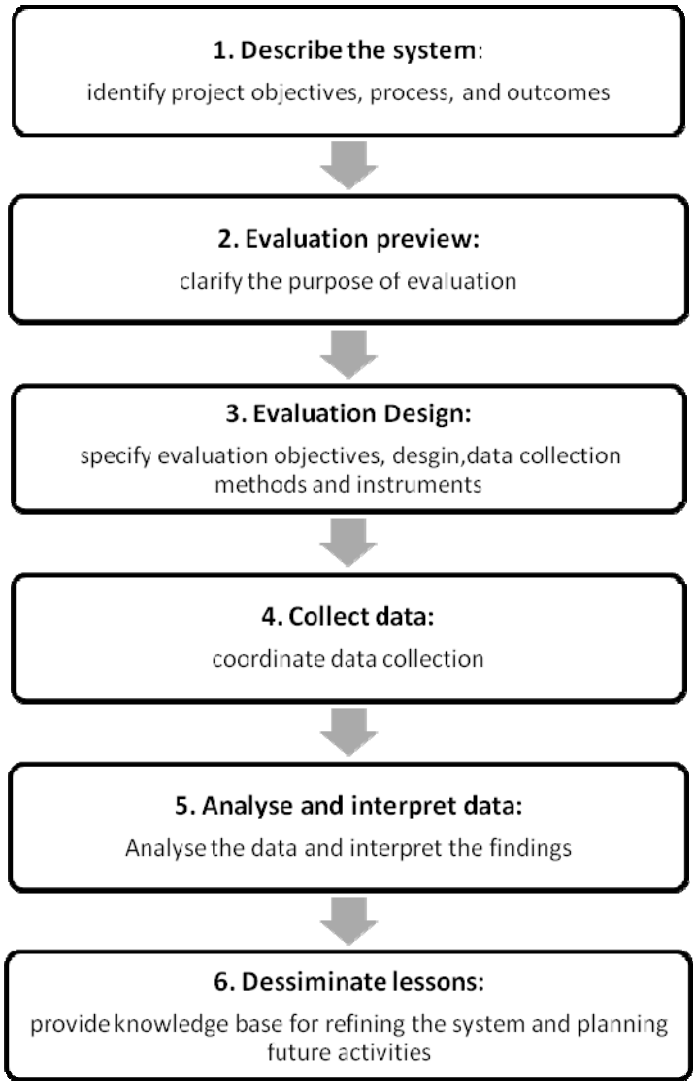
- Involvement of large number of stakeholders, and complex work processes and power structure within healthcare system (68);
- Existence of large number of HIS evaluation frameworks, each looks at different technical, sociological, economic, human, and organizational aspects. Thus, selection of a sufficient framework that fits a specific context is not an easy task (61, 62);
- Wide range of success determinants makes their selection process unclear. Insufficient evaluation criterion has resulted in costly and ineffective studies that has not been able to provide useful information about system performance (62, 70);
- Organizational resistance to publicize their failures and mistakes (61);

Analysis of the evaluation methodologies such as PRISM,CHEATS, TEAM, HTA, and 4Cs (67, 71-74) shows how these frameworks differ in terms of theoretical background, evaluation measures, specificity, and timing based on the system development life cycle. Despite all the differences, they follow a six-stage planning guide (Figure 17) that provides a stepwise process for planning and conducting an evaluation project (63, 64).

As seen in Figure 17, the first step towards the design of an evaluation framework begins with clear and concise definition of different aspects of the system under development, including objectives, process, and outcomes. These aspects should be developed in a way that later assessments can clearly indicate the extent they have been achieved. Thus, explicit mission statement for the project is fundamental to having an appropriate evaluation program. This statement should include project's objectives that are

specific, measurable, achievable, relevant, and time specific. Once system's objectives are defined, the likely immediate impacts of the system at individual and organizational level and their indicators should be identified (64).

**Figure 17 - Six steps of evaluation process. Adapted from Round et al,** (64)




Similar to the design and development of any project, evaluation also requires clear vision statement that determines the nature and purpose of it. Having a clear insight on what we want to achieve, what questions need to be answered, who are stakeholders, and what information we need to obtain forms the basis of an evaluation framework. Answers to these questions not only determine the type, scale, and scope of evaluation suitable for each case, but also help to select key evaluation questions. Based on this knowledge suitable indicators or success measures will be defined for later assessment of system performance and outcome (64).

Once the purpose and key question are defined, the overall evaluation design determines the method that will be used to obtain relevant information. This includes identification of quantitative and qualitative designs for data collection. Quantitative approaches focus on gathering numerical data, such as pre- and post implementation surveys, often used to seek differences prior and after the introduction of new systems. Whereas qualitative methods, such as interviews, focus groups, and participatory action research, relies on written or spoken data useful to assess the process. Depending on the evaluation purpose, a single or a hybrid approach will be appropriate (64).

Now that the tasks, the time they should be undertaken, the people in charge of undertaking them, and the required instruments are specified, the whole assessment program can be put in action. Following data collection, information should be extracted from the raw data. Data analysis and interpretation is a crucial step towards forming knowledge and obtaining evidence on the appropriateness of the program in terms of its impacts and outcomes (64).

# MCC Evaluation

## Evaluation Scope and Design

As Figure 17 implies, any evaluation study requires careful investigation and preparation at each step of planning, implementation, and analysis. Considering the limited timeline for this study, evaluation element of the project is limited to the identification of the elements of the first phase. Subsequently, design factors for implementation (data collection strategies) and analysis (how to interpret findings) steps are subject to future research.

This study comprises a comprehensive literature review to obtain insight about the earlier attempts to measure success of medical information resources. The reviewed studies each imply the unique perspective of their designers on the definition of success and introduce specific measures and metrics. It is argued that various proposed HIS evaluation methodologies are complementary approaches in that each of them assesses different aspects, including technology, human, organization, and economy, of HIS. Extracting the domains under investigation in these studies and classifying the evaluation measures under each domain may lead to a large pool of assessment criteria. Depending on the objectives of program evaluation, these different domains can be further combined together and most relevant measures that best fit the context and goal of the assessment can be selected to form a multi-method, comprehensive, and specific HIS evaluation framework (62).

## Proposed Framework

Selected framework for evaluating our intended informatics platforms is based on the Benefits Evaluation Framework proposed by Canada Health Infoway (CHI) in 2007. The framework was originally adapted from DeLone and McLean (D&M) Information Systems (IS) Success Model. Despite being developed for business environments, continuous refinements and incorporation of organizational and social contexts have extended its application to the healthcare environment (69).

Based on comprehensive review of literature on IS research, D&M proposed the first version of their multidimensional IS success model in 1992. The model provides measures to evaluate an information system at three different levels, including technical, semantic, and effectiveness. Facing a period of empirical evaluation and criticism from academia, they introduced the revised version of the original framework in 2003. Considering both process and causal mechanisms of IS success, six interrelated dimensions were proposed (Figure 18).

A process model features step-wise procedure that starts with creation of a system. Once users start using it, they become familiar with different features of the system and its information products. Based on users experience from interaction with the system, system use is going to affect individual users in the conduct of their work and ultimately produce organizational impacts.

Based on D&M arguments, the existing interrelation between the six measures result in a causality flow that is in the same direction as the information flows. For instance, higher system, information, and service quality is expected to result in higher user satisfaction and use, leading to positive individual and organizational impacts. This combination is showed by use of bidirectional arrows to relate the six dimensions (75).

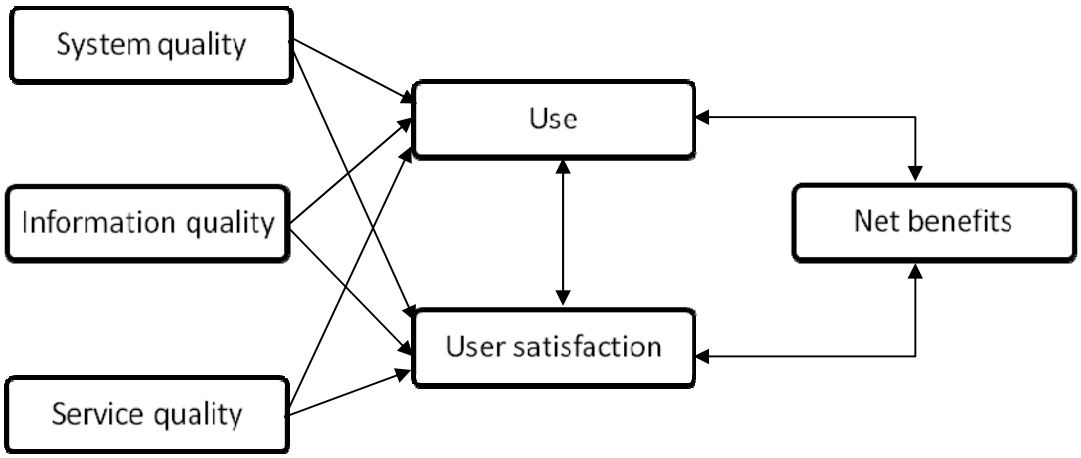



**Figure 18 – Evaluation Framework. Adapted from Delone and Mclean,** (75)

Use of arrows in Figure 18 indicates D&M perception of success as a dynamic process in which the six dimensions interrelate temporally and causally. This means once an IS is developed, the use and user satisfaction will be influenced by system, information, and service quality individually or jointly. The two usage dimensions not only affect each other but also have impacts system net benefits (70).

For the six conceptual dimensions, CHI has defined different categories of success factors (76). These categories are based on the result of a comprehensive literature review by van der Meijden et al in 2003 (70) on determinants of success of inpatient clinical information systems.

1. *System quality* includes attributes to assess the operational capabilities, technical functioning, security features, and level of decision support (report, reference, reminder, alert, assist, guide)

embedded in the information system. These attributes are classified under three categories of *Functionality, Performance, and Security*.

2. *Information quality* concerns content and semantic of information and assesses how well the intended meaning is conveyed. This construct aims at evaluating of the system's input and output. Two categories of *Content* and *Availability* are considered. Content covers the completeness, accuracy, relevance, and comprehension of information. Availability covers the timeliness, where and when needed, as well as reliability and consistency of patient information across existing databases and overtime.

3. *Service quality* comprises attributes to evaluate mainly post-implementation activities such as training programs and technical support. These measures are categorized under *responsiveness*.

4. *Use* is a complex success dimension that evaluates the nature, extent, quality, and appropriateness of the system utilization. It seeks both actual and user-perceived usage intention/pattern. It provides information about the extent to which system's functionalities are being utilized for the intended purpose. The variability in the quality and intensity of system use is likely to influence the realization of desired system deliverables. Three categories of *Use behavior and pattern*, *Self-reported use*, and *Intention* to use are considered.

5. *User satisfaction* has three categories of measures - *Competency*, *User Satisfaction*, and *Ease of use.* They gather users' perception of system usability in terms of users' required competence and prior experience, user-friendliness, and learnability.

6. *Net benefits* covers the impacts of the IS on the larger groups beyond its immediate user. Considering the ever-increasing number of entities affected by introduction of ISs, these measures bring broader view of system impacts by considering work groups, organizations, consumers. CHI suggested three categories of net benefits – *Quality*, A*ccess*, and *Productivity*. Within the context of net benefits, quality refers to the adherence to policy and practice standards, continuity of care, health outcomes, and patient safety. Access measures assess the extent to which services are available to users and their ability (in terms of time) to access them. Productivity measures system efficiency in terms of financial and human resources being used, output, and process improvements.

## Rationale

There are several reasons that make adoption of this framework beneficial for evaluation of the MCC platform. They include:

1. *Large number of empirical studies at both individual and organizational levels to validate the model*: Following the first introduction of D&M success model in 1992, the framework has been gaining more and more attention as the number of publications referenced the model has been increased. To date, over 150 empirical studies have investigated D&M model's performance in several different contexts, including healthcare (77-82). Utilizing the results of these studies to

further refine the approach has made it a mature model in assessing HIS performance. This continued changes and growth has led to a rigorous evaluation method that covers complete range of organizational and context factors (76, 83);

2. *Selective nature of the framework:* One of the key characteristics of D&M success model is its emphasis on the importance of context-specific consideration in the assessment process. As stated in their original model of IS success in 1992, *"no single variable is intrinsically better than another, so the choice of success variable is often a function of the objective of the study, the organizational context … etc."*. This important factor allows the researchers and evaluators to include the most appropriate success determinants that are measurable and contingent on the goals of the evaluation (75). In addition, this important characteristic makes it possible for the evaluators to capture favorable range of perspectives by including variables that focus on certain groups of actors that may be affected by the interventions;

3. *Contribution to the national effort to establish a robust high-level evidence-based HIS evaluation framework:* The idea of incorporating evidence-based strategy within management decision-making has shown relevance to implementation of projects and systems within complex healthcare community. Many countries including the UK, Australia, Canada, Scandinavia and other European Union member states, have been trying to embed evidence-based management approach in their national follow up and evaluation policies. The resulting evidence from the assessment of IT interventions in healthcare is believed to be beneficial for policy makers, developers, and researchers to learn from challenges and experiences and thus, promote future eHealth investment and implementation (84). However, lack of consistent metrics and datasets for evaluation of eHealth interventions has made it difficult to gather and compare the results and assess the progress.

   In Canada, CHI has provided this high-level evidence-based evaluation model to foster the assessment of individual healthcare investment programs. Like national-level assessment programs in the UK, Finland, and Australia, CHI forms the ground of evaluation activities based on the D&M IS success model (84). This framework works as a point of reference that ensures consistency in measurement and meaning across field evaluation studies in Canada. It brings the opportunity to compare the results of evaluation studies with other studies within different programs and jurisdictions;

4. *Supporting health outcome measurements:* Enduring characteristics of health outcome measures make their assessment a resource-intensive and time-consuming activity. Many outcome measures are long-term variables that require long periods of observation. In order to realize full benefits of an outcome measurement activity larger population size that is representative of high proportions of healthcare episodes needs to be formed. It also often requires data collection methods that differ from the conventional approaches being used to record clinical or billing data. In addition, there are many other factors beyond selected variables that could potentially affect health outcomes. Thus, providing clear and interpretable feedback is difficult, as an outcome does not always result from a particular process (85).

Collectively all these factors make healthcare outcome evaluation a burdensome activity that are rarely experience full implementation.

MCC platform has integrated data registry and query capabilities that would facilitate aggregated outcome data capturing and analysis. These system functionalities could be utilized to conduct outcome assessment of not only the new informatics intervention but also various cancer treatment strategies. It is believed that selecting a framework that supports outcome evaluation could provide useful input to clinical and evaluation studies. The proposed evaluation framework incorporates outcome measures to assess changes in individual health status as a result of the new informatics intervention;

5. *Young age of this approach for evaluating HIS in Canada:* Before being widely accepted, CHI framework requires further validation across various types of systems organizational environment. Investigating the performance of this approach can serve as a valuable input to improve its validity, relevance, and utility. An extension of this approach, proposed in the current study, could be considered as a contribution to the national effort to provide a common basis by which HIS success can be described, measured, and compared;

## D&M Constructs – Extension to the MCC Platform Evaluation

The proposed evaluation framework for the assessment of MCC platform is based on my own adoption of CHI's Benefit Evaluation Framework for Health information Systems. Considering project-specific goals, and system and context characteristics, not all the D&M evaluation criteria are applicable. Instead, only those metrics that are of particular interest within the context of MCC were drawn from an extensive literature review. As emphasized by D&M in their early proposal, it is the objectives of the system and organizational context that defines success determinants for a given system. Thus, no single variable leads to superior assessment than another.

In a comprehensive review on the systematic reviews of HIS evaluation studies, Lau et al. (86) and van der Meijden (70) provides detailed list of evaluation measures extracted from HIS evaluation studies. In order to present these metrics in an understandable and meaningful manner, they applied D&M framework as an organizing scheme.

### *MCC Project Mission Statement*

The MCC platform is an internet-based application that seeks to facilitate complex clinical decision-making process in the context of multidisciplinary cancer conferencing. It will address issues that both care providers and patients face throughout cancer care continuum. The ultimate goals of implanting the MCC web-based application are to:

1. Address workflows inefficiencies around case management, clinical communication, and scheduling requests.

2. Enhance clinical productivity by simplifying access to patient information (for all healthcare providers), preparation of presentation materials, report generation and dissemination.

3. Improve quality of care by adhering to best practice guidelines, improving disease management, and reducing medical errors.

4. Provide means for effective, efficient, and timely decision making for healthcare professionals.

5. Leverage synoptic data capture to enhance the measurement/monitoring of the care process and assess health outcomes.

6. Standardize and improve the quality and utility of clinical conference notes.

7. Develop selected high quality clinical templates to aid in preparation and documentation of patient case presentations.

8. Incorporate multi-media as required:
    - Traditional medical images
    - Digital and telepathology
    - Endoscopic, surgical, dermatologic, retinal, etc. images

9. Provide a robust database for secondary users including research, reporting, and financial management.

10. Improve knowledge transfer especially in the training and teaching of medical students, residents, and fellows.

11. Provide a bilateral information flow between research and practice in cancer treatment by capturing clinical intervention and their result. Systematic collection and analysis of subjective data about health staff intervention in the treatment could possibly support complementing research from academia with evidence-based practice.

12. Enhance patient engagement and communication through a patient portal.

### *Evaluation Vision Statement*

Analyzing the desired features and functions of the MCC platform, the evaluation model focuses mainly on issues around administrative and clinical workflow, and various aspects of care quality, including its coordination, continuity, integration, access, timeliness, and cost. The primary question that MCC evaluation project seeks to address is:

*"1. How successful the informatics platform is in supporting MCC process, function, and outcome?"*

Secondary question involves determining:

*"2. Whether technical and semantic features of the system effective enough to achieve the desired functionality?"*

These two main streams of the evaluation are reflected in a set of variables assessing work simplification, improvements in health outcome, and adherence to standardized best practice guidelines. Usability criteria along with elements from technical, semantic, and end-user support levels are incorporated within the framework. These factors will be selected to provide useful information about possible ways to enhance user experience with the systems and promote its use.

## *Framework Components*

Evaluation constructs and measures are selected based on two main criteria:

1. *Stage of development* is a major factor to determine which metrics are suitable for evaluation purpose. Depending on whether or not a HIS exists, evaluation may include measures from system, individual/organization, and environmental levels. Since, to the best of our knowledge, there are no informatics platforms that serve MCCs at the moment, it is thought advantageous to compare the scope of daily practice change that would bring on by the system. This information not only promotes its use but also helps system designer to find solutions for possible flaws in design and development.

2. *Evaluation vision statement* provides the basis for strategic planning regarding future assessment activities. Derived from project objectives, evaluation statement articulates what will be achieved or the questions that will be addresses following assessment activity.

Based on the above two arguments, the main focus of the evaluation study has been placed on the assessment of how various aspects of technology quality, its perceived usefulness, and actual use can affect clinicians workflow and productivity. Table 18 – Framework Components includes selected variables for each of the constructs.

**Table 18 – Framework Components**

| Dimension | Category/Sub-category | Study Question | Indicator | Measure |
|---|---|---|---|---|
| **System Quality** | • *Functionality* | 1. What functionalities are included in the platform? | Review of functionalities | - Availability of functions that were identified through use case analysis<br>- Users perception |
| | | 2. Does the MCC platform provide sufficient level of | Correspondence of decision support level | -Users perception |

| Dimension | Category/Sub-category | Study Question | Indicator | Measure |
|---|---|---|---|---|
| | | decision support (i.e. report/view, reference, reminder, alert, assist, and guide) for its different functionalities? | with each system functionality | |
| | • *Performance* | 1. How reliable is the system in different workload conditions? | System response time for different tasks | - Time to login<br>- Time to search patient<br>- Time to obtain patient clinical information<br>- Time to generate alerts<br>- Time to save the report |
| | | | System success/failure for connection and downloading | - Number of system functionalities that requires data gathering from external data source<br>- Connection failure rate for each functionality that requires external resource access |
| | • *Security* | 1. Does the platform provide suitable functionality to authenticate authorization for services?<br>2. Does the system ensure confidentiality and integrity of patient data? | System security features | - Type of authorization and authentication services<br>- Compatibility of security features with existing technological platforms |
| | | | | |
| **Information Quality** | • *Content* | 1. Does the MCC platform provide means of comprehension and integration of computerized decision support (CDSS) and patient information? | Availability and types of CDSS | Users perception |

| Dimension | Category/Sub-category | Study Question | Indicator | Measure |
|---|---|---|---|---|
| | | 2. Is available information complete enough for the purpose of case review? | Availability of all required information for providing consult | User Perception |
| | | 3. Does the MCC platform provide means for complete and accurate referral and consultation documentation? | Accuracy and comprehension of MCC report | User Perception |
| | | 4. Does the system provide comprehensive, accurate and relevant information regarding patient case? | Relevance, accuracy, and completeness | User Perception |
| | • *Availability* | 1. Does the system provide timely and universal access to information for users? | Availability of information | - User and patient perception |
| | | | | |
| **Service Quality** | • *Responsiveness* | N/A | N/A | N/A |
| | | | | |
| **Use** | • *Use behavior* | N/A | N/A | N/A |
| | • *Self report use* | N/A | N/A | N/A |
| | • *Intention to use* | N/A | N/A | N/A |
| | | | | |
| **User Satisfaction** | • *Competency* | 1. What is the required level of user competency in IT to effectively use the system? | Users knowledge and experience in working with computers | - User perception |
| | • *User satisfaction* | 1. Why do board members use the MCC platform? For those who do not use it, why don't they use it and what would get them to use it? If they used it but stopped using it, why did they stop? | Perceived expectation, value of the system | - Users perception |

| Dimension | Category/Sub-category | Study Question | Indicator | Measure |
|---|---|---|---|---|
| | | 2. What is the level of board members' satisfaction with MCC platform? | Board members satisfaction | - Perceived usefulness (overall and of specific functions)<br>- Relative advantage over current method of practice<br>- Clinical performance |
| | | 3. What is the level of patient satisfaction with the MCC platform? | Patient satisfaction | - Patient perception |
| | • *Ease of use* | 1. How easy is to interact with the system from users' and patients' perspective? | Compliance with usability criteria | - Perceived ease of use<br>- Perceived level of learnability from interaction with the system |
| | | | | |
| **Net Benefits** | • *Quality* | | | |
| | o Patient safety | 1. Does the MCC platform provide more detailed, and complete consultation profile for patients? | Referral and consultation documentation | Perceived effectiveness in referral and consult templates |
| | | 2. Does the MCC platform assist consulting specialists to apply evidence-based standards in providing consults? | Changes in healthcare provider practice | - Availability of clinical practice guidelines and evidence based standards<br>- Improvement in clinical management of disease |
| | o Appropriateness/ effectiveness | 1. Does the MCC platform improve turnaround time for consultation? | Timeliness of access to consultation result | *Pre&Post-Implementation*<br>- Average turnaround time for a referral |
| | | 2. Does the MCC platform support more timely delivery | Timeliness of care delivery | *Pre&Post-Implementation*<br>- Time took for |

| Dimension | Category/Sub-category | Study Question | Indicator | Measure |
|---|---|---|---|---|
| | | of patient care by referring physician? | | the referring physician to make final clinical decision |
| | | 3. Does the MCC ensure adherence to practice standards and guidelines? | Compliance with administrative and clinical guidelines | - Compliance with CCO's administrative standards for MCC<br>- Compliance with diagnostic and clinical best-practice for various organ-specific diseases |
| | | 4. Does the implementation of MCC improve continuity of care for cancer patients? | Provider-provider and patient-provider relationship | - Availability and flow of information through the course of referral and consultation and afterwards |
| | o Health outcomes | 1. Do patients achieve longer life of subjective and objective better quality? | Health related and self reported quality of life | - Mortality rate<br>- Morbidity rate<br>- Health/Well-being measures |
| | | 2. Does the implementation of MCC enhance patient care and recovery? | Efficiency of care and recovery | - Number of Patients readmissions<br>- Time to return to functional status |
| | • *Access* | | | |
| | o Ability of patient/provider to access services | 1. Does the MCC platform increase specialized care centre's capacity to provide consult for outside cases? | Outside consultation rate | *Pre&Post-Implementation*<br>- Number of outside case consultations |
| | | 2. Does the MCC platform increase access to specialized consultation for patients and care providers in remote areas? | Access to previously unavailable specialized consultation | - Number referrals from new sites<br>- Waiting time for specialist consult |
| | o Patient/caregiver participation | 1. Does the MCC implementation enhance patient self- | Access to reliable source of case-related | - Patients perception |

| Dimension | Category/Sub-category | Study Question | Indicator | Measure |
|---|---|---|---|---|
| | | management? | information | |
| | • *Productivity* | | | |
| | o Efficiency | 1. Does the consulting group manage demand and provide consultation to more cases? | Change in consultation provider productivity | *Pre&Post Implementation*<br>- Average number of cases reviewed per week<br>- Average time to sign out each consult |
| | | 2. Does the MCC streamline administrative management of the meeting? | Changes in Administrative management | *Pre&Post Implementation*<br>- MCC coordinators perception<br>- Average administrative staff time spent per case |
| | | 3. By the implementation of the MCC, is there a decrease in the time takes for radiologists to access radiology images and generate the report? | Radiologist efficiency | *Pre&Post Implementation*<br>- Time required by the pathologist to assess the images and generate the report |
| | | 4. By the implementation of the MCC, is there a decrease n the time it takes for pathologists to access an exam and generate the report? | Pathologist efficiency | *Pre&Post Implementation*<br>- Time required by the pathologist to assess the images and generate the report |
| | | 5. How does MCC platform implementation affect consultant workload, workflow? | Specialized consultant workflow | *Pre&Post Implementation*<br>- Clinical staff perception |
| | | 6. Does the MCC enhance board members' experience with the actual run of the session? | Board meeting efficiency | - Meeting attendees perception |
| | | 7. Does the implementation of | Patient efficiency | - Patients perception |

| Dimension | Category/Sub-category | Study Question | Indicator | Measure |
|---|---|---|---|---|
| | | MCC lead to enhanced efficiencies for patients? | | |
| | o Care coordination | 1. Does the implementation of MCC provide clear road map for delivery of care to each patient? | Effectiveness of referral and consultation documentation | - Board members and patients perception<br>- Number of patient visits |
| | o Net cost | 2. Does the MCC implementation decrease number of unnecessary duplicate diagnostic tests? | duplicate diagnostic test rate | *Pre&Post Implementation*<br>- Number of duplicate diagnostic tests<br>- Number of patients visits |

# Discussion

## Limitations

There are a number of limitations that should be considered when interpreting the results of this study. The proposed features of MCC solutions are mainly based on the observations of three types of board discussions, i.e. genitourinary, gastrointestinal, and breast cancer meetings. Therefore, relevant information and requirements that are specific to the context of other body organs or diseases may have been excluded.

In addition, while conducting literature review, wide variation in the format of the documents, as well as the framing of priorities, goals, objectives and strategies have been discovered. This posed a challenge to the establishment of a common structure for analysis and identification of MCC platform functionalities and users demands.

## Implications

There is growing number of publications that have been identifying existing challenges regarding implementation and actual run of MCCs within cancer programs globally. This is the first study that proposes an IT-enabled solution, based on the existing infrastructure, to address current challenges in multidisciplinary care delivery for chronic patients. Its findings add to the current knowledge available, and should contribute to the support of efforts towards improving clinical workflow efficiency, health outcomes, and patient safety.

In many countries around the world, there has been an ongoing effort to make interdisciplinary care delivery an integral part of chronic disease management rather than being treated as an isolated endeavor. This study supports the idea that ICT-enabled solutions are capable of filling up the communication gap between specialized and primary care teams and ultimately improve complex clinical decision-making for chronic patients. In addition, research teams planning to develop new computerized artifacts for medical purposes or improve existing ones could use the proposed evaluation framework, which could be targeted as part of the implementation plan, to identify specific strengths or weakness of their system. The proposed framework could be used as a diagnostic and prescriptive tool for considering barriers and enablers during the design and implementation of IT platforms.

While different approaches and standards have been used in the countries that have already implemented MCC to support cancer care, they share many common challenges that could be addressed in a coordinated fashion. Therefore, the results here could support the establishment of synergies to overcome communication barriers that multidisciplinary care teams are facing in their daily practice.

It is hoped that the standardized stepwise method for the design element of the MCC platform and the proposed evaluation framework arising from this study could be of value to research activities aiming at improving chronic care delivery, and to those interested in the identification and analysis of HIS evaluation methods.

## Future Studies

This MCC project aims at improving process, function, and outcome of tumor boards through the use of a PoS software application. This project follows the first stage of development for HL7 Version 3 artifacts. The final product of this stage, i.e. the Use Case Model, serves as a basis for successful progress in the later stages of development. Future research is required to proceed with the step-wise approach towards implementation through identifying message contents, messaging behavior, and message specifications.

In the second phase of this study, a framework for evaluation of MCC platform is proposed. A number of measures were identified to assess system functionalities and impacts on the process, function, and outcome of MCCs. The value of the proposed metrics should be examined, particularly in their ability to evaluate effectiveness of the proposed computerized platform in improving interdisciplinary care delivery.

Since the proposed framework focuses mainly on post implementation measures, future research is required on evaluation metrics that could assess appropriateness of the method that is going to be used for delivering MCC project's final product. These complementary elements would provide valuable knowledge about level of success at different stages of implementation and delivery, given that having a functional prototype does not always guarantee a successful implementation and acceptance from end users.

Lastly, there exist a diverse number of qualitative and quantitative methods, each with its own implications, for conducting evaluation. Selecting the best approach, which accommodates context specific characteristics while searching empirical support for our research hypothesis, requires future research.

## Conclusion

This study aims at investigating IT-enabled opportunities to improve interdisciplinary care delivery process for patient with chronic conditions. My research shows that growing demand for holding multidisciplinary team meeting for cancer management has brought implications in terms of workflow and communications among specialists and primary care teams. Elimination of technology barriers through broadband, internet-based computing and commoditized hardware solutions has made virtualization of expert care a potential solution to address human resource and case-costing constraints while supporting health equity, sub-specialization, service excellence and research. To the best of my knowledge, there has been no documented effort to utilize IT solutions to improve interdisciplinary care delivery in the context of MCC. This research is dedicated to create a comprehensive use case model that documents the process of MCC along with required functions to support team meetings. The resulting use case model is the most important input for future research on the development and implementation of a computerized system that makes virtualized expert care a reality.

In order to guide future evaluation activities, the work also presents an evaluation framework. This part contributes to the design of assessment element of the MCC project. Based on the two main evaluation

questions that are proposed, a set of measures and metrics are selected. Each is then categorized under the proper evaluation construct. Depending on the inherent nature of the proposed metrics, future decisions need to be made to indentify the most effective way to monitor and gather relevant data. Analysis of information we will obtain through the implementation phase of evaluation will eventually form the basis for future system improvement decisions.

# Appendix A – MCC Patient Summary

EXAMPLE ONLY: Specific Disease Sites may require additional information

## MCC Patient Summary

**Patient Information:**
Patient ID: _____
Medical Record No: _____
Birth Date: ____/____/_____

Primary Physician: _____

Is patient aware of diagnosis? Yes / No

**MCC:**
Meeting Date: ____/____/_____
Chair: _____

☐ New Case
☐ Follow up Case

**Details:**

| | | | |
|---|---|---|---|
| **Diagnosis Summary** | | | |
| **Imaging Findings:** | *Date* | *Test* | *Findings* |
| | | | |
| | | | |
| | | | |
| **Patient Wishes** | (if known, unique wishes that may impact treatment recommendations or be necessary information for social workers, palliative workers, etc) | | |

**MCC Discussion / Treatment Recommendation:**

| | | | | |
|---|---|---|---|---|
| **Further Investigations?** | | | | |
| **Treatment Recommendation** | a) Surgery b) Radiation c) Chemotherapy d) Other _____<br>Description: | | | |
| **Urgency to Treat?** | ☐ Immediate | ☐ Within 7 days | ☐ Within 14 days | ☐ Other _____ |
| **Trial Eligible?** | YES / NO | If Yes, what Trial: _____ | | |
| **Actions & Owners** | *Name* | *Action* | | |
| | | | | |
| | | | | |

**Follow up Information:** *(Delete if another process for follow up)*

| | |
|---|---|
| **Date Tx Received** | |
| **Describe Actual Tx** | |
| **Tx Results** | |
| **Further / Future Action** | |

## Appendix B - Multidisciplinary Cancer Conference (MCC) Record

EXAMPLE ONLY: Specific Disease Sites may require additional information

### Multidisciplinary Cancer Conference (MCC) Record

| Patient Information | MCC Information |
|---|---|
| Patient Name: _____ | Disease Site: _____ |
| Medical Record No: _____ | Meeting Date: ____/____/_____ |
| Birth Date: ____/____/_____ | Chair: _____ |
| Staff Physician: _____ | |

**Details**

| | |
|---|---|
| **Diagnosis and Summary** | |
| **Radiology Findings** | |
| **Pathology Findings** | |
| **Patient Wishes** | (if known, unique wishes that may impact treatment recommendations or be necessary information for social workers, palliative workers, etc) |

**MCC Discussion / Treatment Recommendation**

| | |
|---|---|
| **Investigations** | |
| **Treatment Recommendation**<br><br>**OR**<br><br>**Further Investigation Description** | |
| Note: Please see **"MCC Documentation FAQ"** for additional information on MCC documentation. Please give this completed form to the MCC Coordinator. | |

Original Version: June, 2006
Updated Version: January, 2010

## Appendix C – MCC Attendance Sign-In Sheet

# <<NAME>> Multidisciplinary Cancer Conference (MCC) Attendance Sign-In Sheet

MCC Date: _____
MCC Chair: _____ MCC Coordinator: _____

| Name | Signature | Department | In person/ Tele/Video |
|---|---|---|---|
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Original Version: June, 2006
Updated Version: January, 2010

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