

Design and evaluate a model (prototype) for immunization record system in distributed
healthcare

by

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BSc, University of Science and Culture, 2000

A Thesis Submitted in Partial Fulfillment of the
Requirements for the Degree of

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in the School of Health Information Science

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ABSTRACT

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Since online database applications have become increasingly used in clinical systems, accessing to an online immunization record system needs to be addressed to keep people updated about their latest immunization status and help providers to recommend the next appropriate vaccine at any location and anytime. Sufficient Health Information Systems can bridge the gap between the clinical and technical knowledge and benefit healthcare system. In this study, the requirement of designing a database for an immunization record model was reviewed, and a model was designed; subsequently, a database application was developed, and the qualitative assessment was deployed to evaluate the quality of data and some of usability factors. Through this study, the researcher describes how the data model was designed based on the information gained from Canadian resources such as Public Health Agency of Canada, Centers for Disease Controls, and Canadian Immunization Guide- seventh edition; then, a database application was developed, and the qualitative evaluation was performed to understand healthcare providers' expectation from the real system.

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Dedication

To my parents,

*for unconditionally providing their
love, support, guidance, and encouragement.*

CHAPTER I: Introduction

Everyone needs health protection regardless of age, and vaccines can help to protect individuals from harmful diseases (Pabani, 2009); in other word, “*the need for immunizations does not end with childhood*” (Healthlink BC, 2010, P.1), and adult people can be hospitalized or even died because of a simple disease. An online immunization program can help to track individuals’ immunization records quickly, eliminate traditional paper work, prevent adverse vaccine events and provide lifelong protection against diseases. Such system can also help health providers to monitor the members’ vaccination history and administer appropriate vaccine with regard to members’ reaction to specific vaccine(s).

1.1. Motivation

In 1996, the Canadian Immunization Conference identified an urgent need for creating an immunization tracking system in Canada (Public Health Agency of Canada, 2004). According to Canadian Public Health Association (CPHA): “*The lack of a national immunization registry in Canada is a significant gap that should be addressed through federal government leadership*” (Canadian Public Health Association, n.d. , para. 2). Implementing a centralized and integrated immunization record system would avoid duplication of vaccination, track immunization status and help health providers to administer specific vaccine if required. Some adults are not immunized due to the lack of coordinated immunization programs and availability of up-to-date records (Canadian Immunization Guide [CIG], 2006b). Keeping immunization records and tracking the individuals’ immunization history can assist providers to advise mandatory vaccines in a timely fashion, promote healthy life and increase quality of care. In addition, keeping the

information in paperless format and in a centralized database would enhance accessibility and reduce immunization delays and clinic wait time.

1.2. Recent Progress Related to the Proposal

Currently, Canadian National Immunization registry is under development, and no information is available on coverage rates from the National Immunization Survey 2008 (White & Scott, 2010). Canada Health Infoway is responsible for developing a health information system including a national vaccination registry for Canada, called Panorama, but such a system has not been rolled out in any Canadian jurisdiction yet (Eggertson, 2011). Panorama is a complex product with set of applications that two functional applications designed to enable immunization programs and public health materials and vaccines (Final Report, 2009). According to a publication of Carlton University, Panorama was planned to be operational by the end of 2009, but it is set to be implemented by 2016 (Capital NEWS Online, 2010).

1.3. Objective of Study

The goal of this research is to create a reliable data model based on the information provided by Canadian health resources such as the Public Health Agency of Canada, Canadian Immunization Guide and National Survey on Immunization Data Standards. The researcher also utilizes other surveys to develop an immunization record prototype that can facilitate online record tracking for individuals and health providers. An online immunization tracking system has less shortcoming in comparison with what recognized in paper-based recording system and also enhances accessibility to records at any location and anytime. The feedbacks of health professionals (end- users) help the researcher to understand what their expectations are from the real system.

In brief, the result of this study can be helpful to implement a superior immunization record system which will benefit Canadian population in the future.

1.4. Outline of the Thesis

This thesis includes the following chapters: Chapter 2 provides the literature reviews and background knowledge about the immunization record system in Canada. Chapter 3 describes how the Entity Relation Diagram is designed and how the application is developed. Chapter 4 discusses how the model is evaluated by professional clinicians, and Chapter 5 concludes the research and provides some future research directions.

CHAPTER II: Literature Review

This chapter reviews previous research works and introduces existed systems/implementations.

2.1. Previous Research Work

In 1996, the Canadian consensus conference on the National Immunization Record System recommended that there is an immediate need for an immunization tracking system in Canada to help parents know about their children's immunization status (i.e. due or overdue for vaccination) and to provide a database to assist health care providers to identify and make the right decisions for people with delayed immunizations (Public Health Agency of Canada, 1998). To follow up these recommendations, another conference was held in March 1998 which developed a goal for National Immunization Records Network *"to ensure every provinces/territories will have a comprehensive electronic immunization registry capable of participating in a national immunization records network by 2003"* (Public Health Agency of Canada, 2004, para. 4). In 2002, The National Immunization Records Network was renamed to Canadian Immunization Registry Network (CIRN) and CIRN became responsible *"to provide standards, central coordination, and sustainable planning to support compatible electronic immunization registries in Canada"* (Public Health Agency of Canada, 2004, para. 6). Based on Health Canada *"The registries are being designed as a population-based database, and immunization records will be used as the basis for Electronic Health Records"* (Health Canada, 2006, para. 1). According to Immunize BC, *"An immunization registry is a key component of an immunization information system"* (Immunize BC, 2007, p.27).

In 2003, a \$45 million Federal Budget was provided to assist in the continued pursuit of a national immunization strategy; this budget strengthened the collaboration with the provinces, territories, and the stock holders to improve the effectiveness of immunization program and address the current and future immunization issues in Canada (National Immunization Strategy Final Report, 2003). The supporting activities associated with the National Immunization Strategy (NIS) are described completely in the NIS final report in 2003.

In March 2004, the federal government tasked Infoway (a non-profit organization) with the development of a public health surveillance system called Panorama (Laroche & Diniz, 2012). Panorama has seven modules that the immunization management and inventory management modules were pictured to provide the basis for a national network of immunization registers (Laroche & Diniz, 2012). Based on the Infoway Public Health Surveillance Evaluation final report, "*Panorama is due for completion in March 2009, and the various jurisdictional implementation projects are anticipated to be completed between 2010 and 2012*" (Final Report, 2009, p.8); however, a publication of Carlton University reported that Panorama was planned to be operational by the end of 2009, but it is set to be implemented by 2016 (Capital NEWS Online, 2010). Panorama is behind schedule and provides a partial solution toward a national network of immunization registers that some provinces decided to opt out for the place of other immunization register systems (Laroche & Diniz, 2012).

A study conducted in advance of the 2009 H1N1 vaccination campaign reported that financial and human resource constraints as well as coordination between immunization providers are some of the barriers to implementing an ideal Immunization

Information System (Heidebrecht et al., 2010). Furthermore, additional barriers identified in that study include the following: the amount of staff training, the difficulty and expense of ensuring access to a remote system, and the incompatibility of the systems used across jurisdictions. Based on BIOTECanada Vaccine Industry Committee, type, format, and frequency of data collection varies from province to province and future resources and leadership will be needed to develop a nationwide system of population-based registries that can systematically track vaccination status across the country (Cutcliffe, 2010).

According to the National Immunization Strategy (NIS) Final report in 2003, *“provinces/territories are responsible for planning, delivering and funding the immunization program to their population and support national immunization strategy”* (National Immunization Strategy Final Report, 2003, p.1); therefore, each province or territory is responsible for implementing immunization registers (information or software application) within its jurisdiction and the federal government is to provide leadership in developing a national network of immunization registers (Laroche & Diniz, 2012). National survey on data standards reported that Alberta, Saskatchewan, Manitoba, New Brunswick, Nova Scotia, Prince Edward Island, Newfoundland, Northwest Territories and Nunavut are using a centralized system; whereas, decentralized local programs are used in British Columbia, Ontario, and Quebec which supports the forwarding and recording of immunization data to a central accumulation at the provincial level (National Survey on Immunization Data Standards, 2000). This survey reported that among all these systems, only Alberta and Saskatchewan are using web based systems. A study on improving accountability for children’s health (Guttmann, Shulman, & Manuel, 2011)

provided a report that shows the current immunization registry status by different provinces and territories (Appendix A).

An eHealth strategic framework is currently implemented in British Columbia that describes BC long term vision for eHealth within the next few years (Immunize BC, 2007). This document also says that the long term plan is to implement a single or integrated system of registries that can serve not only in BC, but also across the country.

In this study, the relevant literature is reviewed to gain more information about the immunization tracking systems to design an appropriate dataset and Entity Relation Diagram (ERD). The text “immunization record system” was searched in PubMed and Google scholar and a number of articles were found. In order to design an online immunization record prototype usable for Canadians, the searchable text was restricted to “immunization record system in Canada”. PubMed retrieved 19 results; among those articles, four were relevant to this study and the rest were about specific diseases or vaccines. Searching “Immunization tracking system in Canada” retrieved only one result in Google scholar which was about the National Immunization Conference. Articles and reports provided by the Public Health agency of Canada, Centers for Disease Controls (CDC) and Canadian Immunization Guide - seventh edition were widely used to implement an online immunization tracking model in this study.

2.2. Introduction of Existing Systems/Implementations.

As mentioned, the provinces and territories are responsible for planning, funding, and delivering immunization programs (National Immunization Strategy Final Report, 2003) and they provide immunization manuals and guidelines. This section briefly

describes how people access to their immunization records in different jurisdictions, some system exist and some are under construction.

2.2.1. MyHealth at Alberta

For immunization records, Health Link Alberta helps Albertans find out if their records are available based on their age and where the immunizations were done. Intensive work is currently underway to further develop MyHealth.Alberta.ca and within the next 1-2 years, Albertans will be able to log in securely to access personalized health information, including immunization records (Alberta Health, 2012). Also, Alberta Immunization Strategy 2007-2017 provides appropriate information regarding the immunization objectives in this province for public and providers.

In addition, Community Immunization Health Program (CIHP) is an easy to implement solution to store and manage immunization records for first nations. This system went live in the Stoney and Siksika First Nation communities in September 2011 (Cybera , 2012).

2.2.2. eHealth in British Columbia

Based on ImmunizeBC, there is no central registry of immunization in BC and parents has to keep their children's records as proof of immunization and if it is lost, they have to request a copy from the childhood family doctor or the public health unit that they were immunized (ImmunizeBC, 2011). An eHealth strategic framework is currently implemented in British Columbia that describes BC long term vision for eHealth within the next few years (Immunize BC, 2007).

2.2.3. Manitoba Immunization Monitoring System (MIMS)

MIMS is a population-based monitoring system to compile information on all immunizations administered in Manitoba and to ensure recommended immunizations are received (University of Manitoba [UofM] - Manitoba Center for Health Policy [MCHP], 2009). *“That system gives information on Immunization histories and some demographic information from the Manitoba Health Insurance Registry”* (UofM - MCHP, 2011). The program coverage started in 1990 for children aged 18 and under and started in 2000/2001 for adults, but coverage of adults information still needs to be validated (UofM - MCHP, 2009).

2.2.4. Systems in New Brunswick (NB)

Based on New Brunswick Immunization Program Guide, those who administer vaccine, report information to the minister within one week of administration of the vaccine; At present, there is no universal vaccine registry in NB that can be accessed by all health providers, but there are three systems that report individual level information to the Ministry: Client Service Delivery System (CSDS), the New Brunswick Medicare Program, and the New Brunswick Prescription Drug Program - Plan I (NBImmunizationProgramGuide, 2012). Based on NB immunization program guide, individual’s immunization records are available from local public health offices.

2.2.5. Newfoundland and Labrador

Individuals who wish to receive a certified copy of their Newfoundland Labrador Immunization Record should contact the Regional Health Authority of current residence (Newfoundland and Labrador Department of Health and Community services, 2012). Also, based on the Newfoundland and Labrador Immunization Manual (NLIM), Section

8, immunization information is recorded on the immunization card by Community Health Nurse and that card is required in doctor's office to be reviewed at follow up appointment (Newfoundland and Labrador Immunization Manual, 2012).

2.2.6. Northwest Territories

When individuals visit their doctor or nurse, their information is recorded on a paper chart. Over the next several years, Electronic Medical Record (EMR) will replace that chart (Northwest Territories Health and Social Services, n.d.). Public Health provides immunizations services and disease follow-up and monitoring in Yellowknife, Dettah and Ndilo to preserve health and prevent the incidence of communicable diseases (Yellowknife Health and Social Service Authority Strategic Plan [YHSSASP], 2010). *“The Department of Health and Social Services (DHSS) has developed an informatics strategic plan to set the direction of healthcare Information Management/Information Technology (IM/IT) for the NWT. The long-term objective of all the healthcare IM/IT initiatives in the NWT is to build a solid foundation for the delivery of healthcare services that support the DHSS’s Integrated Service Delivery Model (ISDM)”*. (YHSSASP, 2010, p.21).

2.2.7. SHARE in Nova Scotia

SHARE is an electronic health record system that makes Nova Scotians' health records available to authorized healthcare professionals in Nova Scotia; this system shares patient's clinical information securely and gives healthcare workers a view of a patient's health history including physician visits, hospitalizations, diagnostic images and reports, laboratory test results, prescribed drugs, and immunizations (Government of Nova Scotia, 2011).

2.2.8. Nunavut

The Nunavut Immunization Cards that is initiated at birth, permits regular checking and updating of the individual's immunization status; Initially the Hospital immunizes the infant and forwards their immunization information to the Public Health or the Community Health Center. The nurse or midwife is responsible to give any immunization that is due based on a decision made by checking vaccine inserts or monograms as necessary. Some Community Health Centers have an electronic registry to help keep track of immunizations. (Department of Health and Social Services, 2010).

2.2.9. Ontario Immunization Record Information System (IRIS)

The IRIS was developed for public health departments in 1993 and it was to record and maintain the immunization records of all school-aged children (Ontario Population Health Index of Databases [OPHAD], 2012). Under the Immunization of School Pupils Amendment Act, 1984, parents are responsible to keep immunization records of their children and report any vaccines their children receive in doctor's office; this information is collected by Public Health Units of the province and entered into IRIS (OPHID, 2012).

2.2.10. Prince Edward Island

The Chief Public Health office (CPHO) in the Department of Health and Wellness is responsible for immunization and Vaccine preventable Diseases control; the PEI Immunization Program is directed by CPHO and it is delivered by Public Health Nursing Services (Promote, Prevent, Protect [PPP]- PEI Chief Public Health Officer's Report, 2012). The Public health nursing program provides the childhood immunization program (PEI-Department of Health and wellness, 2012). Immunizations are documented in a

provincial immunization registry ([PPP]- PEI Chief Public Health Officer's Report, 2012).

2.2.11. Québec

For immunization, the Protocole d'immunisation du Québec (PIQ) is the standard of professional practice in Quebec; The PIQ defines the responsibilities between the various healths professionals involved in immunization and provides guidance and a better articulation of professional practices in the implementation of immunization program in Quebec. There is also information on the general principles of immunology and immunization, the management of vaccines, and immunization schedules (Protocole d'immunisation du Québec, 2012). Frequently Asked Questions for vaccinators and information sheets to obtain the consent of the person to be vaccinated are also part of this protocol.

2.2.12. Saskatchewan Immunization Management System (SIMS)

Saskatchewan Immunization Management system (SIMS) stores immunization information in a secure database and this information is available for authorized health provider across the province (Government of Saskatchewan, 2012); if individuals require a copy of their immunization record, they can request this information from their public health practitioner or immunization provider.

2.2.13. Yukon

Yukon Communicable Disease Control (YCDC), in collaboration with the Chief Medical Officer of Health and the Public Health Agency of Canada, is responsible for the prevention, monitoring, and control of all communicable diseases (both vaccine and non-vaccine preventable) throughout the Yukon (Yukon Health and Social Services, 2010).

2.3. Summary

The literature review is conducted and previous works are reviewed through this chapter; based on National Immunization Registry Final report 2003, “*the provinces and territories are responsible for planning, funding, and delivering immunization programs to their population and support national immunization strategy*” (NIS Final Report, 2003, p.1). Regarding the information from the provincial and territorial websites, some Immunization Information systems (IIS) exist and some other systems are under implementation in different jurisdictions, but there is an urgent need to have a centralized immunization recording and tracking system accessible by authorized providers and individuals from all over Canada at anytime. In the next chapter, the design and implementation process are described, and the Entity Relation Diagram (ERD) and the prototype are developed.

CHAPTER III: Design and Implement the Prototype

3.1. Introduction

Since online database applications have become increasingly used in clinical systems, accessing an online immunization record system needs to be addressed in order to facilitate the tracking of immunization records at any time. An online system is more secure than a traditional paper-based system; it can save space because the information is kept in the computer file rather than medical office. Also, an online system enhances access to the information and better serves people if they move from one jurisdiction to another. It is clear that clinical and technical expertise is required to develop a useful immunization information system. Through this chapter, a prototype model is designed and implemented by a technician (researcher) and this model is evaluated by clinicians in the next chapter. Canadian immunization guide and National Survey on Immunization Data Standards are widely used to create the Entity Relation Diagram (ERD) and Application Express (APEX) is employed to implement the prototype model.

3.2. Background

Prototyping methodologies can play a considerable role in the design of a computerized system. A prototype is mostly defined as a functioning version of a system and it is demonstrated to the end-users early in development process in order to assess its usability and functionality (Kushniruk & Patel, 2004). In other words, a prototype is an incomplete version of the software depicting system behaviours and some of the features of the eventual program to the end-user (OSQA, 2009). Prototypes can also help the developer to understand the behaviour of the prospective application and demonstrate the usefulness of a real system to the potential end-user in early development stages

(University at Albany State of New York, n.d.). It allows the end-users to interact with the product and provide feedback for the developer (OSQA, 2009). In brief, it is very important to consider that the prototype helps to identify gaps and weaknesses in the design and development; it reveals unpredictable issues in implementation (Alstad, 2003). Two major types of prototyping are Throwaway prototyping and Evolutionary prototyping (OSQA, 2009).

3.2.1. Throwaway Prototyping

Throwaway prototyping is also known as rapid prototyping (Software Prototyping, n.d.). This type of prototyping involves creating different parts of the system in early stages of development and lets the end-user clarify the requirements; then, the system can be developed based on identified requirements and the model can be discarded (Crinnion, 1991). This type of prototyping is cost effective and gives the ability to build and test interface by the end-user (Software Prototyping, n.d.).

3.2.2. Evolutionary Prototyping

The goal of evolutionary prototyping is to create a robust prototype that can be constantly refined and when it is built, it forms the core of the system. With this type of prototyping, the system can be continuously refined and rebuilt (Software Prototyping, n.d.). With this type of prototyping, users can test the system and they may request more features from the developer; this type of prototyping can eventually become the final system (Software Prototyping, n.d.).

3.2.3. Web Application

Web based application provides instant access to an application and requires the integration of numerous technologies (Ousterhout, 2012). To deliver a successful web

application, several techniques are required to be known such as markup languages, scripting, application programming, database concepts, network concepts, interactive graphics, and security.

Database technology can be used to ease difficulties in maintaining traditional information systems with a large amount of diverse data and many concurrent users (Kuo, 2012). In Table 3.1, a national survey on immunization data standards reported the databases used in different provinces and territories.

Table 3.1 Databases/Systems Used in Different Provinces

Province / Territory	System and databases
Manitoba and Prince Edward Island	Mainframe
British Columbia, New Brunswick, and Newfoundland	Oracle
Northwest Territories, Nunavut, and Alberta	Didn't specify what system they use
Saskatchewan	SQL server
Ontario	FoxPro
Nova Scotia	MSI Billing database

Oracle is chosen to create and manage the database in this study because it is compatible with different platforms and supports multi versioning and read consistency (askTomOracle, 2001). Also, all relational databases must pass the Atomicity, Consistency, Isolation, and Durability (ACID) test and the Oracle database guarantees all these factors (Watson, Ramklass, & Bryla, 2009). Application Express was used to develop the prototype.

3.2.4. Application Express

Application Express or Oracle APEX is a database centric application development tool for Oracle database that allows the user to develop and deploy a rapid professional web application (ORACLE, n.d. c). APEX is easy to use and useful for rapid development; having a strong background in SQL and PL/SQL can help to implement desired reports and functions. No client software, other than the browser, is required for deployment (Figure 3.1) and pages are rendered using HTML within the browser (Oracle Application Express, 2010). In this study, APEX is chosen because it provides the quickest way to produce a functional web based database application with the capability of designing the user interface.



Figure 3.1 Simple Oracle APEX Architecture

Dr Dorsey simply explained the APEX Meta model and its components in Figure 3.2. Workspaces allow developers to work on in the same repository with no interact. Each application is broken into pages and each page consists of one or many regions. Pages correspond to screens in the User Interface (Dorsey, 2009).

Regions can contain one or many components (e.g. grids, reports, fields, and etc). Table and column binding is set for each component in component level at each page. PL /SQL codes defined with the events and events are triggered at page level or component level (Dorsey, 2009).

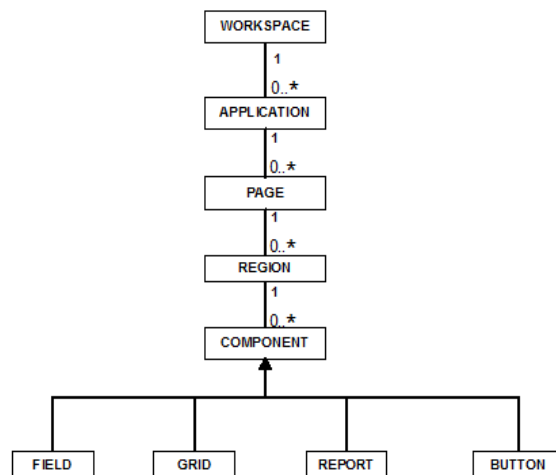


Figure 3.2 APEX Meta Model
(Adopted from Dorsey, 2009)

3.3.Review Datasets

In the year 2000, a national survey was conducted to determine the level of immunization documentation and standardization of data elements in different provinces and territories (National Survey on Immunization Data Standards, 2000); this survey reported that a variety of data types and data formats are used in existing systems in different jurisdictions and the agreement in coding is rare from one province to another. Based on this survey, the following data elements are recorded in different provinces/territories.

Table 3.2 Data Elements Recorded in Different Provinces/Territories

Client demographic Information	
Data Element	Collected % of time
First name and Last name	93%
Middle name	62%
date of birth	93%
sex	93%
client's address ("Street Number", "Street	100% (some provinces use unstructured

Name”, “Apartment Number”, “Box Number”, and “City/Town”)	address(e.g. Address1, Address2). Also, Province and postal code are not collected in two provinces)
Country	33%
Phone Number (Home ,other)	- High level of compliance to collect phone#, but four provinces/territories do not collect “Other”.
Language Spoken	- Not collected in 3 provinces, and optional in one province.
Country of Origin	- Only 2 provinces collect this data
Arrival in Province	- Captured in comment section in Alberta - Collected in numeric format in 2 provinces, and in alphabetic format in two territories.
Aboriginal Status	- Captured in Manitoba, - Optional in Newfoundland, and held in provincial/territorial level in Northwest Territories and Nunavut.
Guardian Demographic Information	
Parent/Guardian demographics	- Alberta keeps it in regional health agency level, but not provincial/territorial level - Same in Quebec, but not mandatory - It is also collected in Northwest Territories and Nunavut. %46 of provinces/territories (British Columbia, Saskatchewan, Manitoba, Ontario, New

	Brunswick, and Newfoundland) collect relationship/Agency, and it is optional in Newfoundland.
Last name and first name	- Consistently collected (optional in 3 provinces).
Middle name	- Collected in 5 provinces (optional in one province). - Two provinces collect this data combined with the first name and one of those uses “Given name” for the combined data.
Other name	- Collected in 3 provinces.
Aliases	- Collected in 4 provinces (optional in one province).
Date of birth	- Collected in 5 provinces (optional in one province).
Sex	- Collected in 4 provinces (optional in one province).
“Street Number”, “Street Name”, “Apartment Number”, and “Box Number”, “City/Town”, “Province”, and “Postal Code”	- Collected in 8 provinces and %50 chose to use an unstructured format (e.g. Address1).
“Home Phone Number”, and “Other Phone Number”	- Collected in 7 provinces.
Language Spoken	- Collected in 3 provinces (optional in 1).

Based on the National Survey on Immunization Data Standards, the data element for vaccine is always kept in the provincial level (National Survey on Immunization Data

Standards, 2000); according to this survey, the immunization event demographic data collected in different provinces/territories can be summarized in Table 3.3.

Table 3.3 Immunization Demographic Data Collected in Different Jurisdictions

	Vaccine	Antigen	Trade Name	Manufacturer	Dose No. Vaccine	Dose No. Antigen	Lot Number	Expiry Date	QVA+	Date of Vaccination	Site of Vaccination	Route of Vaccination	Source of Immunization Info	Provider Id	Provider's Health Authority/Region	Provider's location	Exception+
Quebec	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑		☑	☑	☑	☑
New Brunswick	☑	☑	☑	☑			☑			☑	☑	☑	☑	☑	☑		+
Newfoundland	☑	☑	☑	☑	☑	☑	☑	☑		☑	☑	☑	☑		☑		☑
Alberta	☑	☑		☑	☑		☑			☑	☑	☑	☑		☑		☑
Nova Scotia	☑	☑								☑				☑			
Northwest Territories	☑	☑			☑					☑				☑	☑	☑	
Nunavut	☑	☑			☑					☑				☑	☑	☑	
Ontario	☑	☑	C				☑			☑			☑				☑
Prince Edward Island	☑	C					☑			☑				☑	☑	☑	
British Columbia	☑		☑		☑		☑			☑	☑		☑	☑	☑	☑	☑
Saskatchewan	☑		☑				☑			☑			☑	☑	☑	☑	☑
Manitoba	☑									☑			☑	☑	☑		
Yukon										☑							
QVA = Quantity of Vaccine Administered C = Collected under another or separate field + Exemption by reason of evidence of immunity ++ Automated Assessment (contra-indications)																	

Note: in some provinces, some of the data is not collected as a separate field and it is linked to another field (for example, in Newfoundland, the trade name is linked to the vaccine code in the system).

In another study by Heidebrecht et al, the public health organizations and hospitals across Canada employed a wide range of immunization data collection approaches during the (H1N1) influenza vaccination campaign; the research team observed several immunization clinics in different jurisdictions to see how data is collected. According to this study, 79 clinic sites in 38 organizations were observed between October and December 2009 across 9 provinces and territories. The data collection mechanisms were grouped into two major groups: electronic systems (9/38)

and hybrid systems (29/38). The hybrid systems were comprised of computerized and paper-based data collection tasks. Team members observed tasks related to data collection such as individual registration, medical history collection, vaccine record-keeping (such as lot #, dose, site, date of administration), proof of vaccination preparation, and post-vaccination data entry (2011). In that study, some of the key data elements retained within individual electronic records reported in Table 3.4.

Table 3.4 Data Elements Collected in Electronic and Hybrid Organizations (Adopted from Heidebrecht et al., 2011)

	Element collected in electronic organizations (%) n=9	Element collected in hybrid organizations (%) n=29	Total organizations retaining element electronically ^{†,‡} (%) n=38
Personal and Demographic Information			
Name	9 (100)	29 (100)	38 (100)
Unique identifier (health insurance or employee number)	9 (100)	29 (100)	38 (100)
Sex	9 (100)	29 (100)	38 (100)
Date of birth	9 (100)	29 (100)	38 (100)
Ethnicity	8 (88.9)	2 (6.9)	10 (26.3)
Aboriginal status	9 (100)	20 (69.0)	27 (71.1)
Full address	9 (100)	19 (65.5)	27 (71.1)
Postal code	9 (100)	28 (96.6)	37 (97.4)
Priority Status and Medical Information[§]			
Chronic medical conditions	9 (100)	29 (100)	36 (94.7)
Details of chronic conditions (type and/or meds)	9 (100)	12 (41.4)	9 (23.7)
Pregnancy status	9 (100)	28 (96.6)	34 (89.5)
Health care worker	9 (100)	29 (100)	35 (92.1)
Care provider or household contact of high-risk individual	9 (100)	12 (41.4)	20 (52.6)
From remote community	9 (100)	2 (6.9)	11 (28.9)
Allergies	9 (100)	18 (62.1)	13 (34.2)
Overall health status on the day of immunization – feeling well, fever, etc.	9 (100)	19 (65.5)	10 (26.3)
Vaccination Details			
Vaccination date	9 (100)	29 (100)	38 (100)
Prior receipt of 08/09 or 09/10 seasonal vaccine [¶]	9 (100)	15 (51.7)	22 (57.9)
Vaccinator name/initials/identification	9 (100)	29 (100)	21 (55.3)
Lot number	9 (100)	29 (100)	30 (78.9)

Based on Table 3.4, electronic organizations collect a greater number of data elements; however, all organizations save “Name”, “Unique Identifier”, “Sex”, “Date of Birth”, and “Postal code” for the client’s demographic information. In addition, “Vaccine date”, “Vaccinator name”, and “Lot number” are also collected for Vaccine Detail information.

In this section, two resources are reviewed which provide information about the data elements in different immunization systems throughout Canada: the National Survey on Immunization Data Standards and the study of the data collection approaches during

the (H1N1) influenza vaccination campaign. The Public Health Agency of Canada and the Canadian Immunization Guide are also reviewed in order to choose an appropriate data set to design the prototype in this study. In the next section, the author describes how the Entity Relation Diagram (ERD) is created.

3.4. Design the First Entity Relation Diagram (ERD)

Microsoft Visio is used to create the entity relation diagram. The patient demographic information is recorded in the Patient table, the list of allergies is stored in the Allergy table, and the Patient's Allergies can be tracked by the "Patient_Allergy" table.

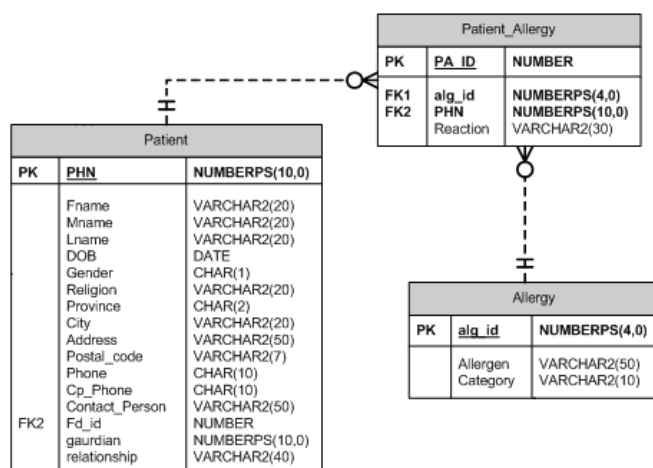


Figure 3.3 Relationships between Patient and Allergy Tables

Based on the Canadian Immunization Guide, the information (e.g. First name, Last name, Address, and so on) and the title of providers who administer vaccinations must be kept in the system. Based on another resource, physicians and public health nurses can administer vaccinations (Healthlink BC, 2010). In addition, immunization can be managed in some pharmacies by pharmacists; therefore, the "Family doctor" table can be used to keep the information of the health care providers' and the provider's specialty can be stored under the "Title" column.

According to national survey on Immunization Data Standards, “Site of Vaccination” is collected in seven provinces/territories and “Route of Vaccine Administration” is collected in six provinces/territories (National Survey on Immunization Data Standards, 2000). Also, based on the Canadian Immunization Guide, both fields are mandatory to be stored in the system; therefore, Vaccine name, Route of Administration, Vaccine Manufacturer, Lot Number, and Dosage are all stored in the Vaccine table. Information of Vaccines is captured from Canadian Immunization Guide - Vaccines Currently Approved for Use in Canada (CIG, 2006d).

Table 3.5 A Snapshot of Table of “Type and Contents of Vaccines Currently Approved for Use in Canada”.



Canadian Immunization Guide 2006
Type and Contents of Vaccines Currently Approved for Use in Canada
 (May 2006)

Brand name	Mfr/ distr.	Route	Vaccine type			Adjuvant	Preservative	Potential allergens (egg, antibiotic, gelatin, latex, trace of thimerosal)	Other materials
			Vaccine type	Immunogen+	Products				
Act-HIB®	SP	IM	Subunit	Hib	Conjugate				
Actacel™*	SP	IM	Subunit	D, T, aP + (Hib)	Proteins + conjugate	Alum	PE		
Adacel®	SP	IM	Subunit	T, d, ap	Proteins	Alum	PE		
Avaxim®	SP	IM	Inactivated	HA	Killed virus	Alum	PE	Neomycin Formaldehyde	
Avaxim® - Pediatric	SP	IM	Inactivated	HA	Killed virus	Alum	PE	Neomycin Formaldehyde	
BCG Vaccine (Freeze-Dried)	SP	Intra-dermal	Live attenuated	BCG	Live bacteria			Polysorbate 80	
Boostrix®*	GSK	IM	Subunit	D, T, aP	Proteins	Alum	PE	Formaldehyde	
DT Polo Adsorbed	SP	IM	Subunit + inactivated	D, T, IPV	Proteins + killed virus	Alum	PE	Polymyxin B, Neomycin Formaldehyde	

Each patient may have one or more immunization records. According to the Canadian Immunization Guide, each method of recording should include the following data elements: “*trade name of the product (or the brand name of vaccine), disease(s) against which it protects, date given (day, month and year), dose, The anatomical site and route*”

of administration, name of the vaccine manufacturer, lot number, name and title of person administering the vaccine” (Canadian Immunization Guide [CIG], 2006a, para.1).

Also each person can receive one or many vaccines at different times and in different places (for example in a facility and/or specific unit); if the “Immunized_tbl” keeps the immunization record information, we can show its relationship with other tables in the following figure (Figure 3.4).

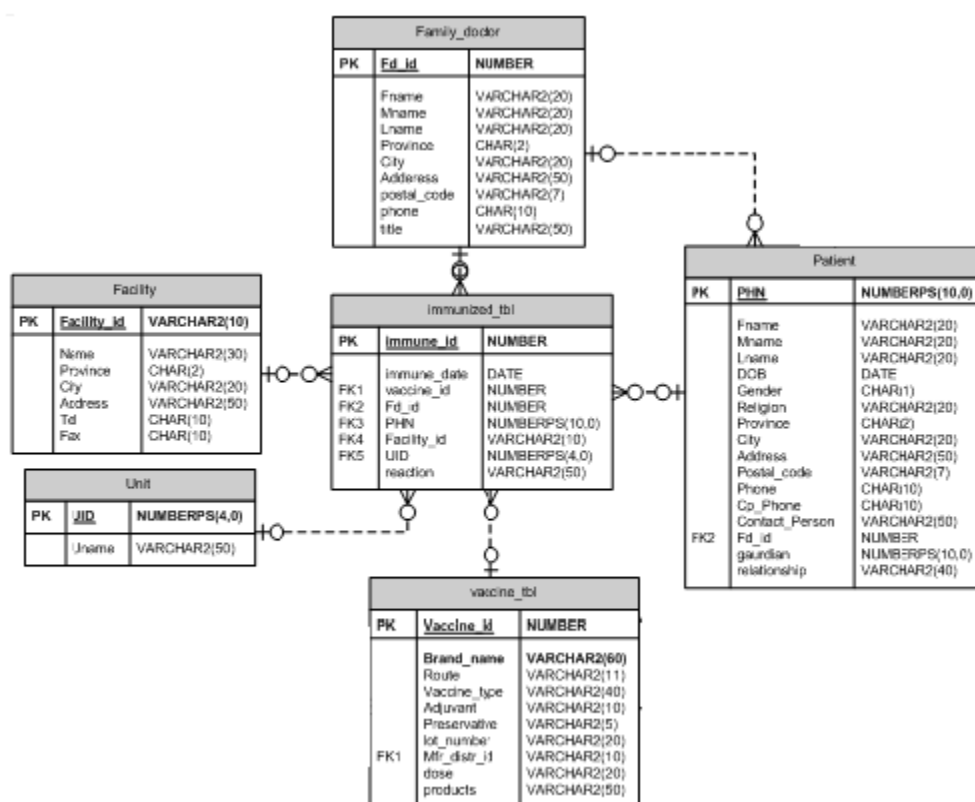


Figure 3.4 Relationships between “Immunized_tbl” and Other Tables Including: “Patient”, “Family_doctor”, “Facility”, “Unit”, “Vaccine_tbl”

Based on the Canadian Immunization Guide, manufacturer/distributor name is required to be recorded in the system (CIG, 2006a); therefore, manufacturer information is kept in the “Mfr_Distr” table. Each manufacturer can produce one or many vaccines; hence, the relationship between manufacturer and vaccine is (1:n). To define relationship

between vaccines and antigens, one vaccine can contain one or many antigens and one disease can be prevented by one or many vaccines; therefore, this relationship is many to many (m:n) and “Vaccine_immune” table relates these two tables to each other (Figure 3.5).

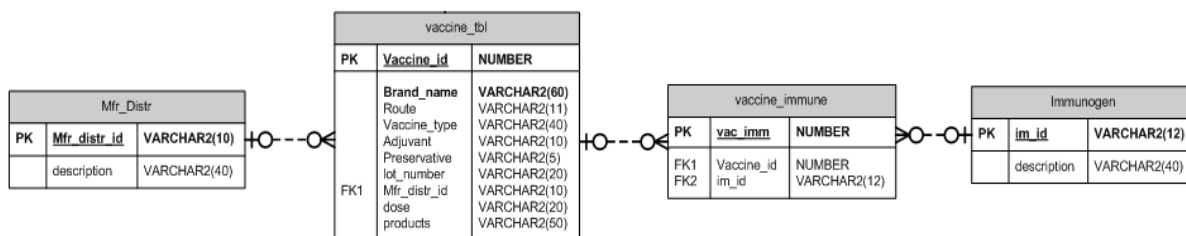


Figure 3.5 Relationships between Vaccine and Manufacturer, and Vaccine and Immunogen Table

Some vaccines have potential allergens and an allergen can be found in one or many vaccines; thus, the relationship between Vaccine (“Vaccine_tbl”) and Allergy is (n:m). This relationship is shown in Figure 3.6.

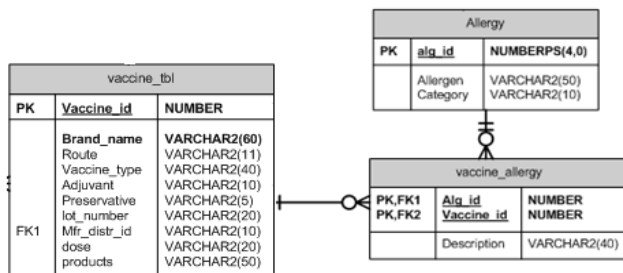


Figure 3.6 Relationships between Vaccine and Allergy Table

People need to be immunized against different diseases; immunization schedules can vary from one jurisdiction to another and from one person to another (NB Immunization program Guide, 2012). The Canadian Immunization Guide recommends four immunization schedules (Table 3.6) for four different age groups: Infants, Children less than 7 years old, Children between 7 and 17, and Adults (CIG, 2006c). The information of the mentioned schedules is kept in the “Immune_Routine”

table (Figure 3.7). Also, this figure shows the relationship between the “Immune_Routine” and “Immunogen” tables.

Table 3.6 A Snapshot of the Recommended Immunization Schedule Provided by Canadian immunization Guide

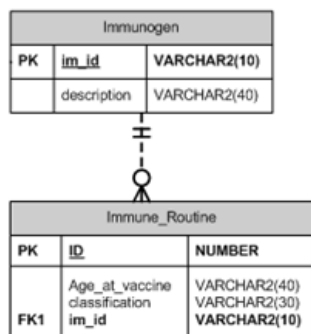
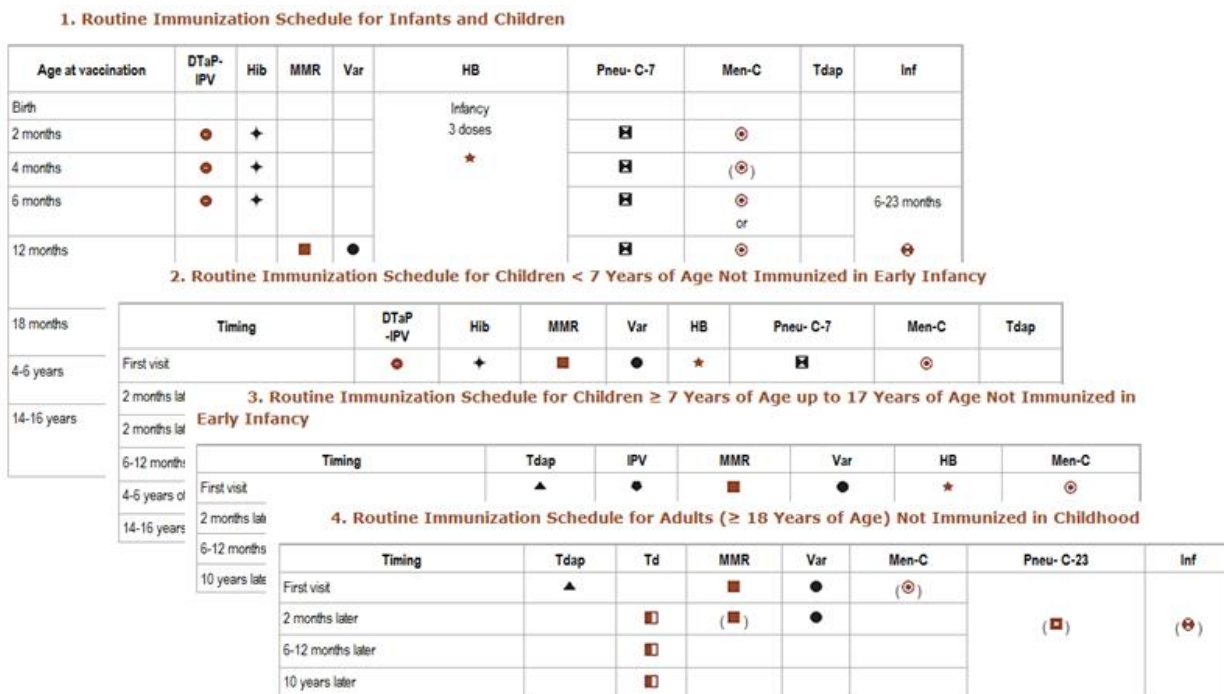


Figure 3.7 Relationship between Immune_Routine and Immunogen tables

Information captured from two studies (“National Survey on Immunization Data Standards”, 2000, and Heidebrecht et al, 2011) is summarized in Table 3.2, 3.3 and 3.4. These three tables provided the information about the data elements collected in different immunization systems in different jurisdictions. The information of those tables together

with the information of Canadian Immunization Guide is used to create the first ERD in this study (Figure 3.8).

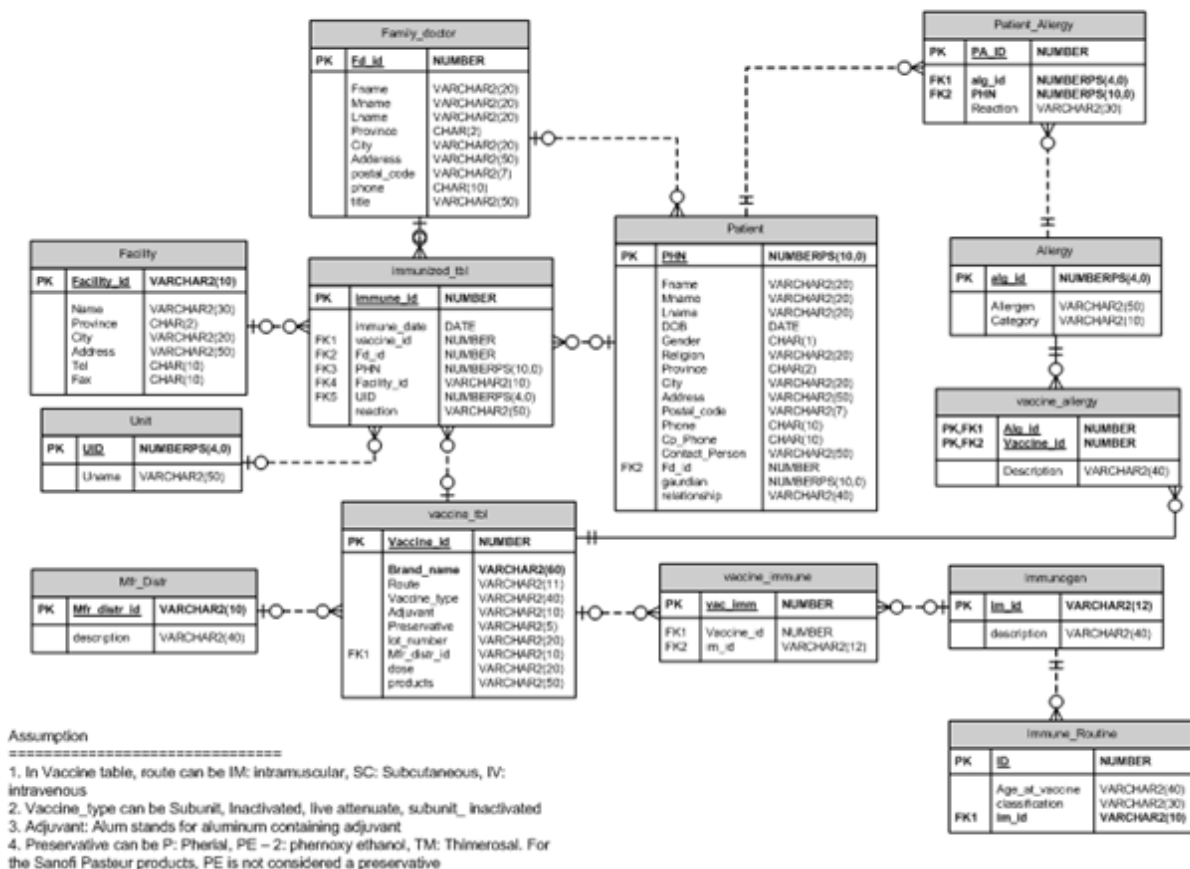


Figure 3.8 First ERD

The first ERD includes 13 tables where parent tables and child tables are connected with primary keys and foreign key(s). The Primary key is a unique identifier in each table and the sequence number is used for some of the tables to automatically generate a sequential number for the primary key and provide more convenient for the end user.

3.5. Implementing user interface for the prototype

Some of the features of an optimal Immunization Information System are defined as system flexibility, availability of real time data, and widespread accessibility (Heidebrecht et al., 2010). Having access to a centralized database application helps health care providers review individuals' immunization histories and their reactions to specific vaccines prior to offering any treatments; this prevents inappropriate immunization. In addition, recording the potential allergies and reactions of individuals to specific vaccines helps avoid adverse events following immunization.

The MINISHELL EHR was a group project implemented by a group of six⁺ people for the “Database Design” course in April 2011. The author of this thesis is the database designer of that project and she utilized the MINISHELL to examine the immunization model. Figure 3.9 shows a snapshot of the login page.

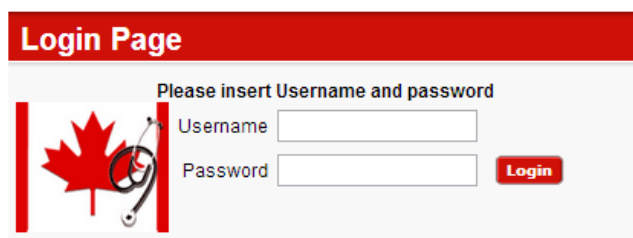


Figure 3.9 Login Page

3.5.1. Home Page

Once the user inserts the valid username and password, the following page (Figure 3.10) will appear. Two navigators are available on the left hand side of this page to facilitate accessing patient information and the data library. The “Patient Data” navigator helps the health care provider access patients' demographic information and their immunization records. The data library is designed to assist the clinicians if they must know the different immunization topics such as Vaccine Information, Immunization

⁺ Group of six included: three registered nurses, one social worker, one quality assurance, and the data analyst/DBA (author of this thesis).

Schedules, Allergies, and Immunogens. The following figure shows a snap shot of the home page.

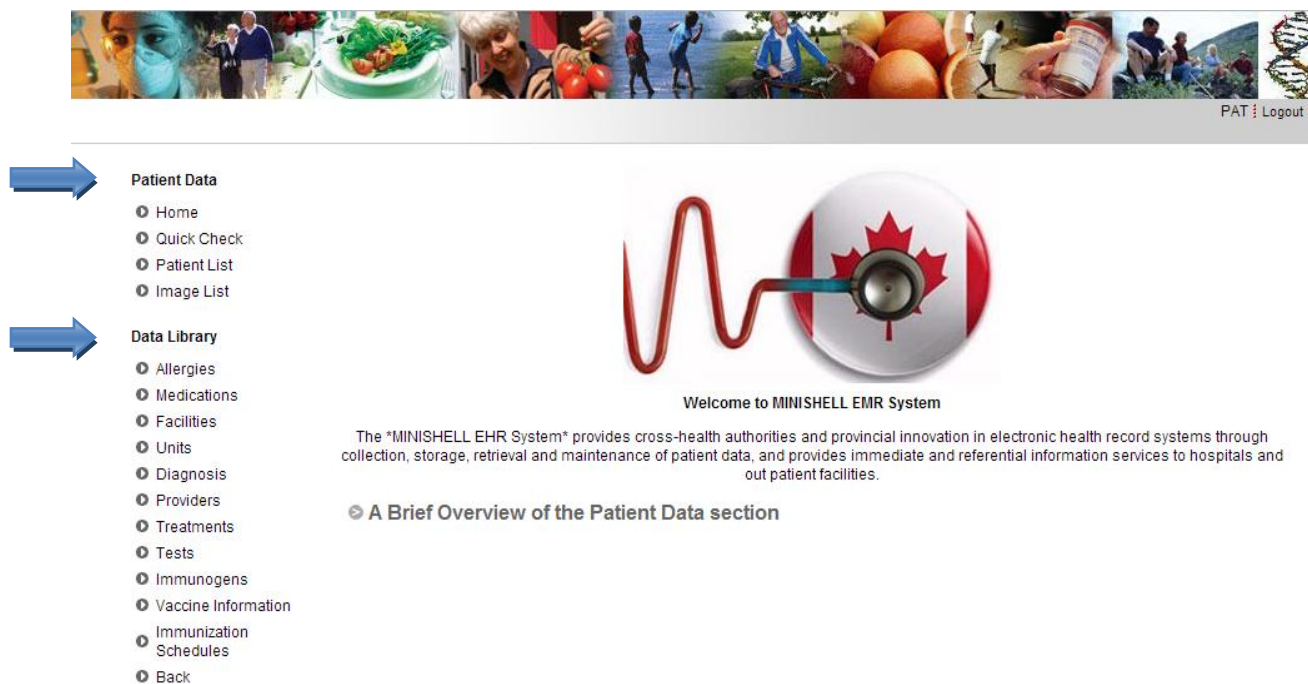


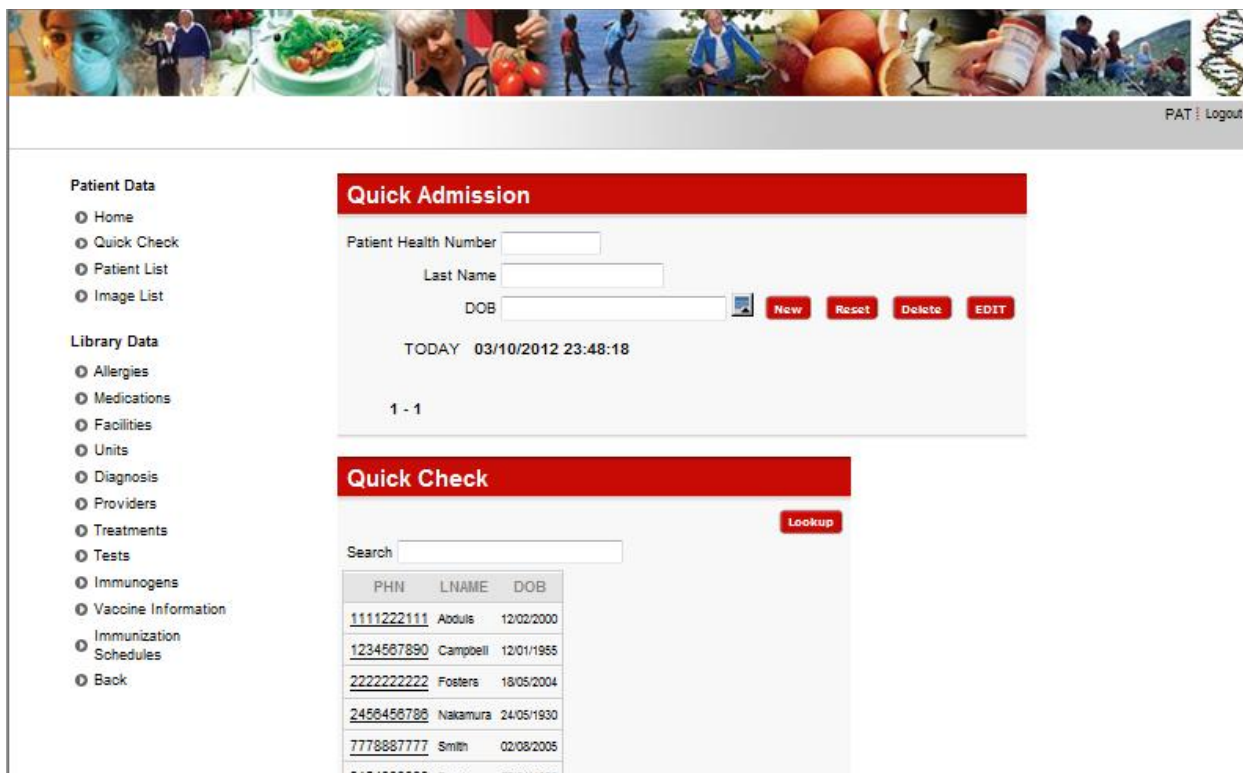
Figure 3.10 Home Page

3.5.2. Quick Check (Quick Admission)

This page is created to boost immunization efficiency by admitting patients in to the system with the minimum amount of information. Patient Health Information (PHN), Last name and Date Of Birth (DOB) are the minimum requirements to add individuals in to the system. This page was created to rapidly admit patients whenever there is high traffic in health care facilities. Within this page, the end users can not insert a alphanumeric or decimal number in the PHN textbox; unless, they will receive an error message to insert a correct PHN. Also, the PHN cannot be empty.

Quick admission (Figure 3.11) reveals the existing members to the end-users and allows them to search for individuals' data by PHN or last name. If an individual's information with the PHN or Last name is not found, another message will be displayed

that the individual is not in the system. Also, two or more records may be retrieved by the last name; for example, twins have the same last name and the same DOB, but their PHNs are different. In that case, the “Patient List” link should be used to retrieve information in detail (e.g. first name, middle name, last name, DOB, address and so on) to ensure the correct vaccination is offered to the right person.



Quick Admission

Patient Health Number

Last Name

DOB

TODAY 03/10/2012 23:48:18

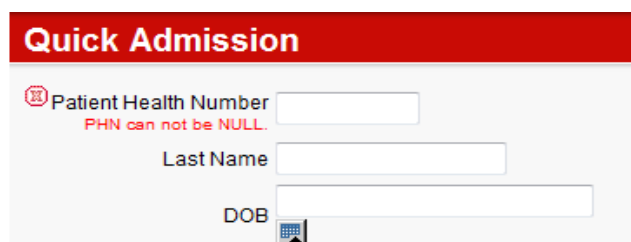
1 - 1

Quick Check

Search

PHN	LNAME	DOB
1111222111	Abduls	12/02/2000
1234567890	Campbell	12/01/1955
2222222222	Fosters	18/05/2004
2456456786	Nakamura	24/05/1930
7778887777	Smith	02/08/2005
9174000000	Boyd	07/04/1939

Figure 3.11 Quick Check



Quick Admission

Patient Health Number
PHN can not be NULL.

Last Name

DOB

Figure 3.12 One of the Error Messages in Quick Admission Form
If the patient is not in the system, the following message will appear.

Figure 3.13 Quick Check, Look up View

3.5.3. Patient List

Via this page, the provider can access a patient's information in detail, create a new encounter, and modify the patient's information. The small pen and paper icon will help providers and secretaries connect to patient demographic information and modify patients' data. The PHN link connects the health care providers to patients' medical information and this link is only visible to health care providers (secretaries are not allowed to view patient's medical data). Users can search for patient information by entering the patient's name, PHN, or address in the search text box and click on the "Go" button. Clicking on the "Create" button connects the user to the patient demographic information.

Patient#	Patient Name	Gender	DOB	Religion	Address	City	Province	Tel
1111222111	Abdul	Male	12/02/2000		770- Fort Ave	Victoria	BC	(250)111-2222
1234567890	Campbell Naomi Elizabeth	Female	12/01/1955	Scientology	#209 Johnson Ave MSW 1E6	Toronto	ON	(416)987-1200
2222222222	Fosters Sarah melody	Female	18/05/2004		123 NW T2L 2J5	Calgary	AB	(403)123-1234
2456456786	Nakamura Hiro	Male	24/05/1930	Shinto	1 Rue Notre-Dame Ouest H2Y 4A7	Montreal	QC	(514)434-1123
7778887777	Smith Sarah	Female	02/08/2005		#23-Fort Ave	Victoria	BC	(778)656-5211
9124000000	Bond James A.	Male	07/01/1932	Christian	#1820 - 6425 Pinetree Place V8U 19H	Vancouver	BC	(604)121-2121
9124111111	Chan Jackie B.	Female	01/12/1990	Jehovah's witnesses	302 Lee Court V8R 4P6	Victoria	BC	(250)434-1123
9876543210	Seresh Mohinder Singh	Male	30/12/1983	Hindu	#214 - 3904 Fake Street T1X 1E2	Campbell River	BC	(250)434-1123

Figure 3.14 Patient List

3.5.4. Patient Demographic Form

The patient demographic information is accessible via the following screen (Figure 3.15) and a new encounter can be added to the system via the following form. (Note: APEX supports field-level help for end-users).

The screenshot shows a web form titled "Patient Information" with three buttons: "Cancel", "Delete", and "Create". The form contains the following fields:

- Patient Health Number:
- First Name:
- Middle Name:
- Last Name:
- Date of Birth: (with a calendar icon)
- Gender: (dropdown arrow)
- Religion:
- Province: (dropdown arrow)
- City:
- Address:
- Postal Code:
- Phone:
- Contact Person:
- Contact Person Phone:
- Family Doctor: (dropdown arrow)
- Guardian: (dropdown arrow)
- Relationship:

Figure 3.15 Patient Information Form

The screenshot shows a help dialog box titled "Relationship" with a "Close" button. The text inside the dialog reads:

Define Relationship between the patient and Guardian (For example: Mother, Father, Grand parent, etc)

Figure 3.16 A sample of Help Dialogue on a Field (e.g. "Relationship")

3.5.5. Allergy Screen

The following image shows the list of allergens in the system; users can look for a specific substance, add new data to the allergy table, or modify any information via this

page. The “Create” button connects the user to another form and allows the user to add a new substance in to the system. The “pen & paper” icon on the left hand side of each record helps the user to modify the information of an allergen.

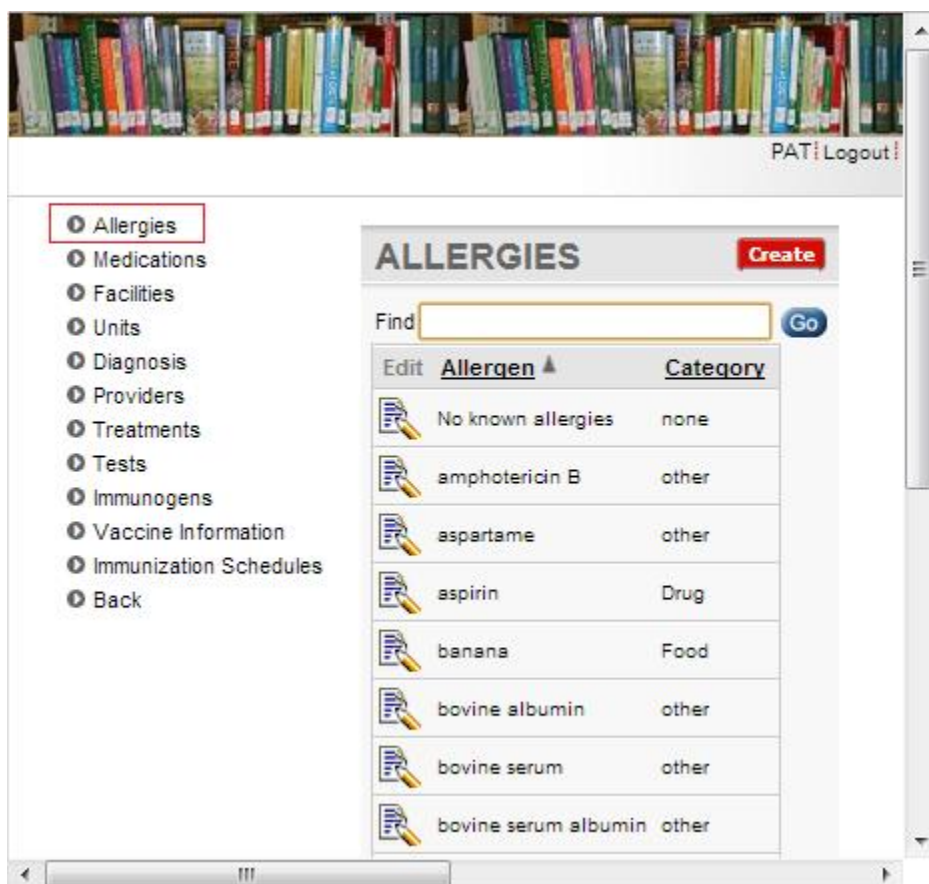


Figure 3.17 Allergy Screen

3.5.6. Vaccine Definitions (Immunogen screen)

This screen allows the user to create or modify information in the immunogen table. The essential information is captured from the Canadian Immunization Guide – Recommended Immunization – Vaccine Definitions (CIG, 2006c).

The screenshot displays the 'IMMUNOGEN' screen. On the left, a sidebar lists navigation options: Allergies, Medications, Facilities, Units, Diagnosis, Providers, Treatments, Tests, **Immunogens** (circled in red), Vaccine Information, Immunization Schedules, and Back. The main content area features a search bar with a 'Go' button and a table of immunogens. The table has three columns: 'Edit' (with a pencil icon), 'Immunization' (with a dropdown arrow), and 'Definition'. The table lists various immunogens such as BCG, Chol-Ecol-O, D, DTaP, HA, HB, Hib, IPV, Inf, JE, MMIX, Men, Pneu, Pneu-C-7,13, and Pneu-P-23. A 'Create' button is located in the top right corner of the main area, with a red box and arrow pointing to it labeled 'To create new record'. Another red box and arrow point from the 'Create' button to a modal form on the right, labeled 'Redirect to this page'. The modal form, titled 'IMMUNOGEN', contains a 'Cancel' button, a 'Create' button, and two input fields: 'Immunization Id' and '*Description'.

Figure 3.18 Immunogen Screen

3.5.7. Immunization Schedules

This page permits users to browse different immunization schedules recommended for different age groups. The search option helps to retrieve the schedule for a specific age category (as mentioned, four schedules are defined for four different age categories). This page is created based on the Recommended Immunization Schedule in Canadian Immunization Guide (CIG, 2006c)

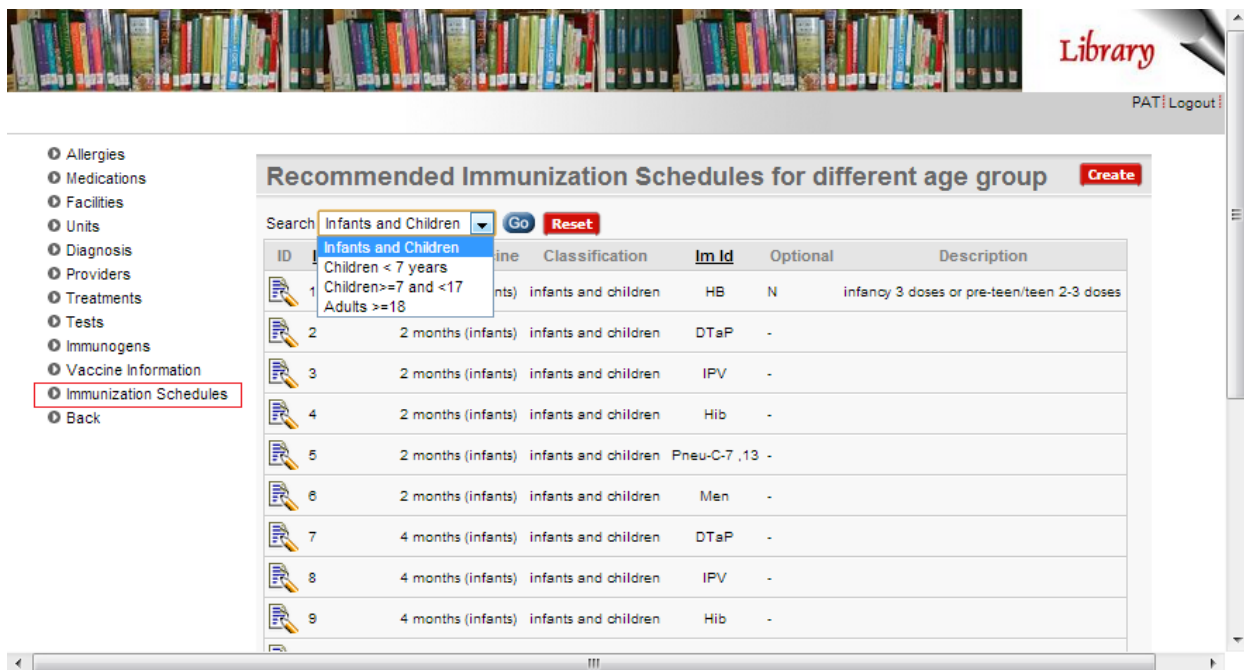


Figure 3.19 Recommended Immunization Schedule Report

To add a new schedule, one can click on the create button and use the following form:

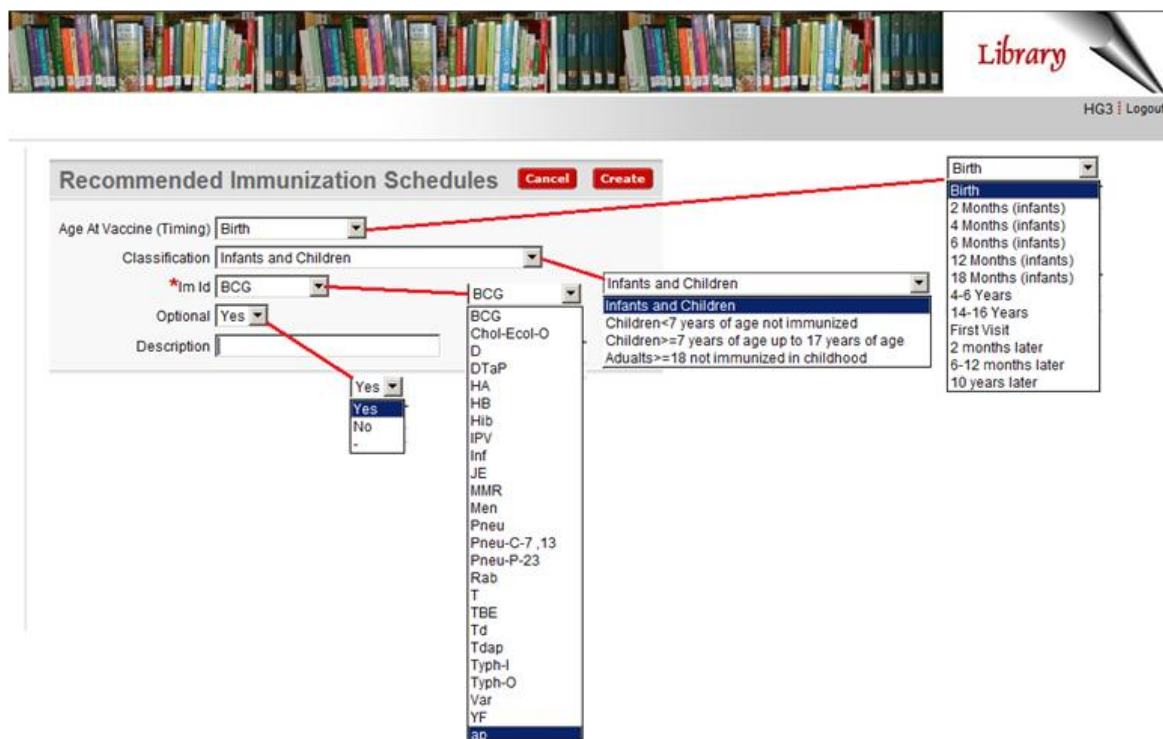


Figure 3.20 Recommended Immunization Schedule Form

3.5.8. Vaccine Information

This page (Figure 3.21) assists users to check the list of the vaccines approved for use in Canada; it permits the adding and updating of information based on the Canadian Immunization Guide, and the searching for a precise vaccine for a specific immunogen.

This page is created based on the information of Table 3.5

The screenshot displays a web application interface for vaccine information. The main content area is titled "Type and Contents of Vaccines approved to be used in Canada" and features a search bar and a table of vaccine details. The table includes columns for Edit, Brand Name, Mfr/Distributor, Route, Products, Vaccine Type, Adjuvant, and Preservative. A sidebar on the left provides navigation options such as Allergies, Medications, Facilities, Units, Diagnosis, Providers, Treatments, Tests, Immunogens, Vaccine Information, Immunization Schedules, and Back. On the right, a "Vaccine and Immunogen" report is shown, with a dropdown menu set to "DTaP" and a "Go" button. The report table lists Brand Name and Immunogen.

Brand Name	Mfr/Distributor	Route	Products	Vaccine Type	Adjuvant	Preservative
Act-HiB	Sanofi Pasteur Ltd	IM	conjugate	Subunit	-	-
Actacef(TM)	Sanofi Pasteur Ltd	IM	proteins + conjugate	Subunit	Alum	PE
Adacel	Sanofi Pasteur Ltd	IM	proteins	Subunit	Alum	PE
Avaxim	Sanofi Pasteur Ltd	IM	killed virus	Inactivated	Alum	PE
BCG vaccine(freeze-dried)	Sanofi Pasteur Ltd	Intradermal	live bacteria	Live attenuated	-	-
Boostrix	GlaxoSmithKline	IM	proteins	Subunit	Alum	PE
DT Polio Adsorbed	Sanofi Pasteur Ltd	IM	proteins + killed virus	Subunit + inactivated	Alum	PE
Fluviral S/F	IDBiomedical Corporation	IM	killed virus	Inactivated	-	Tm
Haurix	GlaxoSmithKline	IM	killed virus	Inactivated	Alum	PE
Influvac	Solvay	IM/SC	killed virus	Inactivated	-	-
M-M-R II	Merck Frost	SC	live virus	Live	-	-
Meningococcal						

Figure 3.21 Type and Contents of Vaccines Approved to Be Used in Canada

The screenshot shows a "Vaccine and Immunogen Report" for the vaccine "IPV". The report table lists Brand Name and Immunogen. A red callout box points to the "IPV" immunogen in the table.

Brand Name	Immunogen
DT Polio Adsorbed	IPV
Pediarix	IPV
Pentacel	IPV
Td Polio Adsorbed	IPV
inovax polio	IPV
infanrix - hexa	IPV

Figure 3.22 Vaccine and Immunogen Report

The Vaccine and Immunogen Report is created to assist the health care providers to find the appropriate vaccine for specific immunogen.

A user-friendly form is designed for inserting, updating, and deleting data in the vaccine library and it is accessible through the “vaccine information tab”. In the following figure, the “Immunogen and Potential Allergens Report” is empty because no information is yet inserted for the vaccine. (Note: each vaccine may contain one or more immunogens which cause multiple allergies; therefore, two other forms are designed to store immunogen(s) and potential Allergens for each vaccine.)

The screenshot displays a web application interface for vaccine management. At the top, there is a header with a bookshelf image and the word "Library". Below the header is a navigation bar with tabs: "Vaccine information", "Vaccine Immunogen", "Vaccine allergen", and "Back". The "Vaccine information" tab is selected. The main content area is divided into two sections. The left section, titled "Type and Contents of Vaccines", contains a form with the following fields: Vaccine Id (text input), Brand Name (text input), Mfr Distr Id (dropdown menu with "Baxter healthcare corporation" selected), Route (dropdown menu with "Intramuscular (IM)" selected), Vaccine Type (dropdown menu with "Subunit" selected), Products (dropdown menu with "Conjugate" selected), Adjuvant (dropdown menu with "Aluminum - containing adjuvant" selected), Preservative (dropdown menu with "Phenol" selected), and Dose (text input). There are "Cancel" and "Create" buttons at the top right of this form. The right section, titled "Immunogen(s)", shows "no data found". Below it, the "Potential Allergens & other materials" section also shows "no data found".

Figure 3.23 Vaccine Information Tab

If a user clicks on “Create” or clicks on “Vaccine Information tab”, the above form will appear which allows the user to add new Vaccine information into the system; the following figure (3.24) shows the contents of drop down lists in this form.

Type and Contents of Vaccines Cancel Create

Vaccine Id:

Brand Name:

Mfr Distr Id: **Baxter healthcare corporation**

Route: **Intramuscular (IM)**

Vaccine Type: **Subunit**

Products: **Conjugate**

Adjuvant: **Aluminum - containing adjuvant**

Preservative: **Phenol**

Dose:

Manufacturer List:
 Baxter healthcare corporation
 Baxter healthcare corporation
 Berna Biotech
 Biken
 Chiron
 GlaxosmithKline
 IDBiomedical Corporation
 Merck Frosst
 SBL Vaccine
 Solvay
 Sanofi Pasteur Ltd
 Wyeth Canada
 --Others

Route List:
 Intramuscular (IM)
 Intramuscular (IM)
 Subcutaneous (SC)
 Intravenous (IV)
 Intramuscular/Subcutaneous (IM/SC)
 Oral
 Intradermal

Vaccine Type List:
 Subunit
 Inactivated
 Live attenuated
 Subunit + Inactivated
 Live

Products List:
 Conjugate
 Proteins
 Killed virus
 Live bacteria
 Proteins + Conjugate
 Proteins + Killed virus
 Proteins + Killed bacteria
 Inactivated whole virus
 Recombinant Protein
 Live virus
 Proteins + Killed virus + Conjugate
 Polysaccharide
 Recombinant Protein + Killed virus
 Polysaccharide + Killed virus

Adjuvant List:
 Aluminum - containing adjuvant
 Aluminum - containing adjuvant
 None

Preservative List:
 Phenol
 2 Phenoxy Ethanol (PE)
 Thimerosal (Tm)
 PE/None
 Tm/None
 None

Figure 3.24 Vaccine Form and Content of Drop Down Lists

The following image (Figure 3.25) shows the information of one vaccine (e.g. Avaxim) together with its immunogen and Potential allergens.

Library HG3 | Logout

Vaccine information **Vaccine Immunogen** **Vaccine allergen** **Back**

Type and Contents of Vaccines Cancel Delete Apply Changes

Vaccine Id:

Brand Name:

Mfr Distr Id: **Sanofi Pasteur Ltd**

Route: **Intramuscular (IM)**

Vaccine Type: **Inactivated**

Products: **Killed virus**

Adjuvant: **Aluminum - containing adjuvant**

Preservative: **2 Phenoxy Ethanol (PE)**

Dose:

Avaxim Immunogen(s)

Vaccine Id	Immunogeon
1003	HA

1 - 1

Avaxim Potential Allergens & other materials

Vaccine Id	Allergen	Description
1003	formaldehyde	other materials
1003	neomycin	potential allergen

1 - 2

Figure 3.25 Sample of Vaccine Information

As mentioned, each vaccine may contain one or many immunogens; therefore, another form is required to store immunogen(s) related to a specific vaccine. The following report shows inserted immunogen(s) for a vaccine (e.g. Avaxim).

Action Processed.

Avaxim Immunogen(s) [Create](#)

Edit	Vaccine Id	Immunogeon
	1003	HA
	1003	HB

1 - 2

Figure 3.26 Vaccine Immunogen Tab

Each vaccine may have one or many potential allergens; “Vaccine Allergen tab” assists users to add vaccine allergens in to the system. In order to insert the potential allergens, first we need to choose the specific vaccine, and then click on the “Vaccine Allergen tab”. The following Form and report can assist users in adding/modifying/removing potential allergen(s) for a vaccine (e.g. Avaxim).

Avaxim Potentiel Allergens & other materials [Create](#)

Edit	Vaccine Id	Allergen	Description
	1003	Formaldehyde	other materials
	1003	Neomycin	potential allergen

1 - 2

Figure 3.27 Vaccine Allergen Tab

When a user clicks on the “Create” button, the following Form (Figure 3.28) appears so the user can insert immunogen data for a vaccine (e.g. Avaxim).

Library

HG3 | Logout

Avaxim Potentiel Allergens & other materials Cancel Create

Alg Id:

Vaccine Id:

Description:

Figure 3.28 Vaccine Allergen Form

The following figure shows the contents of drop down lists for adding allergen(s) and other materials for a vaccine (the list of allergens is retrieved from the allergy table).

Potentiel Allergens & other materials Cancel Create

Allergen:

Vaccine Id:

Category:

potential allergen

potential allergen

other materials

None

None

amphotericin B

aspartame

aspirin

banana

bovine albumin

bovine serum

bovine serum albumin

chicken protein

chlortetracycline

demerol

dextran

egg

egg proteins

formaldehyde

gelatin

gentamicin

glutamate

glutaraldehyde

human Albumin

human albumin Lactose

human serum albumin

lactose

latex

latex in stopper

latex in stopper pre-filled syringes

latex in stopper pre-filled syringes for diluent

milk

mouse serum

neomycin

Figure 3.29 Form of Vaccine Allergen and Field Contents

3.5.9. Immunization Record Information

Health care providers can access a patient's immunization information via the "Patient List". In the "Patient list", a user can click on the PHN of a specific patient and view a patient's medical information (for example: we choose PHN: 7778887777 , Sarah smith and click on the PHN link).

Patient List

Search Display **15**

Patient#	Patient Name	Gender	DOB	Religion	Address	City
1111222111	Abdul	Female	12/02/2000		770- Fort Ave	Victoria
1234567890	Campbell Noam Elizabeth	Female	12/01/1955	Scientology	#209 Johnson Ave M5W 1E6	Toronto
2456456786	Nakamura Hiro	Male	24/05/1930	Shinto	1 Rue Notre-Dame Ouest H2Y 4A7	Montreal
7778887777	Smith Sarah	Female	02/06/2005		#23-Fort Ave	Victoria
9124000000	Bond James A.	Male	07/01/1932	Christian	#1820 - 6425 Pinetree Place V8U 19H	Vancouver
9124111111	Chan Jackie B.	Female	01/12/1990	Jehovah's witnesses	302 Lee Court V8R 4P6	Victoria

The following image will appear which contains a patient's information and allergies, and the tabs that direct the user to the Patient's immunization record page and the Recommendation page.

Patient Information

Patient Health Number **7778887777**
 Patient Name **Sarah Smith**
 Date of Birth **02/06/2005**
 Gender **Female**

1 - 1

Patient Allergy for 7778887777

Phn	Patient	Reaction	Allergen	Categories
7778887777	Sarah Smith	skin redness and itching	latex in stopper	other

1 - 1

Figure 3.30 Medical Information Page

The first time a user clicks on the “immunization records” tab, no immunization report will appear; for example, if we click on patient with PHN 1234567890 and click on “immunization records tab”, no immunization is reported for that person. (Following image).

The screenshot displays a web application interface for immunization records. At the top, there is a navigation bar with tabs for "Immunization records", "Recommendation", and "Back". A user profile "PAT | Logout" is visible in the top right. On the left, a navigation menu includes "Home", "Quick Check", "Patient List", and "Image List". The main content area is divided into two sections:

Patient Health Number: 1234567890 Immunization Records (with a "Create" button)

Name: Naomi Elizabeth Campbell
Guardian: Unknown
Relationship: NOTHING
Age: 57
Month: 8
No Immunization record reported

Routine immunization for this age group

IM_ID	AGE_AT_VACCINE	CLASSIFICATION	OPTIONAL
Inf	first visit	>=18 years	Y
MMR	first visit	>=18 years	-
	2 months later	>=18 years	Y
Men	first visit	>=18 years	Y
Pneu-P-23	first visit	>=18 years	Y
	2 months later	>=18 years	-
Td	6-12 months later	>=18 years	-
	10 years later	>=18 years	-
	first visit	>=18 years	-
Tdap	first visit	>=18 years	-
	2 months later	>=18 years	-

1 - 11

Figure 3.31 Immunization Record tab with no Immunization Record

The Left report indicates that no immunization record has been inserted for this member yet and it lists some basic information such as name, Guardian, Relationship, and age. (Note: Age is calculated based on the member’s Date of Birth).

The Right hand side report is generated automatically based on age of patient to assist a health care provider to suggest required vaccine(s). Based on the Canadian Immunization Guide (CIG, 2006c), four different vaccination schedules are available; the above image shows the routine immunization for adults because the patient is 57 years old. If we choose another patient, for example, Sarah Smith who is 7 years old, the following report will appear.

Figure 3.32 Immunization Record tab with Some Immunization Record

In the above image, there is another immunization schedule for Sarah. This image shows all the vaccines given to Sarah (left hand side report) together with the immunization schedule recommended based on her age (right hand side report). The idea of creating the left hand side report is taken from the sample provided by the Immunization Action Coalition (Immunization Action Coalition [IAC], 2011).

Vaccine Administration Record for Children and Teens

(Page 1 of 2)

Patient name: Emily Jacobs

Birthdate: 6/2/2005

Chart number: _____

Before administering any vaccines, give copies of all pertinent Vaccine Information Statements (VISs) to the child's parent or legal representative and make sure he/she understands the risks and benefits of the vaccine(s). Always provide or update the patient's personal record card.

Vaccine	Type of Vaccine ¹	Date given (mo/day/yr)	Funding Source (F,S,P) ²	Site ³	Vaccine		Vaccine Information Statement (VIS)		Vaccinator ⁵ (signature or initials & title)
					Lot #	Mfr.	Date on VIS ⁴	Date given ⁴	
Hepatitis B ⁶ (c.g., HepB, Hib-HepB, DTaP-HepB-IPV) Give IM. ⁷	HepB	6/2/2005	F	RT	0651M	MRK	7/11/01	6/2/05	JTA
	Pediarix	8/2/2005	F	RT	635A1	GSK	7/11/01	8/2/05	DCP
	Pediarix	10/2/2005	F	RT	712A2	GSK	7/11/01	10/2/05	DCP
	Pediarix	12/2/2005	F	RT	712A2	GSK	7/11/01	12/2/05	DLW
DTPaP-HepB-IPV (Pediarix) Diphtheria, Tetanus, Pertussis ⁸	Pediarix	8/2/2005	F	RT	635A2	GSK	7/30/01	8/2/05	DCP
	Pediarix	10/2/2005	F	RT	712A2	GSK	7/30/01	10/2/05	DCP

Figure 3.33 Sample of Vaccine Administration Record Provided by immunize.org

The above image is a snap shot of the Vaccine Administration Record form provided by the Immunization Action Coalition. (Note: In the American system, Date on VIS is captured, but this field is not collected by Canadian systems; In Canadian systems, the Expiry date is required to be stored in order to support this data element).

Patient Health Number: 7778887777 Immunization Records Create

Name: Sarah Smith
Guardian: James A. Bond
Relationship: Grand father
Age: 7
Month: 2

Edit	Phn	Given Date	Brand Name	Immunogen	Site	Lot Number	Location	Vaccinator	Expiration Date	Mfr Dist Id	Route	Dose
	7778887777	02/05/2005	Pediarix	DTaP	RT	635A2	Foothills Hospital	Kaehl	30/07/2001			
	7778887777	02/10/2005	Actoael(TM)	DTaP	RA	P0897AA	Foothills Hospital	Kaehl	30/07/2001			
	7778887777	02/06/2005	multi dose vial engeri -B single dose vial	HB	RT	0651M	Royal Jubelle Hospital		11/07/2001			
	7778887777	02/05/2005	Pediarix	HB	RT	635A1	Foothills Hospital	Kaehl	11/07/2001			
	7778887777	02/09/2006	Actoael(TM)	Hib	RA	7172AA	Foothills Hospital	Kaehl	16/12/1996			
	7778887777	02/08/2005	Pediarix	IPV	RT	635A2	Foothills Hospital	Kaehl	01/01/2000			
	7778887777	10/02/2012	varivax	Var	RA		Foothills Hospital	Kaehl				

1 - 7

Routine immunization for this age group

IM_ID	AGE_AT_VACCINE	CLASSIFICATION	OPTIONAL
HB	first visit	=> 7 and <17 years	-
	2 months later	=> 7 and <17 years	Y
	6-12 months later	=> 7 and <17 years	-
IPV	first visit	=> 7 and <17 years	-
	2 months later	=> 7 and <17 years	-
	6-12 months later	=> 7 and <17 years	-
MMR	first visit	=> 7 and <17 years	-
	2 months later	=> 7 and <17 years	-
Men	first visit	=> 7 and <17 years	-
Tdap	first visit	=> 7 and <17 years	-
	2 months later	=> 7 and <17 years	-
	6-12 months later	=> 7 and <17 years	-
	10 years later	=> 7 and <17 years	-
Var	first visit	=> 7 and <17 years	-
	2 months later	=> 7 and <17 years	Y

1 - 15

Again, immunization records can be edited or removed by clicking on the “pen & Paper icon”. To create the new encounter, a user can click on the “Create” Button and the following form will appear which helps the provider create a new immunization record for an individual (for example, in the below form, one can insert the immunization information for Sarah Smith with the PHN 7778887777):



Form for Immunization Record Cancel Create

PHN

Vaccine

Type of Vaccine

Given Date

Site

Lot Number

Date on VIS

Vaccinator

Facility/Hospital/Clinic

Unit

Reaction

Figure 3.34 Immunization Record Form

The health care provider can manage vaccine administration by using the drop down lists. The following image shows the immunization record form with the content of the drop down lists:

Form for Immunization Record Cancel Create

PHN

Vaccine

Type of Vaccine

Given Date

Site

Lot Number

Date on VIS

Vaccinator

Facility/Hospital/Clinic

Unit

Reaction

Vaccine List: Act-HIB, Act-HIB, Actafacel(TM), Adacel, Avaxim, BCG vaccine(freeze-dried), Boostrix, DT Polio Adsorbed, Fluviral S/F, Havrix, Influvac, M-M-R II, Meningococcal polysaccharide, Groups A,C, Menomune A/C, Pediarix, Pentacel, Priorix, Td Adsorbed, Td Polio Adsorbed, Twinrix, Varivax III, imovax polio, infanrix, infanrix - hexa, multi dose vial engerix -B single dose vial, multidose vial Menomune A/C/Y/W-135 Single dose vial, multidose vial Pneumovax 23 single dose vial, neisvac-C, pneumo 23, prenar, varivax

Type of Vaccine List: BCG, Chol-Ecol-O, D, DTaP, HA, HB, Hib, IPV, Inf, JE, MMR, Men, Pneu, Pneu-C-7, 13, Pneu-P-23, Rab, T, TBE, Td, Tdap, Typh-I, Typh-O, Var, YF, ap

Site List: Right Arm, Left Arm, Right Thigh, Left Thigh, Intranasal

Vaccinator List: Sita A. Kashi, Chris Tucker, Sarah Miller, Robin Williams, Jack m. Mc Donald, other

Facility/Hospital/Clinic List: Cardiac Care Unit, Critical Care Unit, Emergency Department, Intensive Care Unit, Medical Unit, Neonatal Care Unit, Outpatient Clinic, Palliative Care Unit, Psychiatric Unit, Psychiatry, Surgical Day Care, Surgical Unit, Foothills Hospital, Royal Jubillee Hospital, St. Joseph's Health Centre, Surrey Memorial Hospital, The Ottawa Hospital, Victoria General Hospital

Figure 3.35 Immunization Record Form with Contents of the Drop Down Lists


3.5.10. Adverse Event Alert

While the benefits of vaccines are obvious, people are often concerned about the drawbacks and adverse consequences of vaccines. The adverse events following immunization occurs when the vaccine is administered, so the system must be capable of sending an alert if a patient has an allergy to the vaccine's ingredients. In the following example, Sarah has a Latex allergy and if the provider wants to give Pentacel to her, she/he will receive an alert because latex is in the list of potential allergens of Pentacel.

Pentacel Potential Allergens & other materials		
Vaccine Id	Allergen	Description
1028	formaldehyde	other materials
1028	polysorbate 80	other materials
1028	bovine albumin	other materials
1028	latex in stopper	potential allergen
1028	polymyxin B	potential allergen
1028	neomycin	potential allergen


1 - 6

Figure 3.36 List of Allergen for Pentacel Vaccine

Patient Allergy New Allergy				
Phn	Patient	Reaction	Allergen	Categories
 7778887777	Sarah Smith	skin redness and itching	latex in stopper	other

1 - 1

Figure 3.37 List of Allergies for a Patient (e.g. Sarah)



1 error has occurred

- Patient has allergy to this vaccine!

Form for Immunization Record Cancel Create

PHN

Vaccine
Patient has allergy to this vaccine!

Type of Vaccine

Given Date

Site

Lot Number

Date on VIS

Vaccinator

Facility/Hospital/Clinic

Unit

Reaction

Figure 3.38 Snapshot of the Vaccine Alert

3.5.11. Recommendation tab

The “Recommendation” page provides information about which vaccine has been given to which individuals and what may be missing. This tab assists health care providers to recommend the required vaccine for patients.

In the following example, the left hand side report shows when and what vaccine has been administered to Sarah. The right hand side report shows the missing immunization (e.g. MMR, Men, Tdap) and the bottom report shows the recommended vaccines for the missing immunization (e.g. it recommended three different vaccines for MMR that clinician can decide which one is appropriate for the patient).

Immunization records Recommendation Back PAT | Logout

- Home
- Quick Check
- Patient List
- Image List

PHN: 7778887777 has been immunized for:

GIVEN_DATE	IM_ID
02/06/2005	HB
02/08/2005	HB
02/08/2005	DTaP
02/08/2005	IPV
02/10/2005	DTaP
02/09/2006	Hib
10/02/2012	Var

1 - 7

Missing Immunization:

IM ID	DESCRIPTION
MMR	Measles, mumps, and rubella vaccine
Men	Meningococcus (meningococcal C conjugate vaccine)
Tdap	Tetanus, diphtheria, acellular pertussis vaccine, adult formulation

1 - 3

Suggested Vaccines

IM ID	BRAND_NAME	Manufacturer_Distributor
MMR	M-M-R II	Merck Frosst
MMR	Priorix	GlaxoSmithKline
Men	neisvac-C	Baxter healthcare corporation
Men	Meningococcal polysaccharide, Groups A,C, Menomune A/C	Sanofi Pasteur Ltd
Men	multidose vial Menomune A/C/Y/W-135 Single dose vial	Sanofi Pasteur Ltd
Tdap	Adacel	Sanofi Pasteur Ltd

1 - 6

Figure 3.39 Recommendation Tab

3.5.12. Managing Interval Vaccine

In order to manage interval vaccines, we designed two types of forms: one is easy to use and the other provides more information for health care providers, but also requires navigation to another page. The tabular form (Figure 3.40) is accessible via the immunization tab and assists providers to schedule future vaccinations; it is *easy to use* and it doesn't require the user to navigate to another page.

Interval Vaccine Scheduler Cancel Delete Submit

Inv Id	Phn	Im Id	Due Date1	Due Date2	Due Date3	Due Date4	Due Date5	Comments
<input type="checkbox"/> 2	912400000	Td	01/02/2003	01/02/2013				1st vaccine is administered; two more is required.
<input type="checkbox"/> 76	912400000	MMR	15/08/2012					
<input type="checkbox"/> 90	912400000	Var	01/09/2002					
<input type="checkbox"/> 92	912400000	Inf	08/08/2012					

1 - 4
Add Row

Figure 3.40 Tabular Form to Manage Interval Vaccine

The following form is more user friendly and provides more information for health care providers (Figure 3.42), but it is linked to a report (Figure 3.41) and the user must access this form via the report. The interval report is accessible via the immunization tab and connects the provider to another page to schedule a future vaccination (Figure 3.41); this page is more user friendly because it provides more information to assist health care providers. We created both forms to check which one is preferred by health care providers.

Interval Vaccine Schedule								Create Interval
Edit	Phn	Im Id	Due Date1	Due Date2	Due Date3	Due Date4	Due Date5	Comments
	9124000000	Td	01/02/2003	01/02/2013				1st vaccine is administered; two more is required.
	9124000000	MMR	15/06/2012					
	9124000000	Var	01/09/2002					
	9124000000	Inf	08/08/2012					

1 - 4

Figure 3.41 Interval Report

The Interval Report shows the future schedules for vaccinations; to edit or create a new interval, the providers will need to connect to another page (Figure 3.42)

Form on INTERVAL_TBL Cancel Delete Apply Changes

PHN 9124000000

Type of Vaccine: MMR

Due Date1: 15/06/2012

Due Date2:

Due Date3:

Due Date4:

Due Date5:

Comments:

Recommended Immunization for specific vaccine type

CLASSIFICATION	IM_ID	VACCINE_TIME	OPTIONAL	DESCRIPTION
>=18 years	MMR	first visit	-	-
>=18 years	MMR	2 months later	Y	-

1 - 2

Vaccine Administered for PHN: 9124000000

GIVEN_DATE	IM_ID
01/08/2002	MMR

1 - 1

Figure 3.42 Interval Form

The Interval form gives more information to providers about scheduling the right vaccine and it is accessible via the report in figure 3.41 by clicking on the “create” button or pen & paper icon.

3.5.13. Managing the Security

According to the Canadian Immunization Guide – Immunization records (CIG, 2006a), vaccines administered to an individual must be held by the individual or his /her guardians/parents, the provider who administered the vaccine, and the local/provincial registry. The primary function of this is to make the record accessible by the aforementioned people and keep the information of individuals confidential.

To address the security feature, we grouped the end-users to three major categories: Health providers, secretaries, and patients; health providers have full access to both “Patient Data” and “Data Library” navigators, so they can monitor all the information(Figure 3.43). Secretaries have access to both navigators, but they cannot view, insert, or modify medical information; however, they can insert and update patients’ demographic information (Figure 3.44). Patients only have access to their records and they have no access to the “Data Library” (Figure 3.45).

Patient Data

- Home
- Quick Check
- Patient List**
- Image List

Data Library

- Allergies
- Medications
- Facilities
- Units
- Diagnosis
- Providers
- Treatments
- Tests
- Immunogens
- Vaccine Information
- Immunization Schedules
- Back

Patient List Reset Create

Search Display Go

Patient#	Patient Name	Gender	DOB	Religion	Address	City	Province	Tel
111222211	Abduls	Female	12/02/2000		770- Fort Ave	Victoria	BC	()-
1234567890	Campbell Naomi Elizabeth	Female	12/01/1955	Scientology	#209 Johnson Ave MSW 1E6	Toronto	ON	()-
2222222222	Fosters Sarah melody	Female	18/05/2004		123 NW T2L 2J5	Calgary	AB	<input type="text" value="(403)123-1234"/> <input type="checkbox"/>
2456456786	Nakamura Hiro	Male	24/05/1930	Shinto	1 Rue Notre-Dame Ouest H2Y 4A7	Montreal	QC	<input type="text" value="(514)434-1123"/> <input type="checkbox"/>
7778887777	Smith Sarah	Female	02/08/2005		#23-Fort Ave	Victoria	BC	()-
9124000000	Bond James A.	Male	07/01/1932	Christian	#1820 - 6425 Pinetree Place V8U 19H	Vancouver	BC	<input type="text" value="(604)121-2121"/> <input type="checkbox"/>
9124111111	Chan Jackie B.	Female	01/12/1990	Jehovah's witnesses	302 Lee Court V8R 4P6	Victoria	BC	<input type="text" value="(250)434-1123"/> <input type="checkbox"/>
9876543210	Seresh Mohinder Singh	Male	30/12/1983	Hindu	#214 - 3904 Fake Street T1X 1E2	Campbell River	BC	<input type="text" value="(250)434-1123"/> <input type="checkbox"/>

Figure 3.43 View of the Patient List in the Browser of the Health Care Providers (they can access the medical information via the PHN link)

Patient Data

- Home
- Patient List**

Data Library


- Allergies
- Medications
- Facilities
- Units
- Diagnosis
- Providers
- Treatments
- Tests
- Immunogens
- Vaccine Information
- Immunization Schedules
- Back

Patient List Reset Create

Search Display Go

Patient Name	Gender	DOB	Religion	Address	City	Province	Tel
Abduls	Female	12/02/2000		770- Fort Ave	Victoria	BC	()-
Campbell Naomi Elizabeth	Female	12/01/1955	Scientology	#209 Johnson Ave M5W 1E6	Toronto	ON	()-
Fosters Sarah melody	Female	18/05/2004		123 NW T2L 2J5	Calgary	AB	<input type="text" value="(403)123-1234"/> <input type="checkbox"/>
Nakamura Hiro	Male	24/05/1930	Shinto	1 Rue Notre-Dame Ouest H2Y 4A7	Montreal	QC	<input type="text" value="(514)434-1123"/> <input type="checkbox"/>
Smith Sarah	Female	02/08/2005		#23-Fort Ave	Victoria	BC	()-
Bond James A.	Male	07/01/1932	Christian	#1820 - 6425 Pinetree Place V8U 19H	Vancouver	BC	<input type="text" value="(604)121-2121"/> <input type="checkbox"/>
Chan Jackie B.	Female	01/12/1990	Jehovah's witnesses	302 Lee Court V8R 4P6	Victoria	BC	<input type="text" value="(250)434-1123"/> <input type="checkbox"/>

Figure 3.44 View of the Patient List in the Browser of the Secretary. (They have no Access to medical records.)



7778887777 Logout

- Home
- Patient Information
- Immunization Record

Immunization Records

Name Sarah Smith
Guardian: James A. Bond
Relationship: Grand father
Age: 7
Month: 2

Given Date	Brand Name	Immunogen	Site	Reaction	Location	Vaccinator
02/06/2005	multi dose vial engerix -B single dose vial	HB	RT		Royal Jubelle Hospital	
02/08/2005	Pediarix	DTaP	RT		Foothills Hospital	Kashi
02/08/2005	Pediarix	HB	RT		Foothills Hospital	Kashi
02/08/2005	Pediarix	IPV	RT		Foothills Hospital	Kashi
02/10/2005	Actace(TM)	DTaP	RA		Foothills Hospital	Kashi
02/09/2006	Actace(TM)	Hib	RA		Foothills Hospital	Kashi

Routine immunization for this age group

CLASSIFICATION	AGE_AT_VACCINE	IM_ID	OPTIONAL	DESCRIPTION
>= 7 and <17 years	2 months later	HB	Y	-
>= 7 and <17 years	first visit	HB	-	-
>= 7 and <17 years	6-12 months later	HB	-	-
>= 7 and <17 years	2 months later	IPV	-	-
>= 7 and <17 years	first visit	IPV	-	-
>= 7 and <17 years	6-12 months later	IPV	-	-
>= 7 and <17 years	2 months later	MMR	-	-
>= 7 and <17 years	first visit	MMR	-	-
>= 7 and <17 years	first visit	Men	-	-
>= 7 and <17 years	10 years later	Tdap	-	-
>= 7 and <17 years	2 months later	Tdap	-	-
>= 7 and <17 years	6-12 months later	Tdap	-	-
>= 7 and <17 years	first visit	Tdap	-	-
>= 7 and <17 years	2 months later	Var	Y	-
>= 7 and <17 years	first visit	Var	-	-

Figure 3.45 View of the Patient Immunization Records in the Browser of the Patient (e.g. 7778887777).

3.6. Summary

An online immunization program eliminates traditional paper work and record duplication. It prevents adverse events following vaccination and provides lifelong protection against diseases. A centralized immunization record system can provide required information for individuals and assist health providers to make the best decision before recommending any services. Through this chapter, the first model is created based on the information found in the Public Health Agency of Canada, the Canadian Immunization Guide and the National Survey on Immunization Data Standards. The researcher also utilizes other surveys to design the model. The MS Visio is used to design the first ERD, and the Application Express (APEX) is employed to implement the model. Next step describes how this model is evaluated.

CHAPTER IV: Evaluation

4.1. Introduction

Evaluation can play an important role in software development; it facilitates the capturing of system issues and helps to check if the system behavior matches the end-user requirements. It is important to consider the end-users in developing systems since they are the main beneficiary of the eventual system (Ogedebe & Jacob, 2012). Usability evaluation is often used to determine strengths and weaknesses of an application during system development to improve the usability of that software system (Gediga, Hamborg, & Dunsch, 2002). With usability methods and prototyping, functionality of healthcare systems can be appraised by health professionals before finalizing the implementation (Kushniruk & Patel, 2004). Although the use of IT in healthcare has existed for more than three decades, methods to assess outcomes of the use of IT systems is still a challenge (Rahimi & Vimarlund, 2007). Prototyping methods help to assess the usability of software during system development (Kushniruk & Patal, 2004). Based on Hamborg et al., summative and formative evaluations are both required in software evaluation; while summative is usually quantitative and is performed at the end of the development process and formative evaluation is usually used to improve the system's weaknesses during engineering life cycle or before further development (Hamborg, Vehse, & Bludua, 2004). In this study, formative evaluation is deployed to assess some of the factors.

Rahimi reviewed 61 Health Information System (HIS) evaluation studies among hospital and primary care systems; he reported that effects of elimination of paper based records, user satisfaction, and the usefulness of the system including time of service delivery, usability, and feasibility are important factors to adopt in a system (Rahimi &

Vimarlund, 2007). To select appropriate evaluation factors, Delone and Mclean IS success model is used in this study; Delone and Mclean (D&M) IS Success model consists of six success categories or dimensions that demonstrates clear categories of success together with relationship among them (Yusof, Kuljis, Papazafeiropoulou, & Stergioulas , 2008). These six categories include: System Quality, Information Quality, Service quality, System use, User satisfaction, and Net benefit that are demonstrated in figure 4.1 (Delone & McLean, 2004).

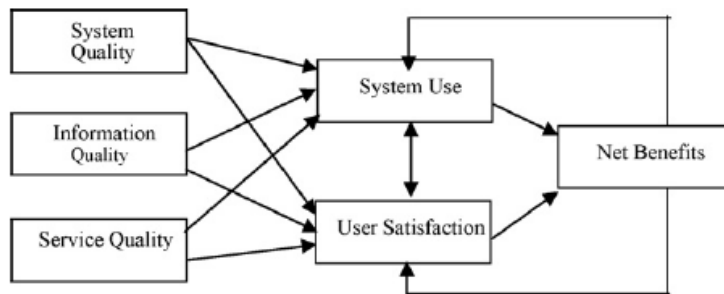


Figure 4.1 Delone and Mclean IS Success Model

The above dimensions include different measures; System Quality includes measures of the information processing system (e.g. ease of use, ease of learning, usefulness of system features and functions), Information Quality includes the measures of IS output (including but not limited to usefulness, accuracy, reliability, timeliness), Services Quality includes measures of service (e.g. Quick responsiveness , technical support), System use considers consumer responses to the IS output, and User satisfaction that reviews impact of the system on user which can be satisfaction with specific function, software, decision making satisfaction, or overall satisfaction (Yusof et al., 2008). The Infoway Benefit Evaluation Framework is also developed based on the Delone and

McLean model and it is currently used to evaluate HIS systems in Canada (Figure 4.2). This figure also shows different factors under each category.

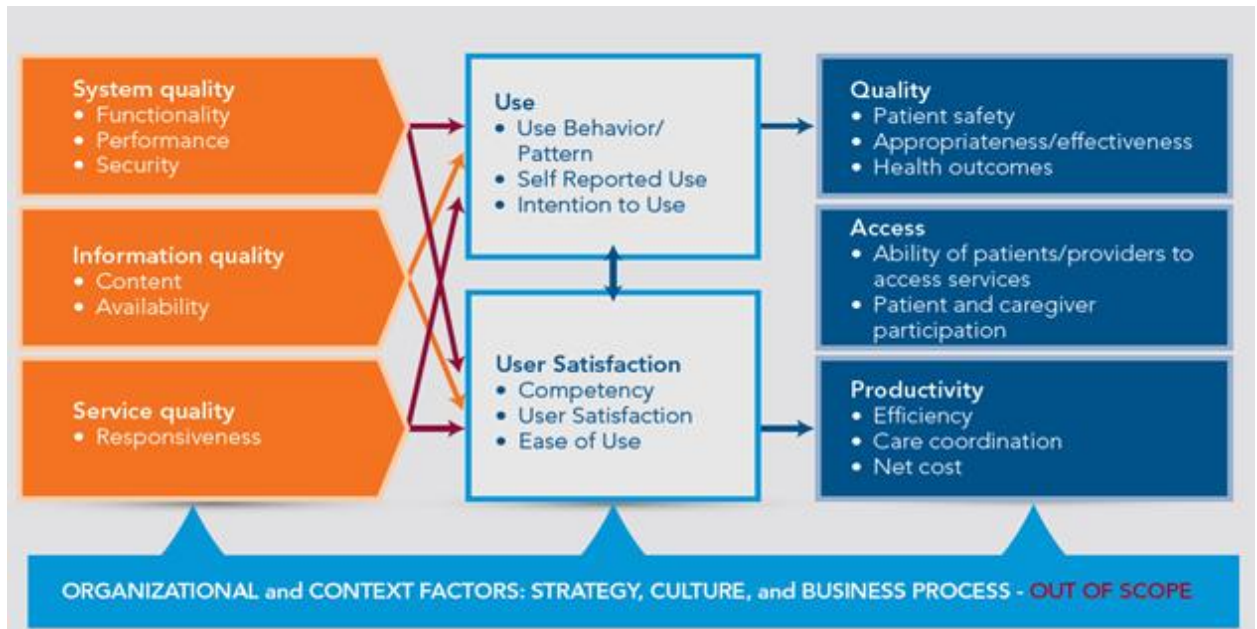


Figure 4.2 The Infoway Benefits Evaluation Framework

As mentioned before, prototyping methods help to assess the usability of software during system development (Kushniruk & Patal, 2004). In this study, the qualitative evaluation approach and usability engineering is used to assess information quality in terms of the content of data, system quality (e.g. some of system features and functions), and user-friendliness of model to understand health professional expectation from a real system.

4.2. Method

Based on Kaplan's study, qualitative method can be used throughout the system development and evaluator can offer assessment once the project is under process (Formative evaluation) rather than waiting until the project is completed (Summative evaluation) (Kaplan & Maxwell, 1994). In this study, the qualitative method was used to evaluate contents of data, quality of system (in terms of features and functions), and user

friendliness of system; this method helps the researcher to understand whether the model functions well or poorly before any further development.

As mentioned, usability engineering applied throughout the development of Health Information System (Kushniruk & Patal, 2004). Think aloud and constructive interaction methods are two of the common usability engineering methods that constructive interaction was deployed in this study. Kahler's study indicates, "The constructive interaction method helps system designers determine whether the basic concepts underlying a system are well understood by users and whether its implementation and usability are satisfactory" (Kahler, Kensing, & Muller, 2000, p. 27). Constructive interaction which is also known as co-discovery method (Vandenhak, Dejong, & Schellens, 2004), allows two participants to work together on a common task (Greenberg & Pawson, 2009). Kahler also showed that constructive interaction can be effective when there is distribution of parts of the task among the two people (Kahler et al., 2000).

In this study, SKYPE, a proprietary voice-over-internet software application, was used to conduct usability sessions over the internet. Tasks were distributed between two participants; the developer (researcher) demonstrated the system features and functions and the clinician observed the system. Within this collaborative assessment task, participants were able to discuss the system features and all recommendations were collected in two locations. Clinicians completed the open-ended questionnaire and added their comments when each task was completed and the researcher took a separate note from each session discussion to prevent any missing points. By the end of the evaluation

session, both the completed questionnaire and the notes were gathered by the researcher and used for data analysis.

4.3. Process

Kushniruk described different phases that can be employed in performing usability evaluation in clinical setting as follows (Kushniruk & Patel, 2004):

Phase 1: Identification of Evaluation Objects

Phase 2: Sample selection and study design

Phase 3: Selection of representative experimental tasks and contexts

Phase 4: Selection of background questionnaire

Phase 5: Selection of the evaluation environment

Phase 6: Data collection

Phase 7: Analysis of the process data

Phase 8: Interpretation of finding

Phase 9: Iterative input into design

4.3.1. Phase 1: Identification of Evaluation Objects

In the first phase, the researcher can determine what aspects of the prototype he/she wishes to assess. Based on Kushniruk, some of the objectives for conducting evaluation include but are not limited to assessment of a system's functionality and usability, input into refinement of emerging prototypes, and assessing computer-human interactions (Kushniruk & Patel, 2004). This study focuses more on evaluation of content of data, quality of features and functions, and user friendliness of the model. In addition, the researcher was initially interested to know clinicians' points of view and what they expect from the eventual system.

4.3.2. Phase 2: Sample Selection and Study Design

The second phase involved the selection of a sample of target subjects for the evaluation process; subjects should be representative of those who would be expected to use the system under study; also, the system may have different categories of users (Kushniruk & Patel, 2004). The factors that can be considered in classifying the users may include: the expertise of subjects in use of computer systems, the role of end-users, and knowledge of them in the domain of work that for which the information system is targeted (Kushniruk & Patel, 2004). This model is designed to provide information for three different categories of users: clinicians, secretaries, and individuals (public users). Clinicians have the highest level of access to information and system functions, which allows them to create and modify immunization records as well as patients' demographic information. Similar to clinicians, secretaries have access to patients' demographic information, but they can only view, enter, and update demographic information, and have no access to medical and immunization records. Individual public users have the least access to this system and can only view their own immunization information. Level of access to the system is summarized in the following table:

Table 4.1 Users and the Level of Access

	Insert/update Medical & immunization records	Insert/update patient Demographic Information	View individual information
Clinicians	☑	☑	☑
Secretary		☑	☑
Public User			☑

Clinicians are the power users in the system and have full access to information and all the system features and functions; that is why they were invited to assess this model. In this study, the researcher ensured that all the participants (clinicians) were familiar with immunization process and had prior experience working with Health Information Systems.

4.3.2.1. Sample Size

As evaluation involving cognitive analysis provides a rich resource of data, a considerable amount of information can be obtained from a small number of participants (e.g. 8 -10 subjects) especially if participants selected are representative of target users of the system being assessed (Kushniruk & Patel, 2004). In addition, quantitative evaluations use numbers gathered from measures over comparatively large samples, but the sample size is small in qualitative evaluation (McDavid & Hawthorn, 2006). The researcher needs to collect data until it reaches a point of data saturation. This occurs when the researcher is no longer hearing or seeing new information (Simon, 2011). Based on Nielsen, up to 80% of interface issues can be detected with as few as 8-12 transcripts of participants' interaction with the system (Kushniruk & Patel, 2004). In this study, the data saturation occurred after interviewing eight participants, but 12 interviews were conducted to achieve the most correct result.

4.3.2.2. Recruitment

Twelve health professionals participated in this study. Inclusion criteria required that the participants:

- Had knowledge of immunization;
- Had experienced working with Health Information Systems (HIS); and

- Lived in Canada

The majority of participants were registered nurses who were all familiar with immunization and vaccination concepts and were experienced in working with Health Information Systems. Three of the registered nurses were the researcher's classmates and they were previously involved in implementation of the MINISHELL EMR. As a teacher's assistant, the researcher had access to the list of potential participants and some of the clinicians were invited via email; five participants accepted the invitation and two participants were introduced via the mentioned evaluators. One participant was a pharmacist who has been administering vaccinations for more than 25 years; she was invited via telephone call and the contact number was taken from vaccine411.ca. The last participant was an experienced pediatrician from Ottawa who was introduced via a friend. All the participants were very knowledgeable and provided very good feedback for this study.

4.3.2.3. *Ethics*

The ethics approval was obtained from the University of Victoria Human Research Ethics Board to conduct the evaluation process. After the issuance of the approval, the clinicians were invited to participate in the study. The diagram below shows the process from the beginning to the receiving of the ethics approval.

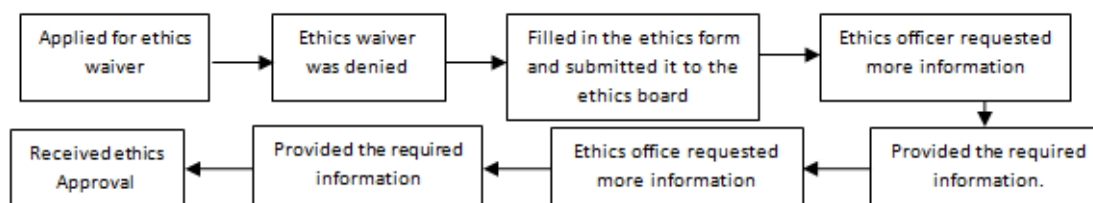


Figure 4.3 Process of Receiving the Ethics Approval

4.3.3. Phase 3: Selection of Representative Experimental Tasks and Contexts

Developing a series of pre-defined tasks or scenarios can help to extract quality data about user interaction with a system. Based on Kushniruk, cases or scenarios can be drawn from cases commonly used for evaluation in medical education, or they can be created with the assistance of an appropriate medical expert working with the investigators (Kushniruk & Patel, 2004). In this study, the researcher defined a series of tasks in a test script, which idea was inspired by the Agile test script template (Test Script, n.d.) and one of the scripts used at Royal Jubilee Hospital ⁺⁺. The test script then was reviewed by a professional clinician and its suitability was confirmed before it was used in this study.

As discussed before, this research was conducted in Victoria. The database and the application resided on the UVic web server and remote distance assessment was used via Skype to conduct usability sessions over the internet; therefore, the participants were only required to have Skype accounts. Eventually, tasks were distributed between the two participants in each interview session: the researcher and the experienced clinician.

4.3.4. Phase 4: Selection of Questionnaire

Clinicians were presented with a test script that comprised a background questionnaire, two open-ended questions regarding system factors, and some pre-defined tasks. The tasks were performed during a system demonstration and the clinicians were asked to make observation comments.

⁺⁺*Katherine Lodge-Childs is the designer and owner of the test script reviewed in this study.*

4.3.4.1. *Background Questionnaire*

A background questionnaire can be used to collect information about participants; it can include items to assess the level of participants' health practices or their prior experience with computer systems (Kushniruk & Patel, 2004).

In this study, the background questionnaire was designed to capture participants' information such as names, email addresses, provinces/cities of residence, years of experience, knowledge of immunization/vaccination and the level of their experience with Health Information Systems. Participants were asked to rate their knowledge of immunization (A. very knowledgeable, B. moderately knowledgeable, C. somewhat knowledgeable, D. not very knowledgeable, E. unknowledgeable, F. do not wish to disclose). The purpose of this question was to ensure that no one selected choice E. In response to the questionnaire, three participants chose A (33%), five chose B (41%), three chose C (33%), and one chose D (8%). This result indicated that all participants were familiar with the immunization process. Participants were also asked to rate their experience with Health Information Systems (HIS) (A. a lot of experience, B. some experience, C. very little experience, D. no experience, E. do not wish to disclose). This question was to ensure that all the participants worked with HIS to provide efficient feedback about system features and functions. In response, six participants selected choice A (50%), and six participants chose B (50%); this indicated all participants had more than enough experience to assess a HIS.

4.3.4.2. *Open-Ended Questions*

Two open-ended questions were designed to collect clinicians' suggestions about the quality of data (data content) and user friendliness of this model. These two general

questions were asked for each screen that was demonstrated to participants and the result was analyzed and interpreted in phase eight.

4.3.4.3. *The Predefined Tasks*

As mentioned in phase three, a series of pre-defined tasks was developed by the researcher to test different functions and features of the model. These tasks were performed at the demonstration time to clinicians and were designed to help the researcher to understand the end-users' expectations about the system. The researcher followed the steps in the test script and applied each task in the system; simultaneously, clinicians entered their observation comments on each task. In Victoria, while performing the test, the researcher separately took notes from their discussion.

By the end of each session, the clinicians forwarded the completed test scripts to the researcher for data analysis. The following image shows the content of the test script for one of the forms.

A	B	C	D	E	F	G	H	I
Interviewer		Participant Email Address:						
Date tested:		Participant province/City:						
Participant Name:		Years of experience:						
Please rate your knowledge of immunization/vaccination:(A.Very knowledgeable, B. Moderately knowledgeable, C. somewhat knowledgeable, D. not very knowledgeable, E. unknowledgeable, F. Do not wish to disclose).								
Please rate your experience with health information systems. (A. a lot of experience, B. some experience, C. very little experience, D. no experience, E. Do not wish to disclose).								
Columns: U stands for User friendliness , Q= Quality of data After completion of each step, Please use P to indicate "Pass" and F to indicate "Fail" under user friendliness (U) and Quality of data (Q) columns.								
Assess Quick check - Quick Admission form								
Test "Quick Check"	Perform following Actions	Expected result	Observation Comments	U	Q			
Step1	Search for patient information by PHN/name(e.g. Smith, 777,...)	If Patient exists, his/her information will be listed. (Search works on PHN or Last name).						
Step2	Create New encounter that doesn't exist in system. (Null PHN, alphanumeric PHN e.g. 123abc , existed PHN e.g. 9124111111 cannot be added)	Insert new Patient information (e.g. 2222222222, Foster,18/05/1990) New patient is created with Last name, PHN, and DOB information.						
Step3	Reset the form and click on new created record.	Patient information will be appeared on free textboxes and it's ready to be edited or deleted.						
Step4	Edit Patient information	Patient information will be edited and recorded correctly.						
Q1- Content: This form is designed to quickly add or check patient's information in system. Does this basic information enough to find or add new patient? If not, please explain what needs to be added or modified.								
Q2- User friendliness: Is this form easy to be used? If not, please explain how the user interface can be improved in this form?								

Sample of Background Questionnaire

Sample of pre-defined tasks to test several actions in a form

Sample of Open-Ended Questions for each Form/Report

Figure 4.4 View of Part of the Questionnaire Used in This Study

4.3.5. Phase 5: Selection of the Evaluation Environment

As stated before, the constructive interaction usability method was employed to assess the model. The researcher and a clinician took part in each evaluation session and the researcher explained and demonstrated the model to the clinician. The clinician completed the test script during system demonstration and explained his/her points of view about the system features and functions. Skype was deployed for communication and the model was assessed collaboratively over distance. In this study, the researcher

tried to simulate the environment in which two individuals could see each other and talk to each other while each person was able to see the system functionalities at the same time.

4.3.6. Phase 6: Data Collection

Assessment sessions were conducted at the clinician's convenience. As mentioned, a test script with pre-defined tasks, together with two general open-ended questions, was designed for the purpose of evaluation. While the researcher performed these tasks, the clinician observed system functionalities, recorded comments on the test script, and answered open-ended questions. In addition, the researcher took separate notes from the conversation to guard against data loss or accidental omission. The tasks included entering, modifying and searching information, examining functions such as vaccine and allergy alerts, testing dynamic vaccine schedulers, assessing the "Recommendation" tab, and examining different levels of access for different types of users. The pre-defined tasks are accessible via Appendix D. The clinicians were asked to verbalize their thoughts about the system functionalities once they observed different forms and reports and to write their findings about each completed task. As a result, both researcher and clinician captured data in two different sites and by the end of each session, the former had two sets of data to analyze. Some of the advantages of the constructive interaction method in this study were saving time for both researcher and clinician, avoiding data loss, and gathering accurate information in written format during the interviews. The following figure depicts how this evaluation took place over the internet via Skype.

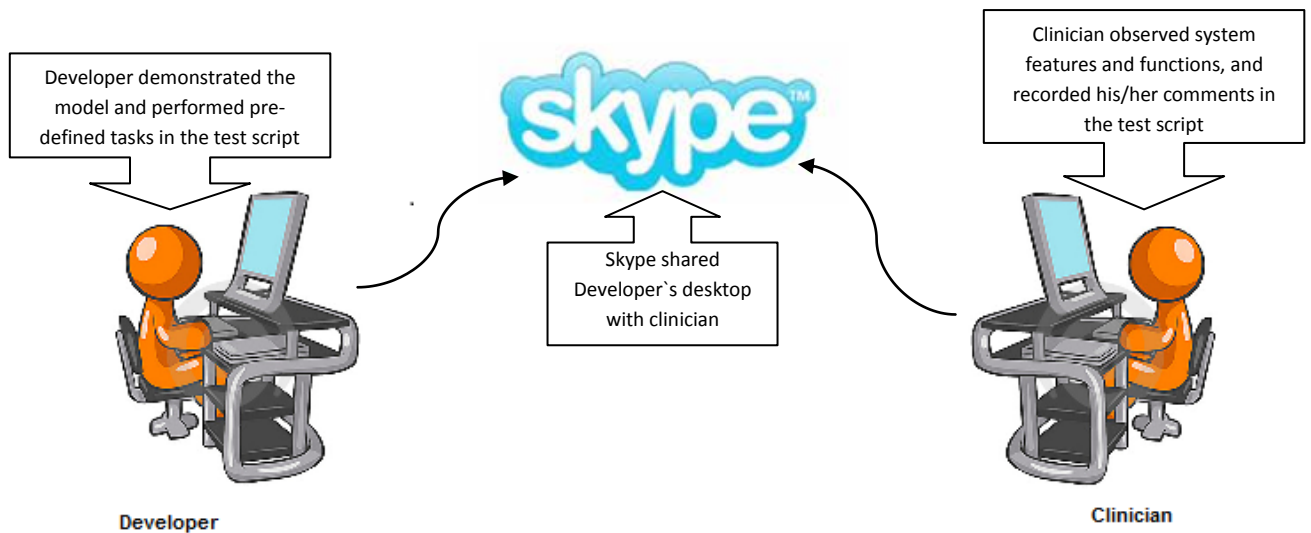


Figure 4.5 View of Collaboration between the Developer and the Clinician

4.3.7. Phase 7: Analysis of the Process Data

The objective of evaluation in most of the studies is to identify problems experienced during the evaluation. The data collected from usability assessment can be compiled in different ways depending on the goals of the evaluation (Kushniruk & Patel, 2004).

As described in previous phase, clinician's thought was captured in written format in both sites by the clinician and the developer. In this study, the participants' feedbacks were analyzed and categorized, and their information and comments were classified into three main categories including *quality of information*, *user friendliness* of model, and *quality of system*. Afterwards, responses that fit each category were detected and counted. Overall, the system was assessed in terms of data content, functionality, and ease of use to determine how practical the model was.

4.3.8. Phase 8: Interpretation of Finding

As discussed in previous phase, participant's feedback was classified into three main categories and frequency of observation comments was counted. Also, as described

before, the qualitative evaluation that is typically used during system development was employed in this research. According to Mays: “*Statistical representativeness is not normally sought in qualitative research*” (Mays cited in Britten, 1995, p. 253), however, we employed quantitative approach to estimate the level of agreement on participants’ recommendation.

Table 4.2 Summary of Participants’ Comments

Categories	Comments
Quality of Information (Content of Data)	<ul style="list-style-type: none"> - Nine of the participants (75%) recommended adding <u>Manufacturer name</u> to immunization form in case of recall into the “immunization record”. - Six of participants (50%) stated that <u>Dosage</u> is required in immunization form. - Four participants (33%) were agree to add <u>Route</u> to immunization form. - One participant (8%) advised to add <u>Monograph product</u> for vaccines, six participants (50%) mentioned it is good to add this field to Vaccine Information, but it’s not necessary, and two participants (16%) were completely negative about adding this item since this information can be downloaded easily from internet and it is available in vaccine inventory database. <p>Final Decision: Manufacturer name, Dosage, and Route were decided to be added to immunization table as well as the immunization form to provide more accurate information for providers and individuals. The “Product Monograph” was not</p>

	<p>added to vaccine table.</p>
<p>Quality of System (System features and functions)</p>	<ul style="list-style-type: none"> - All participants (100%) agreed that “Quick Check” is easy to use and flexible. One of participants (8%) recommended to restrict the search to just PHN and not to allow searches for partial information. Two (% 16) mentioned this link is user friendly, but it is redundant since we can enter and update individual’s information via “Patient List”. <u>The purpose of creating this link was to collect the minimum demographic information at registration time</u> in high volume clinics. According to one participant, the first name and address are also valuable. In addition, another participant pointed out, these three identifiers (PHN, Family name, and DOB) together with where the individual lives are required as minimum demographic data. - In terms of security, three participants (25%) recommended to restrict secretary’s access to patient information (The secretary should be able to enter and modify patient demographic information, but not medical information). This recommendation was applied into the model previously. - Two of Participants were concerned about deleting information - According to one of the participants (8%), clinician should be able to override the message if physician decides the benefit of vaccination outweighs possible mild allergic reaction.
<p>User friendliness of Model</p>	<ul style="list-style-type: none"> - Some of wording needed to be modified for interface improvement.

- As mentioned in Chapter three, two different forms were designed to manage “Interval vaccines”. All participants (100%) believed that “Tabular scheduler” is more useful and easy to use for clinicians and the plain report is good for individuals.
- Six participants (50%), advised to add “Next of Kin” and “contact number” to “patient List” report.
- One participant (8%) advised “Never use red as the main color for an Oracle website”.
- One participant (8%) advised to show the complete name of the disease to individuals instead of the Vaccine type or immunogen abbreviation (e.g. Tetanus-Diphtheria instead of Td).
- One of participants (8%) suggested adding “Reaction” to the immunization report for individuals.

4.3.9. Phase 9: Iterative Input into Design

The result of this study was reviewed by the developer (researcher), and a number of suggestions that clinicians identified were also considered. Some changes were applied to the model based on the end-users’ recommendations, and additional changes might be necessary in specific organizations in order to meet their expectation and requirements. To utilize this model for a national purpose, the model should be used by health providers in local public health centers and iterative feedbacks can be collected to see if all expectations are met. Once the model is assessed with a high volume of data by a number of participants in different locations, summative evaluation (which is out of scope of this study) needs to be employed; eventually, this process can help to transform the model to a national IIS. What can be learned from this study is explained in the discussion section.

4.4. Discussion

All the participants provided positive feedback in terms of data content, functionality, and ease of use regarding the designed IIS prototype. The researcher was required to collect and analyze data, design the database, implement the application and interview the participants in a limited period of time. APEX was recognized as a suitable tool to develop a quick web-based application, especially due to time constraints. APEX was also helpful to assist the researcher in implementing the ERD and to demonstrate the model's functionality to health professionals; this tool provided a view of an actual system for clinicians and assisted the researcher to understand end-users expectations of a real system. However, there were some limitations with APEX that other web development techniques such as AJAX (Asynchronous JavaScript and XML) could enhance its capability.

Previous projects have shown that APEX is a good choice in the healthcare industry with regard to user friendliness, easy-to-use configuration and information management feature capabilities (ORACLE, n.d. *a*). A good example of deploying APEX in the healthcare industry is AGILAB, a French company that designed its first Laboratory Information Management System (LIMS) web application with APEX and named it AGILIMS. In fact, AGILIMS provided spontaneous laboratory information management features. Currently, AGILAB aims to use APEX to fill important gaps in laboratories. Another example is CarePathPlus, an advanced Patient Care Management application designed to be used by a Health Coach (Care Manager, qualified nurse) in a call centre in the UK that deployed APEX for its projects. (ORACLE, n.d. *a*).

Overall, APEX can be a suitable choice to implement a centralized Immunization Record System to track and manage Canadian immunization information with its easy to use capabilities. As discussed in phase seven, participants' feedbacks were classified into three categories, and their comments were summarized in Table 4.2. Also, according to phase nine, some changes were applied to the model based on the end-users' recommendations and some changes might be necessary in specific organizations in order to meet their expectation and requirements. A discussion associated with each factor is addressed as follows.

4.4.1. Discussions with Respect to Information Quality:

As described in previous chapters, the model was implemented based on the information of Canadian resources such as the Canadian Immunization Guide and National Survey on Immunization Data Standards, and it benefited from reviewing studies such as data collection surveys conducted for specific vaccine coverage. Based on the participant's feedback, three new fields were determined to be added to immunization form.

As mentioned earlier, nine of participants suggested adding "Manufacturer name", six suggested "Dosage" and four suggested adding "Route" to the immunization form. Based on the Canadian Immunization Guide, each vaccine has several attributes (Figure 4.6) such as Brand name, Manufacturer/Distributor, Route, Vaccine type and so on. Also, this figure shows different data elements that are kept in the vaccine table.

Brand name	Mfr/ distr.	Route	Vaccine type			Adjuvant	Preservative	Potential allergens (egg, antibiotic, gelatin, latex)	Other materials
			Vaccine type	Immunogen+	Products				
Act-HIB®	SP	IM	Subunit	Hib	Conjugate				
Actacel™*	SP	IM	Subunit	D, T, aP+ (Hib)	Proteins + Conjugate	Alum	PE		

Figure 4.6 Snapshot of “Type and content of Vaccines currently approved for use in Canada” (CIG, 2006d)

Vaccine information is kept in “Vaccine table” and its information is managed via “Vaccine form” which is accessible via the Library navigator (Figure 4.7).

The screenshot shows a web application interface for managing vaccine information. At the top, there is a navigation bar with the following tabs: Vaccine information (selected), Vaccine Immunogen, Vaccine allergen, and Back. The user is logged in as HQ3. The main content area is divided into two sections:

Type and Contents of Vaccines (Left Panel):

- Vaccine Id: 1003
- Brand Name: Avaxim
- Mfr Distr Id: Sanofi Pasteur Ltd
- Route: Intramuscular (IM)
- Vaccine Type: Inactivated
- Products: Killed virus
- Adjuvant: Aluminum - containing adjuvant
- Preservative: 2 Phenoxy Ethanol (PE)
- Dose: (empty field)

Avaxim Immunogen(s) (Right Panel):

Vaccine Id	Immunogen
1003	HA

1 - 1


Avaxim Potential Allergens & other materials (Right Panel):

Vaccine Id	Allergen	Description
1003	formaldehyde	other materials
1003	neomycin	potential allergen

1 - 2

Figure 4.7 Snapshot of the Vaccine Form

Once a vaccine is administered for an individual, the information of “Manufacturer Name” and “Route” are inherent in the description of the vaccine, and for this reason, these fields were not set in immunization form. Based on the clinicians’ recommendations, these two items together with “Dosage” are required to be set in Immunization Form because some vaccine could be administered in different routes, and same vaccine may have different doses if given intradermally compared to intramuscularly. To illustrate, Figure 4.8 shows the snap shot of the old Immunization form:



PAT Logout

Form for Immunization Record

Cancel
Create

PHN

Vaccine

Type of Vaccine

Date of Administration

Site

Lot Number

Expiration Date

Vaccinator

Facility/Hospital/Clinic

Unit

Reaction

Administering Vaccines

For More information about Vaccines, Dose, Route, Injection Site, and Needle Size, Please Check [CDC Recommendations](#) webpage.

Figure 4.8 Snapshot of the Old Immunization Form

Applying changes into the Immunization Form impacted the ERD, data structure and the interface design; the following tasks were performed to apply the required changes:

1. The Entity Relation Diagram (ERD) was modified, and a new relationship was defined between the immunization and the manufacturer tables.
2. Table structure was modified. Three fields and a foreign key were added to the immunization table (in the test environment).
3. The immunization interface was modified (in the test environment)
4. Step 2 and 3 were applied to the production environment once everything worked properly in the test environment.
5. New fields were added to the report for Clinicians.

Above steps can be simply demonstrated as follows:

Step 1: ERD Modification (Figure 4.9, Figure 4.10, Figure 4.11)

Before

immunized_tbl		
PK	immune_id	NUMBER
	date_given	DATE
FK1	vaccine_id	NUMBER
FK2	Fd_id	NUMBER
FK3	PHN	NUMBERPS(10,0)
FK4	Facility_id	VARCHAR2(10)
FK5	UID	NUMBERPS(4,0)
	reaction	VARCHAR2(50)
	site	VARCHAR2(2)
	lot_number	VARCHAR2(20)
	exp_date	DATE
FK6	im_id	VARCHAR2(12)

After

immunized_tbl		
PK	immune_id	NUMBER
	date_given	DATE
FK1	vaccine_id	NUMBER
FK2	Fd_id	NUMBER
FK3	PHN	NUMBERPS(10,0)
FK4	Facility_id	VARCHAR2(10)
FK5	UID	NUMBERPS(4,0)
	reaction	VARCHAR2(50)
	site	VARCHAR2(2)
	lot_number	VARCHAR2(20)
	exp_date	DATE
FK6	im_id	VARCHAR2(12)
FK7	Mfr_distr_id	VARCHAR2(10)
	Route	VARCHAR2(11)
	Dose	VARCHAR2(20)



Figure 4.9 ERD, Before and After the Changes

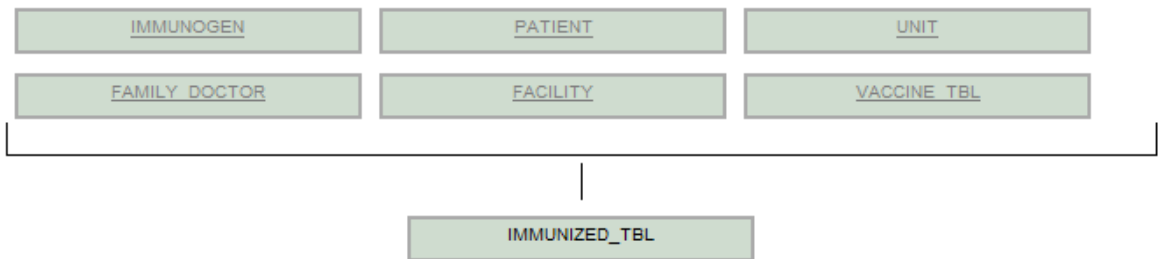


Figure 4.10 Previous Relationships between Immunized_tbl and Other Tables

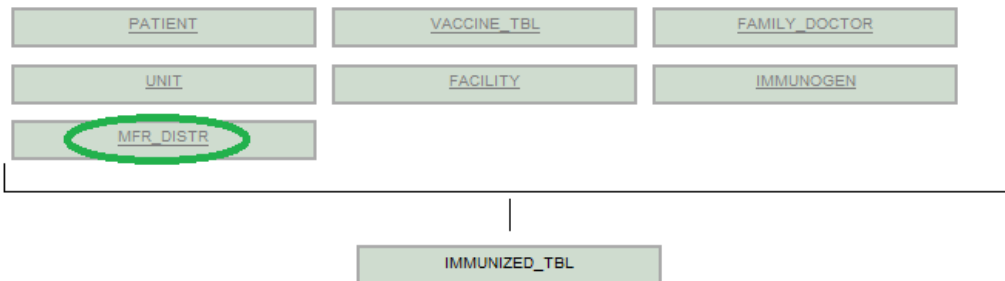


Figure 4.11 Current Relationships between Immunized_tbl and Other Tables

Step 2: Structural modification

Three data elements and one foreign key were added to immunization table (IMMUNIZED_TBL):

"MFR_DIST_ID" VARCHAR2(10),
 "ROUTE" VARCHAR2(11),

"DOSE" VARCHAR2(20),
 CONSTRAINT "IMMUNIZED_MFR_FK" FOREIGN KEY ("MFR_DIST_ID") REFERENCES "MFR_DISTR" ("MFR_DISTR_ID")

Step 3: Interface Modification - the immunization form

Figure 4.12 and 4.13 shows immunization form before and after changes.

Form for Immunization Record Cancel Create

PHN 222222222

Vaccine Act-HIB

Type of Vaccine BCG

Date of Administration

Site Right Arm

Lot Number

Expiration Date

Vaccinator Chris Tucker

Facility/Hospital/Clinic Foothills Hospital

Unit Cardiac Care Unit

Reaction

Administering Vaccines
 For More information about Vaccines, Dose, Route, Injection Site, and Needle Size, Please Check [CDC](#) Recommendations webpage.

Figure 4.12 Immunization Form before the Changes

Form for Immunization Record Cancel Create

PHN 222222222

Vaccine Act-HIB

Type of Vaccine BCG

Date of Administration

Site Right Arm

Lot Number

Expiration Date

Mfr Dist Id Baxter healthcare corporation

Route Intramuscular (IM)

Dose

Vaccinator Chris Tucker

Facility/Hospital/Clinic Foothills Hospital

Unit Cardiac Care Unit

Reaction

Administering Vaccines
 For More information about Vaccines, Dose, Route, Injection Site, and Needle Size, Please Check [CDC](#) Recommendations webpage.

Figure 4.13 Immunization Form after the Changes

Step 4: Applying step 2 and 3 to the production environment

Step 5: Adding new fields to the report for Clinicians


Patient Health Number: 2222222222 Immunization Records												Create
Name: Sarah melody Fosters												
Guardian: Sarah Smith												
Relationship: Mother												
Age: 8												
Month: 3												
Edit	Phn	Given Date	Brand Name	Immunogen	Site	Lot Number	Location	Vaccinator	Expiration Date	Mfr Dist Id	Route	Dose
	2222222222	12/08/2012	Act-HIB	Hib	RT	651M	The Ottawa Hospital	Tucker	06/08/2012	GSK	SC	3

Figure 4.14 Immunization Report after Applying the Changes

4.4.2. Discussions with Respect to System Quality

Based on the participant's feedback, some changes were applied, and there would be the possibility of some other changes in the future once this model is used by a specific organization as follows:

- Based on the participants' comments about "Quick Check" link, this option works properly, but if it is deemed redundant, this link can be disabled, and the following fields (PHN, First name, Middle name, Last name, DOB, Province and City) could be marked as mandatory identifiers to be filled in "Patient form" at the registration time.
- In terms of deletion, two of participants were concerned about deleting information; "Delete" option can be disabled, or it can be used by only authorized end-users. Depending on the system policy defined by the organizations' administrators, this option can be tailored.
- Based on one of the participants' feedback, clinicians should be able to over ride the message(s) if the benefit of vaccination out weights possible mild allergic

reaction based on the physician discretion. This suggestion was applied, and one of the controls got disabled; therefore, the clinicians are now able to over ride the messages if the benefit of vaccination outweigh mild allergic reaction.

4.4.3. Discussions associated with User friendliness of the System

- Based on the participants' recommendation, some words were changed in interface, and the following changes were applied: "No one" was changed to "Unknown", "No allergy" to "Not Known Allergies", "Given Date" to "Date of Administration", "Required Vaccine" to "Missing Vaccine" and "Recommended Vaccine" to "Suggested Vaccine".
- To manage "Interval Vaccines", the "Tabular Scheduler" was used for clinician, and a plain report was created for individuals to browse their information.
- "Next of Kin" and "Contact Number" were added to "Patient List" report.
- The complete name of the disease was shown to individuals instead of Vaccine type or immunogen abbreviation.
- Reaction was also added to individuals' reports.

Overall, "Discussions with respect to information quality" showed that adding new data element(s) to database table(s) impacts the ERD, the data structure, the application interface and the documentation. Also, discussion associated with user friendliness of system and quality of system showed that changes can be applied easily into the model when it is implemented by APEX. Therefore, choosing a right development tool with easy to use capability would be time saving and cost effective, and stack holders need to consider these factors when they plan for implementing a large scale project (e.g. Centralized Immunization Tracking System).

Also, leadership plays an important role in implementing a project. Certainly, encouraging provinces and territories to use a uniform dataset with specific data format can promote degree of agreement in both data elements and data types and supports interoperability among systems. This action facilitates transferability of data and promotes accessibility to the information which is the main purpose of utilizing the centralized applications. In general, APEX can be considered as a tool to implement an easy to use web based centralized IIS, and APEX not only could save time and money for governments but also could serve Canadians with timely and reliable system.

4.5. Summary

“The usability of product is considered as a precondition of the usefulness of an application” (Nielsen cited in Hamborg, Vehse, & Bludua, 2004, p.21). In this study, the qualitative evaluation approach was used to assess quality of information (in terms of data content), user friendliness of model and some of system quality factors (e.g. system features and functions). Through this chapter, usability engineering was performed to evaluate the model and nine phases of usability evaluation in clinical setting as described by Dr Kushniruk. As mentioned earlier, think aloud and constructive interaction are common ways to evaluate a system. Constructive interaction was effective in this study since Skype allowed face-to-face communication, and tasks were distributed among two people in each session. With this approach, the researcher did not need to use video recording, and it eliminated extra work of transcribing. Not only did Skype offer possibilities for testing over distance, but it also saved time for the researcher and clinicians by allowing two users in separate locations to work collaboratively on the evaluation process. This approach was helpful to learn about the system concepts and to

capture usability flaws. In addition, APEX was proved to be a good choice to develop a quick web based application. The conclusion of this study is described in the following chapter.

CHAPTER V: Conclusion and Future Research

5.1. Conclusion

The literature review was conducted, and previous works were reviewed; According to National Immunization Strategy Final report 2003, “*provinces/territories are responsible for planning, delivering and funding the immunization program to their population and support national immunization strategy*” (NIS Final Report, 2003, p.1), and Health Infoway (a non-profit organization) was in charged with developing a health information system that would include a national vaccination registry for Canada, called Panorama. This system was planned to be operational by the end of 2009, but it is not rolled out in any jurisdiction yet. Provinces and territories provided brief information about the existed systems or the systems under implementation in their websites, and evidence showed that there is an urgent need to a centralized system accessible by individuals and health providers to track immunization records at any location and anytime. In this study, a database was designed based on information of Canadian Immunization Guide and the common data elements currently used in different jurisdictions; then, an online immunization tracking model was implemented and evaluated by several health professionals.

As mentioned earlier, each province is responsible for planning immunization program to its population and deliver immunization services to individuals. Based on the information found on the provincial websites, residents’ immunization information is accessible to authorized providers but not individuals, and if individuals require a copy of their records, they will need to request this information from their public health practitioner or the public health unit that they were immunized. Besides, some of those

systems just keep infants' or students' immunization record information but not adults' immunization record. In Addition, none of those systems are compatible in data format and data type, and studies show that some organizations are using computerized system and some are using paper-based or hybrid system to keep individuals' immunization information; for instance, in the study in support of immunization data collection approaches during the H1N1 vaccination campaign, 38 organizations were observed that nine organizations were using electronic systems for data collection, and 29 were using hybrid system (computerized and paper-based data collection). Providing an online tracking model based on Canadian Immunization Guide that keeps only the essential immunization information of individuals including children and adults will help all citizens to access their own records via internet at anytime, and it is also beneficial to prevent any outbreak in national level.

In this study, MS Visio was used to design the Entity Relation Diagram (ERD), Oracle application Express (APEX) was used to implement the model, and usability assessment was employed to assess the quality of information and features and functions of this model. The following figure shows the final ERD after evaluation (Figure 5.1).

In light of this study, the researcher understood that leadership plays an important role in conducting, implementing and supporting a centralized web based Immunization Information System (IIS) usable in national level. The result of this study shows that this model has the potential to be transformed into a real system or to be used for implementation of a superior immunization tracking system in the future.

5.2. Future research

5.2.1. RFID Chips

The need to adopt Information technology to facilitate some of tasks is unavoidable; Radio Frequency Identification (RFID) is a technology that is used in variety of applications and in different industries. Locating, asset tracking (RFID Journal, 2005), and identifying objects (Wilkerson, 2007) are all possible with this technology. RFID is used in healthcare industry for variety of purposes such as identifying patients, tracking objects in hospitals, controlling medicine and blood bag quality which result in patients' safety (Huang, Chu, Lin, & Kuo, 2010). Also, RFID can be beneficial in healthcare industry as it accelerates access to the accurate information, reduces paper work, minimizes medical errors and keeps patients' information confidential. Some of the good examples are Chang-Gung Memorial Hospital in Keelung, Taiwan, that implemented the RFID system in its operating room (OR), and Jacobi Medical Center in Bronx, New York, that chose RFID System to replace its manual process of identifying patients in its two acute-care departments (Precision Dynamics Corporation, n.d.).

RFID is a microchip that holds only a number (instead of whole data), so it carries a code instead of mobile database, and data associated with that number would be stored in a separate database (RFID Journal, 2005). Passive RFID activated when the signal

emitted by RFID-reader passes through it, and then it transmits its stored information (e.g. an ID number) as a response (Softpedia, 2005). Unique identification allows matching the actual patients to their medical records, and this unique identifier can be used to reveal patient's clinical information that is stored in a secured database to health providers (Levine, Adida, Mandl, Kohane, & Halamka, 2007). In case of Immunization record tracking system, RFID can be embedded in healthcare card and can keep a unique number (e.g. healthcare number) to protect the individual's information.

A previous research shows that integration of barcodes and RFID tags can reduce the risk of medication errors (Sun, Wang, & Wu, 2008). In a study conducted by Department of MIS, National Chung Cheng University and Chung Shan Medical University Hospital, Taiwan, patient ID was kept in the RFID bracelet, and drug package was equipped with barcode; both the patient's information and medication could be read by Personal Digital Assistant (PDA) scanner, and the nurse could accurately identify medications by type, recommended dosage, patient's record and frequency at the unit-dose level. When a nurse performed a drug dispatch procedure, the PDA was used to browse the barcodes on the drug package, and the RFID wristband carried by a patient in order to determine if the medication and the patient are matched. If mismatch occurred during the dispatch procedure, a warning message would be shown to nurse (Sun et al, 2008).

Vaccine manufacturers in Canada committed to voluntarily adopt the barcode standards, and by 2016, all vaccine products in Canada will be required to adhere to the agreed upon standards (Laroche & Diniz, 2012). If barcode and RFID technologies become integrated, there would be a possibility of preventing adverse event following immunization.

5.2.2. Mobile Apps

There is possibility of connecting to this database via cell phone. jQuery is an open source software and a multi-browser JavaScript library that can be used to create UI on mobile phones to browse individuals their records (jQuery, n.d.). The Oracle Application Express Release 4.2 allows developers to build solutions that can run on any mobile platform; some of the new features of APEX 4.2 include Mobile Applications, HTML5 Charts, and Packaged Applications (ORACLE, 2012). Application builder for mobiles provides supports for building mobile web application and each application can include both mobile and desktop application (ORACLE, n.d. *b*). The new release of Oracle Application Express is downloadable from Oracle Technology Network (OTN).

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Appendix A: Current Immunization Registry Status by Province and Territory (Adopted from Guttman et al., 2011)

Current immunization registry status by province and territory

Province/ territory/region	Registry data accessible at the time of a clinical encounter	Data entered in registry within 7 days of vaccine administration	Ability to determine the immunization(s) needed based on appropriate schedules	Ability to identify individuals due/ overdue for immunizations and to send reminder/ recall notifications	Ability to produce immunization coverage reports	Ability to produce personal immunization records	Ability to consolidate all immunization records from multiple providers	Coverage estimates publicly available
Fully functional centralized registry								
British Columbia	✓PH only	✓PH only		✓	✓	✓		✓
Saskatchewan	✓Some limitations due to lack of Internet access in some rural/remote communities	✓		✓Regions only – directed to families for infant/ preschool-age children	✓	✓		✓2-year-old children only
Manitoba	✓	✓PH only		✓	✓	✓	✓	✓
New Brunswick	✓	✓			✓PH only	✓		
Prince Edward Island	✓	✓	✓	✓	✓	✓		
Yukon		✓	✓	✓		✓	✓	
Registry not fully functional								
Alberta	✓Regions only ²	✓		✓Regions only	✓	✓	✓	
Newfoundland and Labrador	CRMS only	CRMS only				✓		
No centralized registry								
Ontario				✓	✓			
Quebec	CLSCs only	CLSCs only	✓	✓	✓	✓	✓	✓
Nova Scotia	ANDS							
Nunavut								
Northwest Territories								
First Nations and Inuit								

²Data only available for children within the same region – no cross-regional access. ANDS Application for Notifiable Disease Surveillance; CLSC Centre Local de Services Communautaires – data available only within and not across each CLSC; CRMS Client and Referral Management System; PH Public health

Appendix B: Letter of Invitation to Participants

(Date), 2012

Dear [Health Provider],

As a graduate student, I am conducting research as part of the requirements for a Master of Science degree in Health Information Science at the University of Victoria. It is being conducted under the supervision of Dr Abdul Roudsari.

As you are a registered nurse, I am asking for your help in evaluating part of the work please. My project involves the design and evaluation of an immunization record model (prototype) that quality of data and user-friendliness of this model requires evaluation.

The evaluation involves me demonstrating the system to you via Skype at your convenient time, for no more than 45 minutes. As you are aware, I have to perform series of tasks and you will explore the different forms and reports that require evaluation and your feedback is requested using the test-script (questionnaire). Participants are expected to complete the 'Test Script' while I am with them on the Skype connection; it is also possible to email me the completed questionnaire later.

Your participation in this research must be completely voluntary and you should not feel obliged to participate if you are recruited on the basis of a classmate relationship with me. Please feel free to let me know if you agree to participate in this research that we schedule system evaluation at your convenient time.

Sincerely Yours,
Elham Sedghi
Email: esedghi@uvic.ca

Appendix C: Participants Consent Form



Health Information Science

IMPLIED CONSENT FORM

Project Title: Design and evaluate a model (prototype) for Immunization Record System in distributed Healthcare

Dear SIR/ Madam,

As a GRADUATE student, I am required to conduct research as part of the requirements for a degree in Master of Health information Science. It is being conducted under the supervision of Professor Abdul V. Roudsari. You may contact my supervisor at (250) 507- 6011.

As you are a professional clinician, I would like to invite you to participate in a study entitled Design and evaluate a model (prototype) for Immunization Record System in distributed Healthcare.

I, Elham Sedghi am a GRADUATE STUDENT in the department of Health Information Science at the University of Victoria and you can contact me if you have further questions by my phone (250) 884-6296 or email me at: esedghi@uvic.ca

Purpose and Objectives

The purpose of this research project is to evaluate the quality of data and the user-friendliness of a model for immunization record system before any further development. Having Professional health provider's evaluation is an asset to ensure the model is accurate and reliable.

Importance of this Research

Research of this type is important because it can

- Reveal Challenges in implementing a centralized immunization record system.
- Provide consistent data dictionary standards to manage immunization terms correctly and free of typo.
- Eliminate paper based record keeping and facilitate record tracking.
- Develop an immunization record system based on Canadian immunization guide to provide consistent set of data usable at any health authority in Canada.

Participants Selection

Participation in this project is entirely voluntary; Health providers are being asked to participate in this study to test and evaluate this model (system); they will be asked to assess the quality of

data and user friendliness of system by filling a test-script (questionnaire). It will be great that participants have experience working in primary care organization or are familiar with the immunization/vaccination process.

Setting

Research will be conducted in Victoria; database and application will be running on UVIC web server and Database resides on Oracle XE; Participants require having access to internet.

Procedure

If you are agree to voluntarily participate in this research, you will be scheduled to be contacted on your convenient time; the researcher will perform series of tasks with the model (system) via Skype and ask you to complete the test-script (questionnaire) while exploring the system. By the end of demonstration, you will be asked to return the completed test-script together with implied consent form to researcher by email. Filling the questionnaire will take almost 35 - 45 minutes of your time.

Risks

There are no known or anticipated risks to you by participating in this research; however, you may withdraw at any point.

Benefits

The potential benefits of your participation in this research is exploring challenges in implementing a centralized immunization record system, providing a data dictionary to support immunization terms correctly, and providing the results that can be useful for related researches; for example, the result of this research can be used in implementing a superior immunization record system for immunization registries and benefit Canadian society by tracking immunization records, eliminating paper-works, and preventing vaccine duplication that all result in public health promotion.

Voluntary Participation

Your participation in this research must be completely voluntary and you should not feel obliged to participate if you are recruited on the basis of a classmate relationship with me. If you do decide to participate, you may withdraw at any time without any consequences or any

explanation. If you do withdraw from the study, your data will not be used and will be completely destroyed.

Confidentiality

Your confidentiality and the confidentiality of the collected data will be protected in this research. All information collected including participant names and any identifying information and your filled questionnaire (the test-script) will be encoded digitally and stored on flash memory in a secure, locked cabinet. The results of this study will be just used for evaluation purpose in this study and will not be used or shared for any other purpose. Collected data will be disposed by the end of research.

Contacts

If you have further question please contact Elham Sedghi by her phone (250) 884-6296 or email address at: esedghi@uvic.ca

In addition, you may verify the ethical approval of this study, or raise any concerns you might have, by contacting the Human Research Ethics Office at the University of Victoria (250-472-4545 or ethics@uvic.ca).

By completing and submitting the questionnaire, **YOUR FREE AND INFORMED CONSENT IS IMPLIED** and indicates that you understand the above conditions of participation in this study and that you have had the opportunity to have your questions answered by the researchers.

Please retain a copy of this letter for your reference

Appendix D: Interview Questions and Test Script

Tester:		Participant Email Address:	
Date tested:		Participant province/City:	
Participant Name:		Years of experience:	

- **Please rate your knowledge of Immunization/Vaccination** :(A. Very knowledgeable, B. Moderately knowledgeable, C. somewhat knowledgeable, D. not very knowledgeable, E. un knowledgeable, F. Do not wish to disclose).
- **Please rate your experience with health information systems.** (A. a lot of experience, B. some experience, C. very little experience, D. no experience, E. Do not wish to disclose).

Columns:

U stands for user friendliness, **Q** stands for Quality of data

*After completion of each step, Please use **P** to indicate **dPass**" and **F** to indicate **"Fail"** under user friendliness (**U**) and Quality of data (**Q**) columns.*

Assess Quick check - Quick Admission form

Test "Quick Check"	Perform following Actions	Expected result	Observation Comments	Pass/Fail	
				U	Q
Step1	Search for patient information by PHN/name (e.g. Smith, 777,...)	If Patient exists, his/her information will be listed. (Search works on PHN or Last name).			
Step2	Create New encounter that doesn't exist in system. (Null PHN, alphanumeric PHN e.g. 123abc , existed PHN e.g. 9124111111 cannot be added)	Insert new Patient information (e.g. 222222222, Foster,18/05/1990) New patient is created with Last name, PHN, and DOB information.			
Step3	Reset the form and click on new created record.	Patient information will be appeared on free textboxes and it's ready to be edited or deleted.			
Step4	Edit Patient information	Patient information will be edited and recorded correctly.			

Q1- Content: This form is designed to quickly add or check patient's information in system. Does this basic information enough to find or add new patient? If not, please explain what needs to be added or modified.

Q2- User friendliness: Is this form easy to be used? If not, please explain how the user interface can be improved in this form?

Assess Patient List

Test "Patient list"	Perform following Actions	Expected result	Observation Comments	(Pass/Fail)	
				U	Q
Step1	Find new created encounter (use search textbox and search by PHN or last name)	Patient will be listed with correct demographic information			
Step2	Click on pen and paper icon to edit patient information. Edit Patient information (e.g. Add Religion, Address, City, Province, Tel#...)	you will be directed to "Patient information" form. When you "apply the changes", the Patient information will be edited.			
Step3	View Patient information (Click on apply changes and you will be directed to patient list)	Patient information is recorded correctly and listed in Patient list.			

Q1- Content: Does this form list the required patients' information? If not, please explain what needs to be added or modified.

Q2- User friendliness: Is this report easy to be used? If not, please explain how the user interface can be improved in this page?

Assess different forms and reports in Library

Data of Immunogen table is captured from <http://www.phac-aspc.gc.ca/publicat/cig-gci/p03-01-eng.php>

Test "Immunogen list"	Perform following Actions	Expected result	Observation Comments	(Pass/Fail)	
				U	Q
Step1	Search for a immunogen or description information	e.g. Inserting DTap in find textbox will fetch Dtap information			
Step2	Create new immunogen that doesn't exist in system (e.g. HPV, Human Papilloma virus)	New record will be added to immunogen library.			
Step3	Choose new created encounter and edit its information.	Information will be edited.			
Step4	Delete the new encounter.	Record will be removed from the system			

Test "Allergy list"	Perform following Actions	Expected result	Observation Comments	(Pass/Fail)	
				U	Q
Step1	search for a substance or category information	e.g. Inserting Food in find textbox will fetch all substances in food category.			
Step2	Create new substance that causes allergy (e.g. add strawberry, with food category)	New substance will be added to allergen library.			
Step3	Choose new substance and edit its information	The information will be modified.			
Step4	Delete the new substance	New allergen will be removed from system			

Data on "Recommended Immunization Schedules" table is designed based on "Canadian Immunization guide": <http://www.phac-aspc.gc.ca/publicat/cig-gci/p03-01-eng.php>

Test "Immunization Schedule"	Perform following Actions	Expected result	Observation Comments	(Pass/Fail)	
				U	Q
Step1	View different immunization for different age group (Choose different age group from drop down list and click "Go")	The immunization information will be sorted for that age group			

Note: all schedules are inserted into the system, but if you want to see the insertion form, click on Create button

Q1- Content: Do the above forms and Reports for Immunogen, Allergy, and Immunization Schedule provide the required information for system library? If not, please explain what needs to be added, modified or removed.

Q2- User friendliness: Are the above forms and reports easy to be used? If not, please explain how the user interface can be improved in any of those forms/reports?

Vaccine information form/reports

This form is designed based on Canadian Immunization Guide - Type and Contents of Vaccines Currently

Approved for Use in Canada: http://www.phac-aspc.gc.ca/publicat/cig-gci/pdf/avtables_revised0803-eng.pdf

Test "Vaccine Information"	Perform following Actions	Expected result	Observation Comments	(Pass/Fail)	
				U	Q
Step1	search for a specific vaccine information	e.g. Insert Avaxim in find textbox will fetch information of this vaccine			
Step2	Create new vaccine that doesn't exist in system (e.g. Vivotif)	New record will be added to Vaccine library.			
Step3	Add Immunogen(s), potential Allergen(s), and Other Materials for new vaccine	Information will be added.			
Step4	View new vaccine information	Record is updated together with immunogen, allergens, and other materials			
Step5	in "Vaccine and Immunogen" report, choose vaccine for specific Immunogen (e.g. Typh-I)	Vivotif vaccine will be listed.			
Step6	Modify new vaccine information (click on edit icon beside Vivotif vaccine and modify its properties)	Vaccine information will be edited			
Step7	Delete new vaccine information	Vivotif vaccine will be deleted and its immunogen and allergens will be deleted from child tables.			

Q1- Content: Does this form list the required Vaccine information? If not, please explain what needs to be added or modified.

Q2- User friendliness: Do the two of reports easy to be used? If not, please explain how the user interface can be improved in for each of reports?

View different schedules and recommended vaccines for different age group

"Immunization Records"	Perform following Actions	Expected result	Observation Comments	(Pass/Fail)	
				U	Q
Step1	Click on Sara Smith, click on immunization record tab (she is <7 years old)	Her age is calculated (years and months) & Routine immunization is viewed for her age			
Step2	Click on recommendation tab.	Immunogen(s) that has be given via vaccine is listed in left report			
		List of immunogens that has not been given is available in the right report.			
		Recommended vaccines for those immunogens that have not been given are listed in another report.			
Step3	In Patient list, click on James Bond, click on immunization record tab (he is an adult, >=18 years)	His age is calculated (years and months) & Routine immunization is viewed for his age			
Step4	Click on recommendation tab.	Immunogen(s) that has been given via vaccine is/are listed in left report			
		List of immunogen(s) that has not been given is available in the right report.			
		Recommended vaccines for those immunogens that have not been given are listed in another report.			

Q1 Content- Does this data help health providers to manage the vaccination better?

Q2- User friendliness: Are these reports easy to be used? If not, please explain how the user interface can be improved for each of reports?

Immunization Record

Add new allergy for new patient

Add new vaccine for new patient

Test vaccine adverse function

"Immunization form"	Perform following Actions	Expected result	Observation Comments	(Pass/Fail)	
				U	Q
Step1	Find new created encounter and click on PHN Link	Patient Information, list of allergies, ... Will be appeared.			
Step2	Add new allergy for that patient.(e.g. Neomycin)	New allergen will be added to the list of allergies for patient.			
Step3	Click on immunization tab	you will see patient information together with the recommended immunization schedule			
Step4	Modify patient age (via patient list>pen-paper icon), then view immunization schedule again.	Different immunization schedule will be viewed.			
Step5	Add new immunization record for this patient, click on immunization tab, click on create (e.g. Avaxim, HA)	Neomycin is a potential allergen in Avaxim and this patient has allergy to Neomycin; system will send an alert.			
Step6	Give another vaccine (e.g. Act-HIB) Act-HIB is for Hib immunogen; choose another immunogen.	System will send an alert (vaccine and immunogen are not related)			
Step7	Give Act-HIB with right immunogen (Hib)	New immunization record will be stored in system and viewed to health provider.			
Step8	Edit the immunization record (e.g. Add reaction)	The record will be edited.			
Step9	Delete the immunization record	The record will be deleted.			

Q1 Content- Is this data helpful for health providers? If not, please explain what needs to be added, modified or removed.

Q2- User friendliness: Are the form and report to create/modify/delete immunization record easy to use? If not, please explain how the user interface can be improved?

Security

Connect as nurse (e.g. Pat) and check the system options then log off.

Connect as Secretary (e.g Joe) and check the system options then log off.

Connect as patient with PHN (e.g. 9124000000) and check the patient record information then log off.

"Immunization form"	Perform following Actions	Expected result	Observation Comments	(Pass/Fail)	
				U	Q
Step1	Connect as Registered Nurse	You should be able to see two navigators in left hand side; on first navigator, you access to patient information			
Step2	Connect as Secretary	You will see two navigators with limited links in left hand side. (you are not able to access patient Medical information)			
Step3	Connect as specific patient	You are just able to browse that patient information			

Q1- Content- Does this security level help to protect immunization information?

Q2- User friendliness: Are these navigators and links easy to be used by different users? If not, please explain how the user interface can be improved for each level of access?