

# Fully Automated Wait Time Report Generator for Nova Scotia Breast Screening Program

by

Husam Alqatami  
B00541303  
[ahusam@cs.dal.ca](mailto:ahusam@cs.dal.ca)

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Nova Scotia Breast Screening Program,  
603L-7001 Mumford Rd  
Halifax, NS, B3L 2H8  
Canada

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This report has been written by me and has not received any previous academic credit at this or any other institution.

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## Executive Summary

In Canada, breast cancer is the most common type of cancer to afflict women. Although late stages are difficult to treat, prognoses for earlier stages are quite promising. Early detection is of paramount value in the eradication of the disease. This is reflected in the importance of screening tests as they have been shown to improve the outcomes for women with breast cancer.

Due to the fact that breast cancer is so common, waiting lists for screening and diagnostic procedures can become lengthy. Managing these queues has become a priority in the quest for achieving early detection in women with this affliction. Some methods of managing wait times are generally unsatisfactory and prone to exaggeration. Wait time management through manual methods is time consuming and in many cases unstandardized. Other automated methods incorporate databases with archaic design that lead to faulty results. To combat this, the proposed solution in this paper is to use a better designed database structure and to integrate proper statistical and graphical methods for the calculation and management of wait times. To make this solution possible, a series of open source softwares were chosen. Open source programs were used for their ease of access, effectiveness and easy migration between platforms.

The open source applications used for this project were Caisis, which is a database management system; R, which is a statistical analysis program; and Latex, which is a document preparation system. These three applications were used to construct an automatic report generator. This solution generates wait time reports in a time efficient manner from multiple sites spanning multiple time periods. The effect of these reports will hopefully lead to more efficient wait time management and ultimately contribute to the eradication of a lethal affliction that has haunted women the world over.

This project would not have been possible without the consistent effort put forth by the author's partner and teammate, Mr. Abdulhadi Habash. His contribution to the project was immense and integral in its completion. All aspects of the project were performed in tandem between the author and Mr. Habash.

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# 1. Introduction

Cancers are perhaps among the most feared medical ailments of our time. Cancer is a disease that starts off on the cellular level. The afflicted cells reproduce at an uncontrolled rate, leading to the formation of lumps or tumors. Some afflicted cells may travel along the blood or lymphatic systems and manifest as tumors in other body sites [1].

According to the World Health Organization, cancer is among the leading causes of death worldwide. It accounted for nearly eight million deaths in 2007. Cancer mortality is expected to rise to an astounding 12 million worldwide deaths in 2030 [2].

In Canada, it is estimated that in 2011 nearly 180,000 new cases of cancer will be diagnosed [3]. It is also estimated that 75,000 deaths will be attributed to cancer that same year [3]. More than half of these cases can be attributed to cancers of the lung, prostate, colorectal and breasts [3]. The highest incidence of cancer in women is attributed to breast cancer [3]. It trails in mortality rates only behind lung cancer [3]. This type of cancer occurs primarily in women between the ages of 50 to 69 but the highest death rates happen to women above the age of 80 [3]. This perhaps reflects the importance of early detection and treatment in prolonging the life of a cancer patient [3].

Like many other types of cancer, early detection of breast cancer can mean the difference between life and death. Cases of breast cancer that are detected early are easier to treat and involve shorter times of recovery. Early detection is also associated with higher survival rates [4]. Screening for breast cancer has proven to an effective method of early detection. Health Canada has recognized that screening for breast cancer decreases mortality by 40% [5]. They also found that screening is the best and cheapest method of early detection in cases of breast cancer [5].

Due to the fact that early detection is so crucial in the successful treatment of breast cancer, reducing wait times is essential to this process. People waiting for necessary medical procedures are subject to often lengthy wait times. The long wait time may impede on the early detection and the subsequent treatment of breast cancers [6]. This requires more efficient ways of measuring and reporting wait times. As it stands, the methods for doing this are archaic and time consuming. The measurement of wait times and report generation for multiple sites may take days to complete and the whole process is resource heavy.

The author and his teammate Mr. Habash have decided to handle this issue by analyzing wait times in a more efficient manner to assist in the process of reduction.

## 2. The Organization

This project was performed in conjunction with the Nova Scotia Breast Screening Program (NSBSP). This program was first established in 1991 by the Nova Scotia Department of Health. Its initial objective was to reduce the mortality of breast cancer among Nova Scotia women aged 50-69 years through the early detection of the disease by offering information on breast health and mammography. The aim was to reduce the mortality rate by 30% within 10 years following the development of the province wide screening program [7].

In August 1994 the NSBSP launched a mobile breast screening project which offered modified clinical breast examination and breast health information at all sites. The project has served

women in the Eastern, Western and Northern regions of Nova Scotia. Nowadays, the breast screening program is also implemented in all ten provinces and two territories in Canada.

A key function of the NSBSP is the Central Mammography Booking (CMB). This takes care of screening and diagnostic mammography appointments for women in Nova Scotia by managing all bookings through one call center [7].

### **3. The Internship Work**

As mentioned, all mammography bookings are handled by NSBSP in Nova Scotia. A system called Mammography Information System (MIS) is used to manage bookings for screenings, while diagnostic procedures are managed through another system called Diagnostic Reporting System (DRS). These two systems were written using an archaic programming language rendering them both difficult to use for data retrieval. The information contained within these systems is stored in a flat, non-relational table format. As it stands at the moment, only one person has the knowledge required to manage them. On top of that, a rigorous process of statistical analysis must be implemented in order to make use of any data gained. Report generation, such as the wait time report, can take as long as ten business days to complete. The long duration needed to generate these reports is an inefficient method that is also resource hungry. It may also lead to the introduction of errors in the workflow since no standard way has been introduced yet.

As part of a solution to this problem, a new database called Caisis was introduced. Caisis is a web based cancer data management system that was initially created with the aim to improve data quality and accuracy, as well as to help reduce clinicians' time and effort when summarizing and documenting patients' histories. It is an open source database management system that allows the use of additional software such as R, Latex and Structured Query Language (SQL). In terms of security, Caisis was designed and built with a standalone security that exceeds those of many current guidelines. Since Caisis is web based, the costs and staffing requirements are notably less than client server applications and other systems [8].

The migration of data from MIS and DRS to Caisis is currently underway. This is a relatively easy task due to the fact that Caisis uses enterprise level technologies such as ASP.Net and SQL Server [8]. Our proposed solution involves the use of R, Latex and SQL in conjunction with the new Caisis system to generate faster reports.

#### **3.1 Workflow**

Before formulating any solution, the author had to familiarize himself with the actual workflow. This was done by visiting the NSBSP central site in Halifax. All workflow processes starting with answering the phone all the way to the actual booking procedures were observed and noted. A session regarding the entire program was attended. At the end of the visit, the author gained a better understanding of the work processes inherent in the NSBSP.

#### **3.2 Working with Caisis**

After the familiarization with the workflow of the NSBSP, the author had to learn to use Caisis. The process of installing Caisis consumed more than a dozen steps and took more than an hour

to complete. The installation guide can be found in the Appendix A. After the initial step of installing Caisis, the author had to learn how to modify it. This modification could only be done with a programming language called C#. This is the same language Caisis was developed in [8]. The author had no prior experience with C#. A number of video tutorials on how to program using C# were accessed through YouTube [9-12]. These tutorials proved to be extremely beneficial in the process of learning how to use C# as a programming language.

Once a better understanding of C# was gained, the data dictionary and entity relationship diagram which can be seen in Appendix B were studied in depth. This gave the author a thorough understanding of the functionality of Caisis as a database management system.

### **3.3 Mapping of MIS and DRS Data to Caisis**

Due to the fact that the structures of MIS, DRS and Caisis are fundamentally different, the same data is stored differently between all systems. This was overcome by using a program called Talend Open Studio [13]. This program was used to map data from MIS and DRS to the corresponding tables in Caisis. The author was given a copy of Talend Open Studio to serve as a mapping guide for Caisis.

A number of entities were not mapped during the initial data migration. The private contractor who was responsible for the data migration thought that some of these entities weren't important. These were subsequently mapped following a suggestion made by the author.

### **3.4 R and Latex**

In addition to learning the inner workings of Caisis, the author had to familiarize himself with two additional programming languages. These were R [14] and Latex [15]. R is a programming language used for statistical analysis. It is an open source application that is considered to be a leading statistical data analysis tool. R was chosen for its flexibility as it can be integrated with other languages, data sources such as open database connectivity (RODBC) and statistical packages such as SAS and Stata [16]. For the scope of our solution, R is used in conjunction with Statistical Process Control (SPC) which is a package within R that analyzes the variability inherent in a process to ultimately achieve and maintain a state of statistical control [17]. The use of SPC has shown significant progress in the areas of wait time monitoring [18] and healthcare [19-20]. To gain a better comprehension of SPC, the author attended four study sessions during which the analysis of a book called "Mastering statistical process control: a handbook for performance improvement using cases" by Tim Stapenhurst was undertaken [17]. These study sessions were provided by the author's supervisor and they took place at the Radiology Research Office in the Victoria General Hospital in Halifax.

Latex is a programming language used for document preparation. It can be used across multiple platforms [21]. The author used it to generate the report templates.

As with Caisis, the author had no prior experience with any of these programming languages. A number of video tutorials [22-24] and educational documents [25-27] were accessed to gain a better understanding of the inner workings of these programming languages.

R, Latex and C# programming languages were selected by the author's supervisor prior to starting the internship.



### 3.5 Wait Time Indicators

Following the initial visit to the NSBSP and the careful analysis of the mapping guide, the author gained an in-depth view of the workflow processes. Among these are the wait time indicators. In the past wait times were calculated prospectively based on available time slots for appointments. To lessen the resulting wait time indicators, clerks would intentionally reserve appointment slots at the end of the months when the measuring took place. When the actual measuring takes place, the reserved timeslots would be considered to be available time slots. Thus the resulting wait times would be falsely shorter than they really were.

To overcome this bias, wait times are now measured retrospectively by calculating the times waited between key events in the procedural timeline [7]. Table 1 details the indicators used to calculate wait times. Explanation of the acronyms can be found in Glossary & Nomenclature.

Wait Time Name	P90 National Target (Days)	Comments
Screening	90	Date of Call to Date of Screen; First-Time Screens; All Fixed Sites excl. QE
Work-up	35	Date of Abnormal Screen to Date of Work-up; All Fixed Sites excl. DG, CQ & HC
Screen to Report	14	Date of Screen to Date of Final Report; All Sites (Fixed & Mobile)
Report to Work-up	21	Date of Final Report to Date of Work-up; All Fixed Sites excl. DG, CQ & HC
Diagnostic	14	Date of Contact to Date of Diagnostic Mammo; Urgent & Semi-Urgent Cases; All Fixed Sites excl. DG, CQ & HC
Image to Core	N/A	Date of Last Related Imaging Procedure (Mammo, U/S) to Date of Core; All Fixed Sites excl. DG, CQ & HC
Screen to Core	49	Date of Abnormal Screen to Date of Core Biopsy; All Fixed Sites excl. DG, CQ & HC
Core to Surgery	Unknown	Date of Core Biopsy to Date of Surgery

**Table1:** List of Wait Time indicators, along with their national target and definition

### 3.6 SQL Queries for Wait Time Indicators

In the past wait time indicators were calculated by extracting the data from DRS or MIS in the format of database files. These files were put under a rigorous process of statistical analysis using SAS. This process could take anywhere from 10 days to 2 weeks to complete.

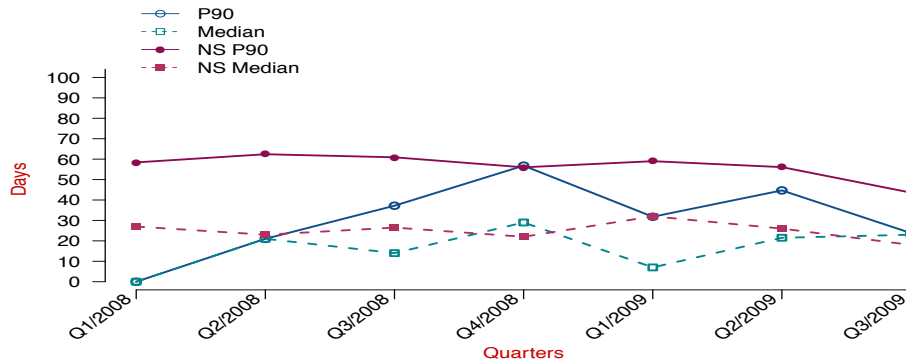
After the data migration to Caisis, this long process can be achieved in a fraction of the time by using SQL queries along with the programming languages R and Latex.

The amount of queries for the new system needed was astonishing. Each indicator as well as each site needed its own query. Along with all the indicators detailed in the above table, there were 12 sites to contend with. The data dictionary had to be consulted continuously throughout the formulation of the queries. This was done to determine which fields in the database corresponded to which indicators.

To check the viability of the queries, the results were checked against these obtained by the older, manual process that involved the use of SAS.

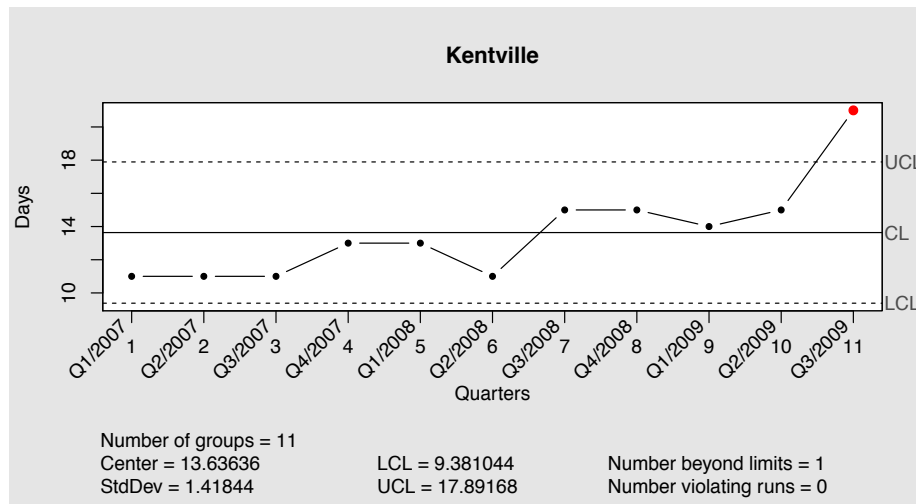
### 3.7 Statistical Processes and Graph Generation

The results of the above mentioned queries are fed into R using RODBC [27]. R calculates the median and the 90<sup>th</sup> percentile (P90) for each quarter of the years under scrutiny. These statistics are then presented in line charts, an example of which can be seen in Figure 1.



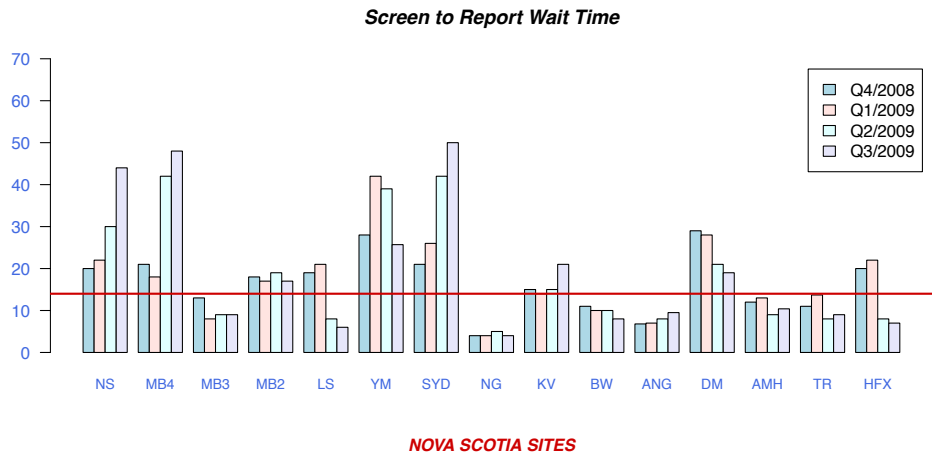
**Figure 1:** Wait Time line chart for Amherst site. Median and 90<sup>th</sup> percentile for the site as compared to the total in NS is presented.

As a quality control measure, SPC is applied to the resulting statistical data to produce a control chart. This is a chart that determines if the wait time range is under statistical control. This is accomplished by determining the upper and lower boundaries of wait times for each site and indicator. This is not an indication of outlying statistical behavior but rather a range where the outputs are considered statistically probable. An example of a statistical control chart can be seen in Figure 2.



**Figure 2:** SPC chart for Kentville site. The red dot indicates that the process is out of control.

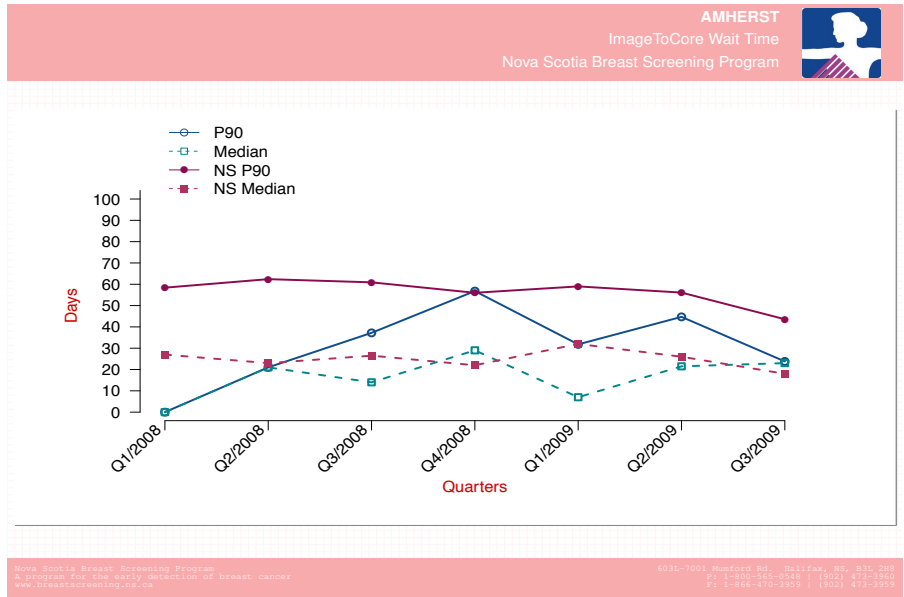
Another chart produced by R is a bar chart detailing the last four quarters for each site against their wait times. This gives a comparative overview between sites and acts as a performance indicator in regards to wait times. An example of this chart can be seen in Figure 3.



**Figure 3:** Bar graph that gives a comparative overview between sites. Red line is the National Target

### 3.8 Latex

The data provided by the analysis in R is passed to Latex. The data is injected into a preapproved template to generate the final PDF. This PDF can be customized dynamically to display wait times based on indicator as well as region, an example of which can be seen in the Figure 4.



**Figure 4:** Image to Core Wait time report for Amherst site.

## 4. Results

The end result of all the previously mentioned steps was a solution called the Wait Time Report Generator (WTRG). This is a set of codes written in C#. The user-friendly interface is a panel that accepts arguments entered by the user. These arguments are passed to a batch file. This

batch file passes the arguments such as user name, password, indicator, site and time period to the remaining sets of code. It also determines the end PDF file name and storage location. The first code receives input from the batch file and runs the queries in R using ODBC. The results of the query are passed to the proper Latex file that corresponds to the users arguments. The Latex file, acting as the second set of codes generates a PDF file according to the naming convention and storage location defined by the batch file. This PDF is read in C# and displayed to the user. Because a picture is worth a thousand words, a diagram of this process can be seen in Figure 5. Examples of R codes, Latex codes and a batch file can be seen in the Appendix C.

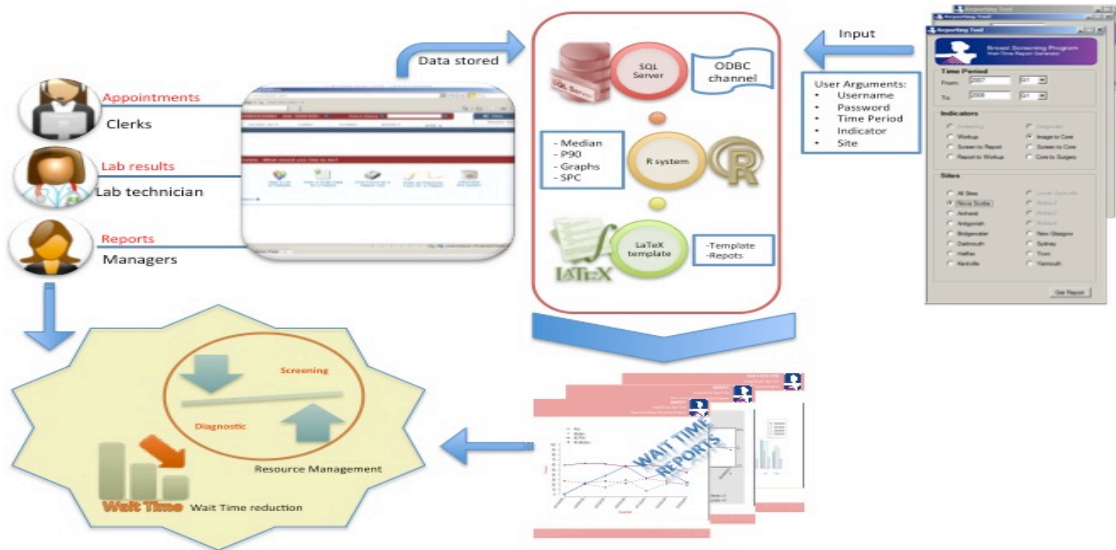


Figure 5: WTRG model

Even though Caisis is an open source code, the author had limited access to implement this solution within the web interface. The codes written by the author were created as a separate desktop application that can be easily integrated in Caisis by someone who has the proper access. This step should be easy since Caisis is a C# based language as is the author's code sets.

## 5. Role Distribution

The knowledge and skills required to complete this project were of two types, medical and programming. The medical aspect was useful in the defining of indicators, dissection of workflows and attribute selection. The programming skills were necessary for coding, mapping and software design.

Even though the author's skills were more technical in nature and Mr. Habash possessed the medical knowledge, the workload was split between the two in equal parts. The benefit of the two different backgrounds was evident in the fact that both parties complimented each other in terms of the skills required.

This dichotomy was seen on a larger scale in the actual work arena. The communication gaps between clinical and technical staff were apparent. This gap is a hindrance to the advancement of

health informatics solutions. Overcoming this gap proved to be a valuable learning experience for the author during the internship period.

## **6. Delivery**

Once the project deliverables were completed, a delivery presentation was conducted by the author. This presentation took place on the 10<sup>th</sup> of August 2011 at the Radiology Research Office in the Victoria General Hospital in Halifax. The major stakeholders were in attendance including the NSBSP Program Director, Program manager, pathologists, researchers and health informaticians.

The feedback received regarding the presentation was positive. The deliverables were deemed acceptable and the implementation was imminent. A copy of the acceptance letter can be seen in Appendix D.

## **7. The Intended Users**

The WRTG was intended to be used by anyone who is involved in the NSBSP. There are three main users to the WRTG. The first user is the program manager, who is involved in resource management and performance evaluation. These evaluations are site specific and based on wait time indicators such as ‘report to workup’ and ‘abnormal screen to report’. These indicators are chosen for evaluation purposes due to their nature. They measure parameters that are directly affected by staff performance. The second types of users are the site personnel. These range from clerks to site managers, all of whom are responsible for the reduction of wait times as well as site-specific resource management. The third and final types of users are patients themselves. Because wait times are published online on the Nova Scotia Government website [28], patients with access to the Internet may choose where they wish to be booked based on this information. Not all wait time indicators are published online since some of them are only to be used by the site manager and/or personnel. The names of the indicators that are published may differ from the ones created in the WTRG to make it easier for the patients to understand the terminologies.

The machines used for screening and diagnostics are the same. Most sites usually have only one machine. Appointments for using it for one process may exceed those for the other process. This is where the resource management aspect comes in. The program manager, as well as the site manager utilizes the data from the WTRG to actively find a balance by manipulating appointments until the bias is corrected.

As for the wait time reduction, this is usually due to the same issue. One type of process is booked more than the other, which causes increased wait times for the patients in the overbooked category. To combat this, the data gained from WTRG can be used to find a balance for bookings that ultimately reduce wait times. This was seen with the previous system that was done manually. A noticeable improvement in performance was graphed for a site after they received a wait time report determining their performance to be inadequate. An example can be seen in Figure 6.

QTR	Median	Median (NS)	p90	p90 (NS)
Q3 2009	11	19	20	53
Q4 2009	8	15	19	53
Q1 2010	6	8	20	31
Q2 2010	12	8	29	24
Q3 2010	22	20	51	55
Q4 2010	14	17	20	47
Q1 2011	6	19	27	83
Q2 2011	11	15	23	100

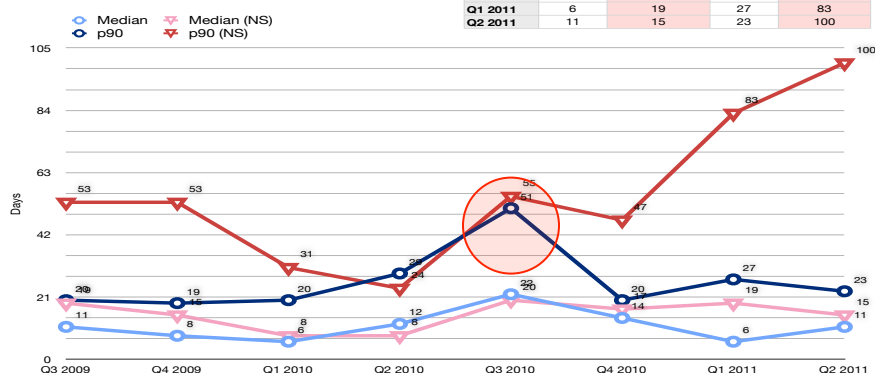


Figure 6: Wait Time is reduced after report was first introduced in Q3 2010 for Amherst site.

## 8. Challenges

Due to the fact that the whole process is lengthy, a number of challenges had to be overcome. These are:

- The database data dictionary was immense and data intensive. The dictionary contained more than 470 entities. The author had to sift through them all several times to determine which ones were needed for the SQL queries.
- Some of the entities that were needed for the queries could not be found in the Caisis data dictionary but were present in MIS and DRS. These entities had to be mapped in order to find and utilize them. This issue was raised to the private contractor who was responsible for the initial data migration. The author worked closely with the contractor to map these entities that were not mapped to begin with.
- The author had limited time to learn multiple programming languages. Although the experience gained through learning these languages was immense, the actual learning process was arduous.
- The issue of connectivity between SQL, R, Latex and C#. These four languages provide limited interoperability. Getting the results from one to be read into another involved a lengthy process. Getting the SQL results to be compatible with R was done by a package called RODBC. Results from R that needed to be read in Latex were converted by a package called Sweave [25]. The resulting PDF had to be read in C#.

## 9. Relation to Health Informatics

Due to the complex nature of the proposed solution, the project cycle took a multitude of steps to be completed. These steps had to be coordinated and planned out so as to reduce redundancies and errors. The skill applied to the process to ensure this was project management. The author implemented various project management techniques to planning, building, testing and delivery

processes. The planning table and a useful guide for the WTRG can be seen in Appendices E and F.

The proposed solution utilizes the concept of data visualization in the pursuit of resource management and the reduction of wait times. The reports generated by WTRG provide a graphical representation to the program manager that allows easier management of resources according to trending needs between screening and diagnostic. The same reports can serve as a motivation for site personnel to reduce wait times by initiating better booking procedures. Since the report exhibits statistics from all sites, the improvements take on a competitive tone. This competitive aspect insures better wait time management.

Another health informatics aspect this solution fulfills is the concept of standardization, which was given in Health Information Flow and Standards course. The flexibility of Caisis has led to it being implemented across multiple provinces in Canada such as Nova Scotia, Newfoundland and Northwest Territory. Other provinces such as New Brunswick, Prince Edward Island and recently British Columbia have shown a keen interest to implement it in the near future. If this is achieved, a standardized method of breast screening will be created across the nation. The Caisis database is flexible enough to be customized at the users' end and any new templates created through R and latex can be integrated and modified easily while still maintaining the same standard structure between sites. Another factor contributing to the standardization inherent with the use of Caisis is that it is designed to include new modules that can be easily shared due to the fact that they are open source.

## 10. Conclusion

While working on this project, the author implemented various skills to achieve the required results. Some of these skills had to be learned for the sake of the project while others were already within the grasp of the author. All in all, the process of completing this project, with all the inherent challenges it posed rendered the internship period highly educational. The entire experience was a series of lessons, some of which are detailed in the following points.

- The initial planning phase required close work with the Radiology Department in the Victoria General Hospital in Halifax. The author gained a detailed understanding of the inner workings of a functioning radiology department as well as the breast screening program.
- A large portion of the work performed was made possible for the fact that all software used such as Caisis, R and Latex are open source. This led to the realization that working with open source software is easier and leads to better productivity.
- The author had to learn 3 new programming languages. Their application will exceed the scope of this study and prove to be invaluable in future endeavors.
- One lesson learned from this project is that people will often be adept at working in sub optimal conditions without seeking a solution such as the one proposed in this paper. Change can only happen once the solution is introduced by an interested party and seldom sought after by the majority of people involved in the actual work process.

## 11. Recommendation

During the process of completing the work required for this project, the author noticed a couple of points in the workflow that need addressing. These points may be addressed by a few suggestions. These recommendations are detailed in the following points.

- As it now stands, the only person with the required knowledge to manage wait times between screening and diagnostic patients is the NSBSP Program Manager. The proposed suggestion to remedy this is the acquisition of the manager's tacit knowledge to construct a case based reasoning decision support system that may be used in lieu of the manager's expertise. The cases can be built by recording each transaction the manager has with the system in terms of time periods, sites, indicators and how the problem was addressed as well as the outcome. Over time, a sufficient number of cases may be reached to act as a knowledge base for the decision support system.
- To ensure consistently better outcomes, a system of incentives may be introduced. This will create a competitive aspect that will lead to improvement and ultimately reduced wait times and better resource management.
- Although the system generates a number of reports by accessing statistical data within the database, a number of additional templates can be added to generate other types of reports as well. For example, educational reports that can be sent to family physicians or patients. These reports would be generated in much the same way, by accessing information in the database, analyzing it statistically with R and presenting it in a visual format with Latex.



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# APPENDIX A: Caisis, R and Latex Installation Guide

Note: Husam Alqatami, Abdulhady Habash and James Wills prepared this installation guide

## Installation of CAISIS and R/LaTex

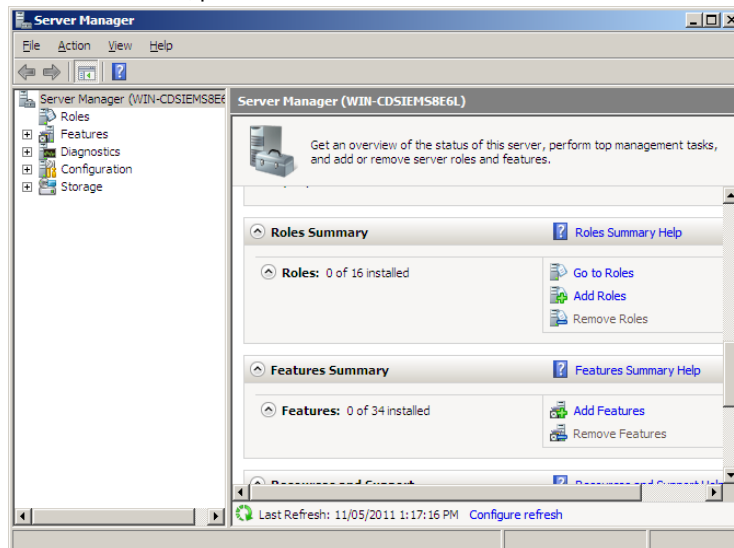
### Windows Server

Installed Version: 2008

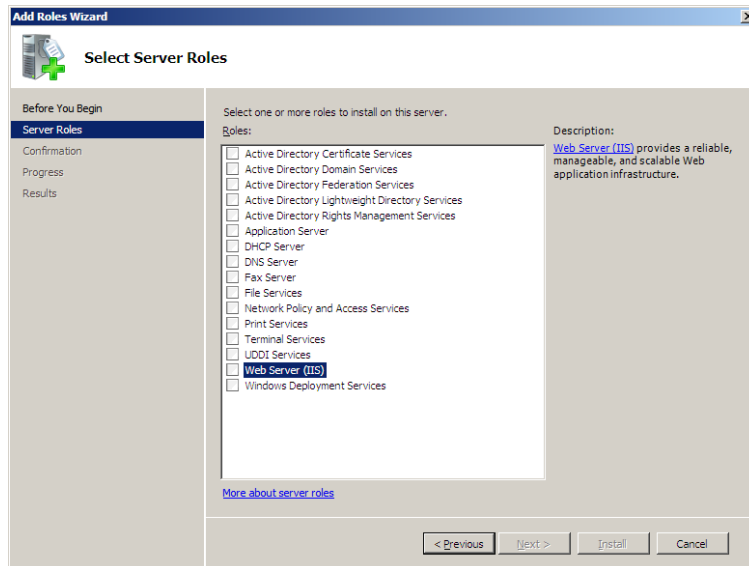
Installed using default options on CD and enabled Windows Update to install latest updates.

### Internet Information Server (IIS)

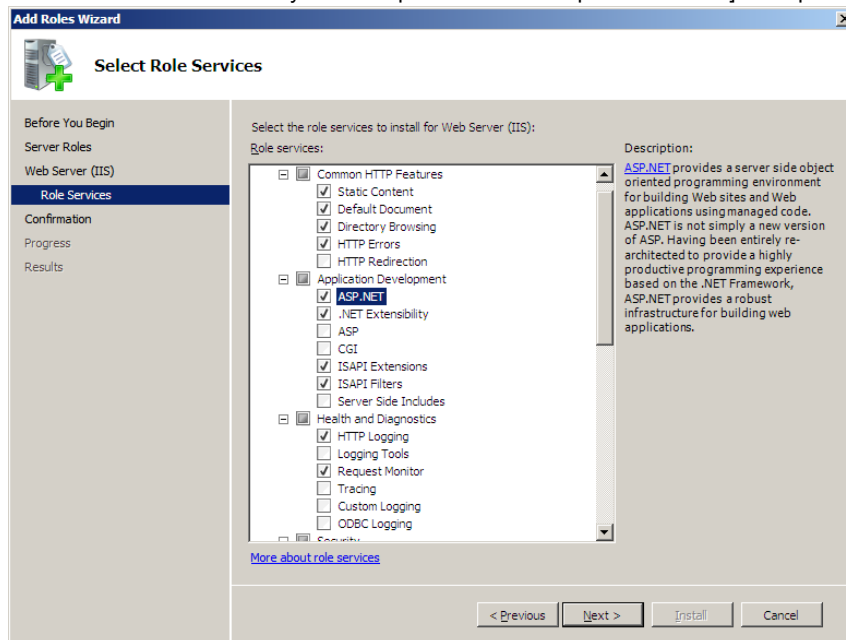
1. Click **Start**, point to **Administrative Tools** and then click **Server Manager**.



2. In **Roles Summary**, click **Add Roles**.



3. Use the **Add Roles Wizard** to add the Web server role. [JW - Added ASP.NET and .NET Extensibility and accepted additional required modules.] Accept and install.



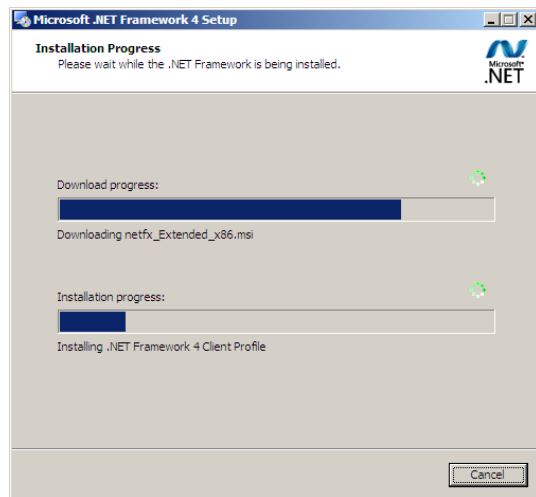
Confirm that IIS has installed correctly by opening an Internet browser and browsing to http://

localhost. The IIS main screen should be displayed.

## Microsoft .NET Framework

Installed Version: 4 Full

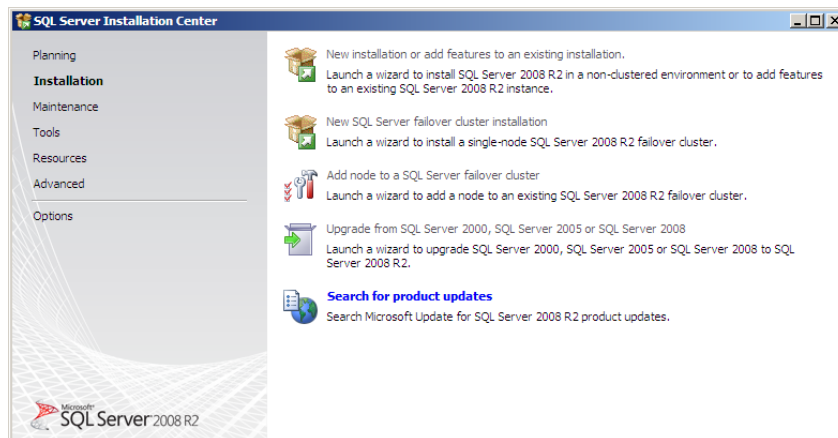
Download and install from Microsoft Website.



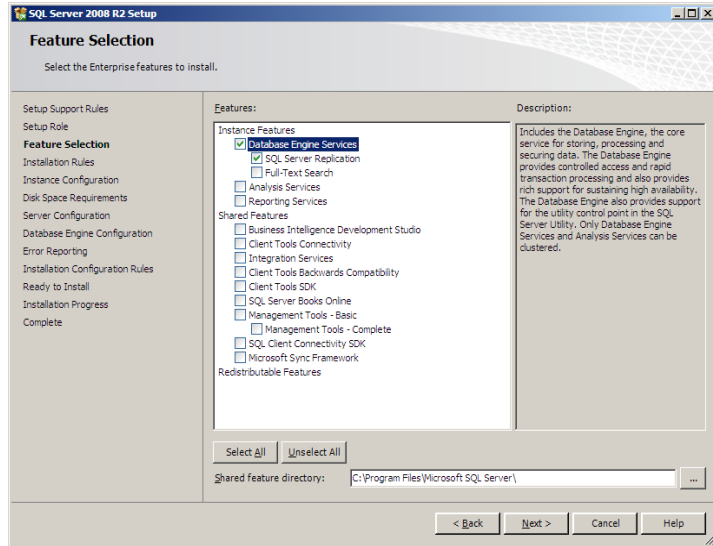
## SQL Server

Installed Version: 2008 R2

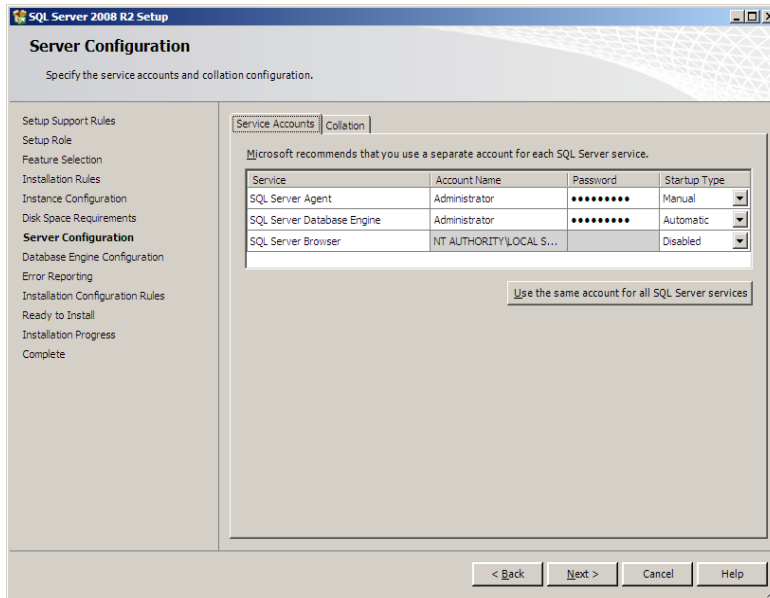
1. Run setup.exe and click OK to install prerequisites. This may download and install the .NET framework v3.5 SP1. A restart may be required.
2. Select "New installation or add features to an existing installation."



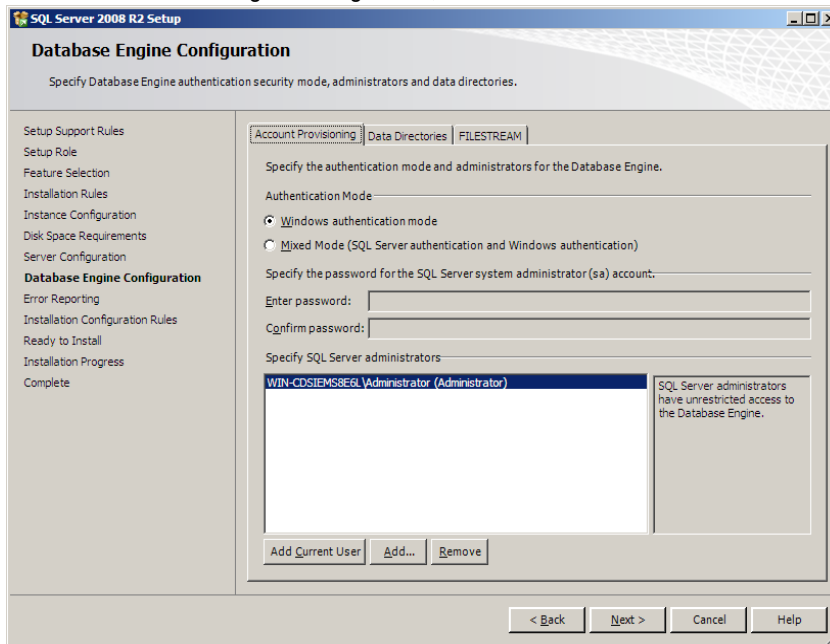
3. Enter the product key, accept the license agreement, and click Install to continue.
4. Click Next for "Setup Support Roles" and "Setup Role".
5. For Feature Selection, click Select All.



6. Continue pressing Next with the default options until reaching Server Configuration. Choose a user account to use for each service (eg. Administrator) and enter the password for the user account.



7. For Database Engine Configuration, click Add Current User before continuing.

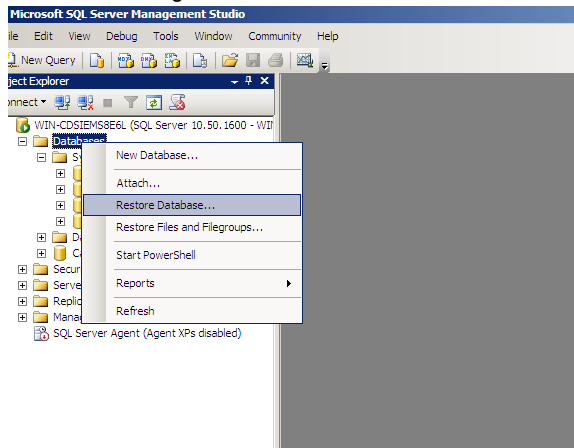


8. Continue with the remainder of the default options and click Install.

9. Download and install SQL Server Management Studio Express from the Microsoft Website.

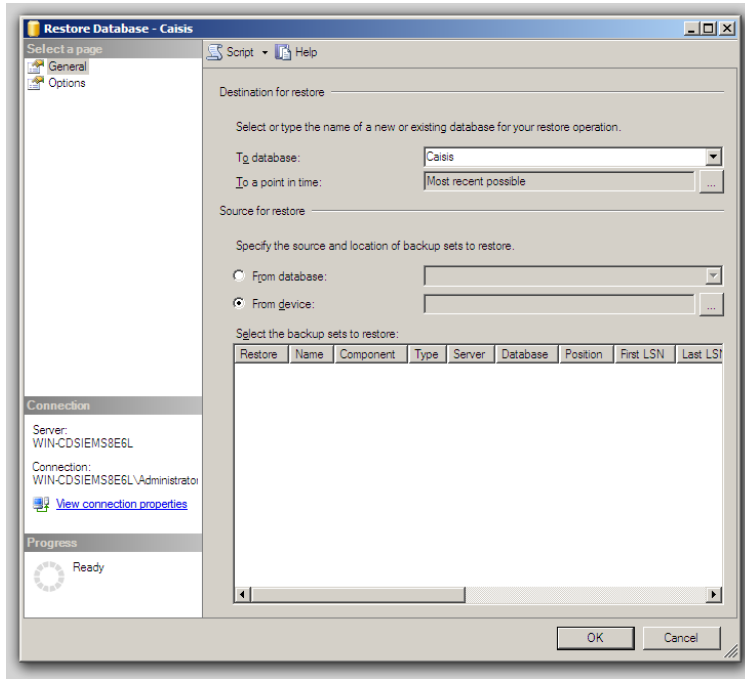
## Import of NSBSP Database

1. Open SQL Server Management Studio and create a new CAISIS database following the instructions on the CAISIS wiki: [http://www.caisis.org/wiki/index.php?title=Installation#New\\_5.0\\_Database](http://www.caisis.org/wiki/index.php?title=Installation#New_5.0_Database) Stop after the caisisweb login has been created.
2. Right-click on Databases and click Restore Database. Note: If there are any active connections, they may have to be dropped by bringing the database down before continuing.

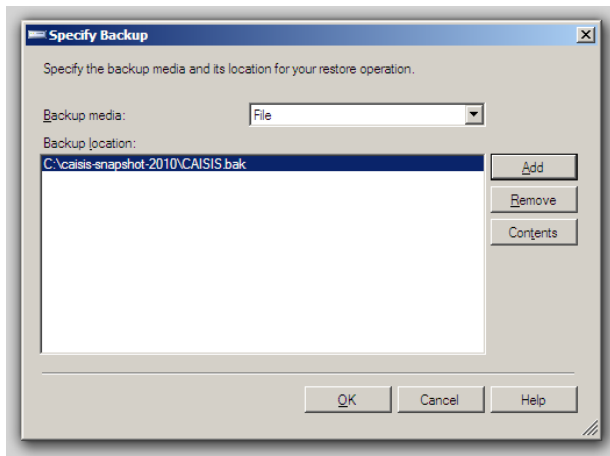


3. Select CAISIS as the "To database" and "From device". Click on the button next to the From device field to select the file to restore.

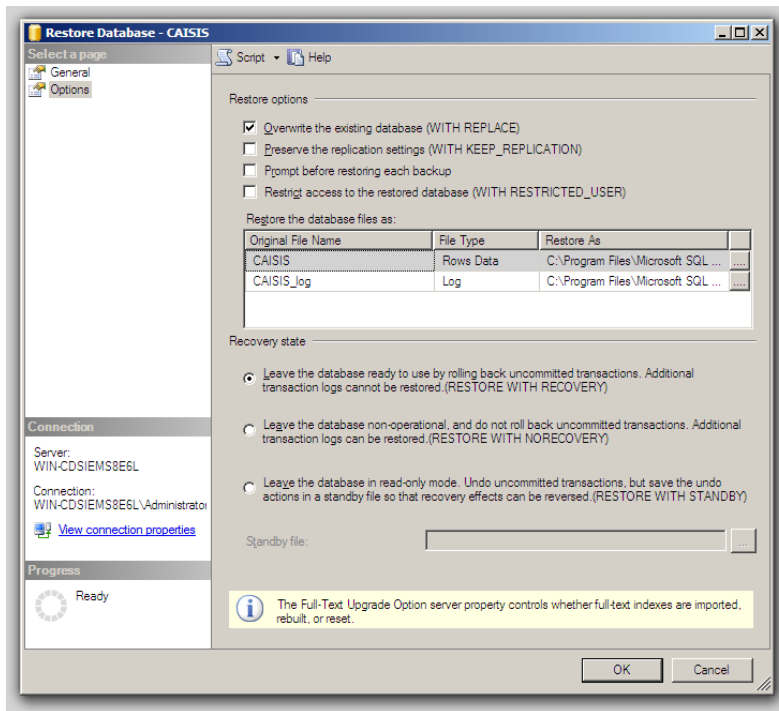




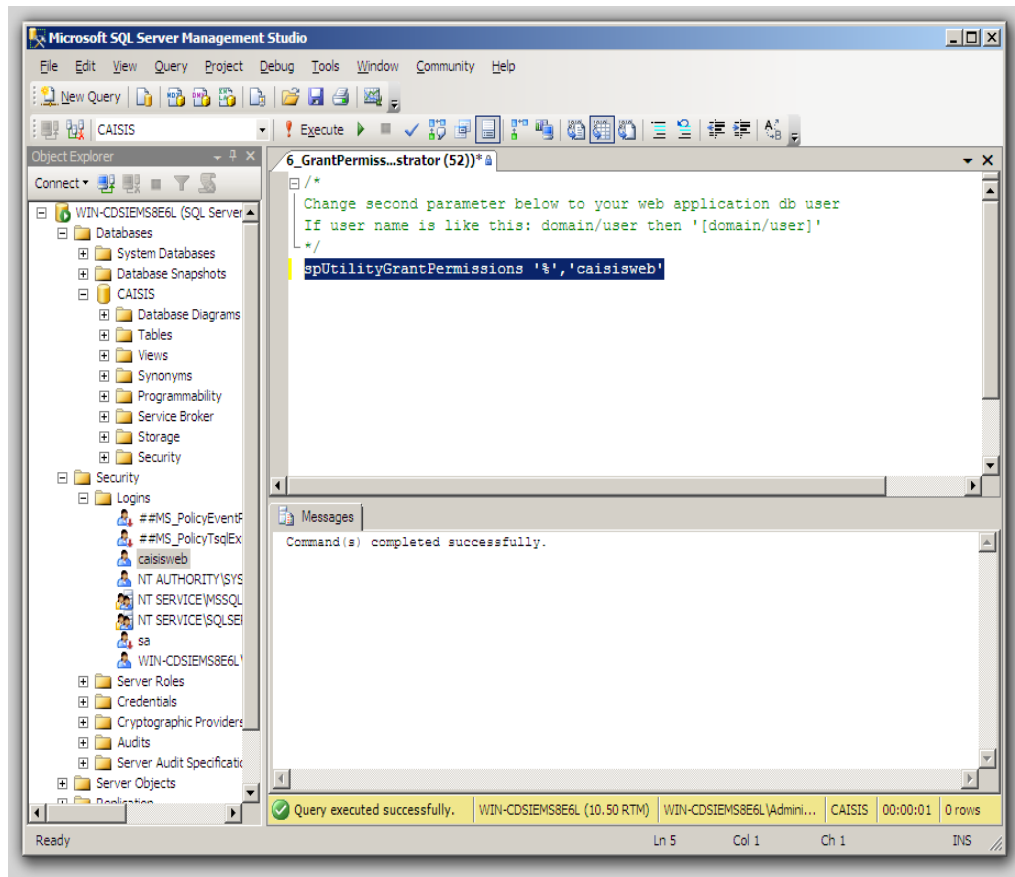
4. Click Add and navigate to the .bak file containing the snapshot of the CAISIS database. Click OK.



5. Click on Options and click "Overwrite the existing database." Click OK.



6. Run the final SQL script in the CAISIS installation folder for the user you created. That is, run the command `spUtilityGrantPermissions '%', 'caisisweb'`



## CAISIS UI

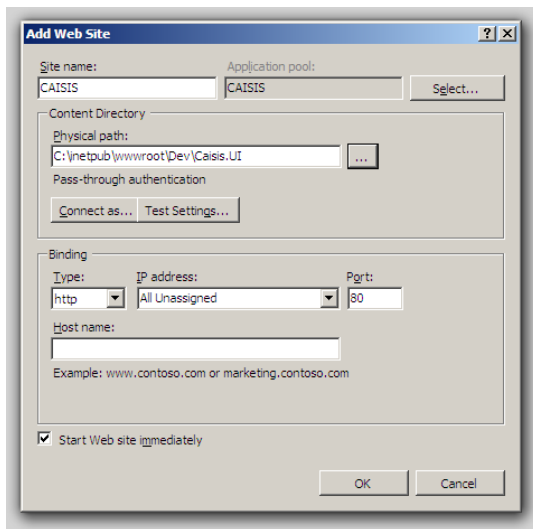
Installed Version: as customized by Stephen

1. Extract files provided by Stephen to C:\inetpub\wwwroot (if this doesn't exist you will have to revisit the IIS installation).
2. Edit the line in the file C:\inetpub\wwwroot\Dev\Caisis.UI\web.config as follows:
 

```

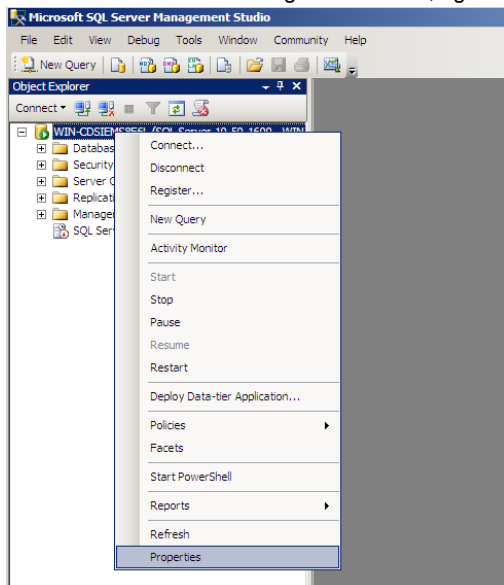
<add key="dbConnectionString"
value="SERVER=yourcomputename;DATABASE=CAISIS;PWD=caisiswebpw;UID=caisisweb;persist security info=True;packet size=4096;"/>

```
3. Open IIS Manager. (Control Panel -> Administrative Tools -> Internet Information Services (IIS) Manager).
4. Expand the "Sites". You will see the Default Site. Right click on this and remove it.
5. Right-click Sites and click Add Web Site.
6. Configure the CAISIS site as shown below:



7. Click OK to start the website.

8. In SQL Server Management Studio, right-click the server and click Properties.



9. On the Security tab, choose SQL Server and Windows Authentication Mode.

10. Click OK.

11. Right-click on the server again and select Restart.

12. You should be able to browse to <http://localhost> and log in to CAISIS. **Note:** You may

need to adjust your Windows Firewall settings to prevent other computers on your network from connecting to the CAISIS website you are hosting.



## R

Installed Version: 2.13.0

Used downloaded installer and accepted default options.

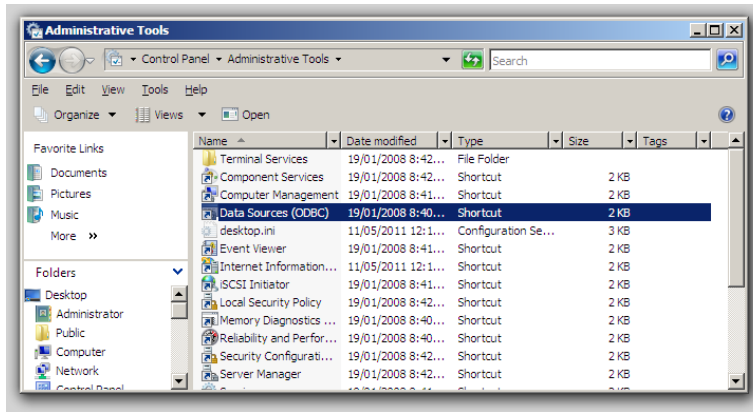
Additional packages installed:

- RODBC
- spc
- mnspc

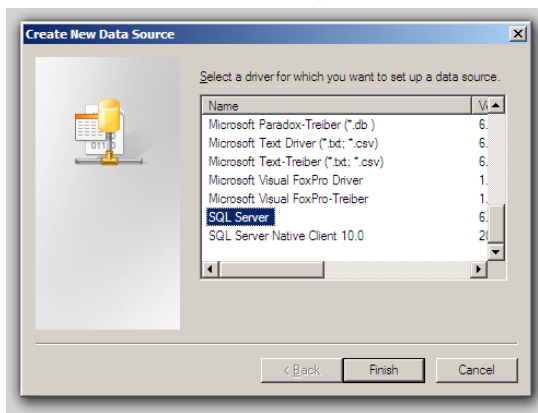
### ODBC Connection

An ODBC connection must be configured for R to access the CAISIS database.

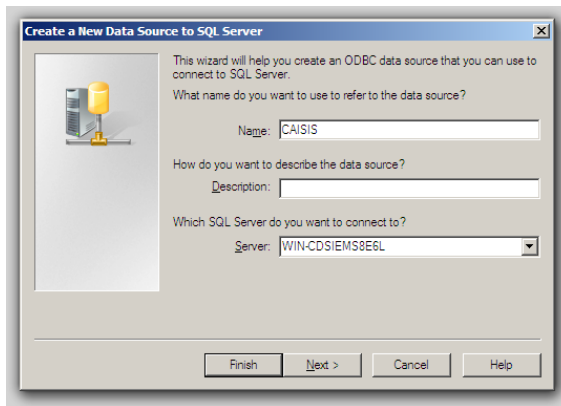
1. First, create a new login for the R ODBC connection using the same process that was used to import the NSBSP database.
2. Open the Data Sources (ODBC) from Control Panel -> Administrative Tools.



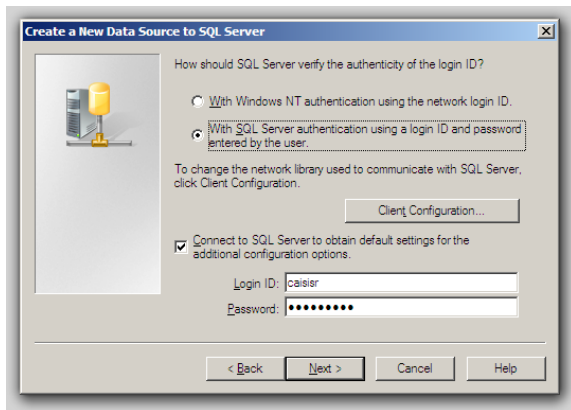
3. Click Add and select SQL Server.



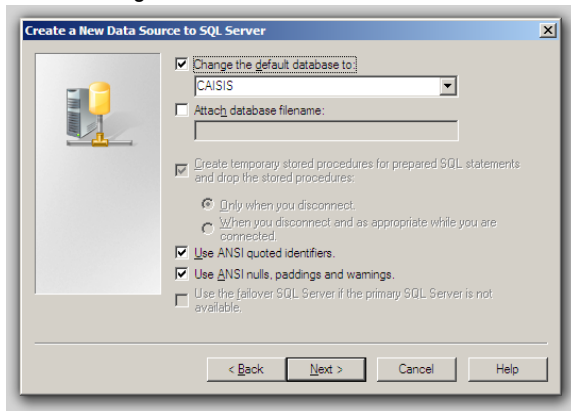
4. Call the data source CAISIS and enter the name of the computer as the Server.



5. Use SQL Server Authentication and use the new login created above.



6. Change the default database to CAISIS. Click Next and Finish.



## ProTeXt

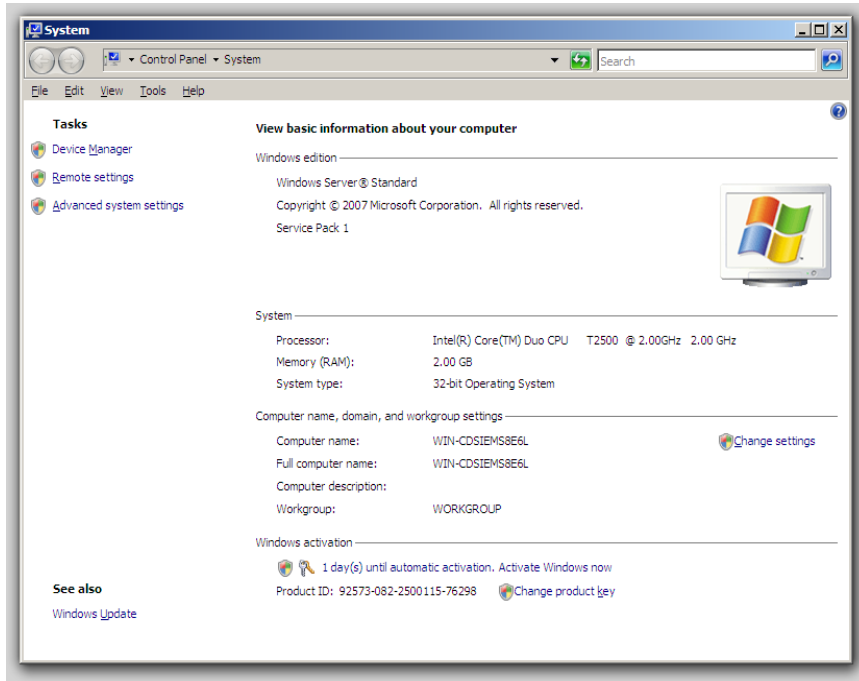
Installed Version: MikTeX 2.8.3541

Used downloaded installer and accepted default options.

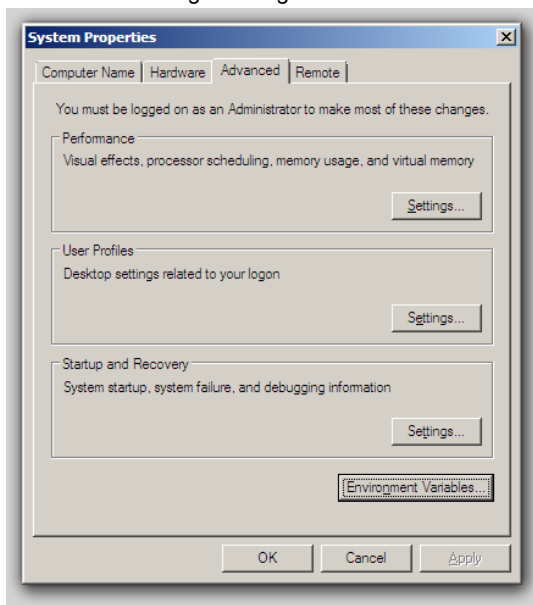
## Finishing Up

There are a few final steps necessary to be able to generate reports:

1. Add the R path to the Windows Path variable. This allows R to be run from any windows directory. Open the System console (Control Panel -> System).

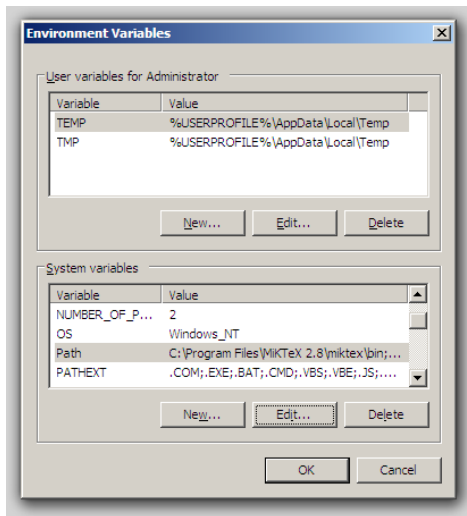


2. Click Change Settings and select the Advanced tab.



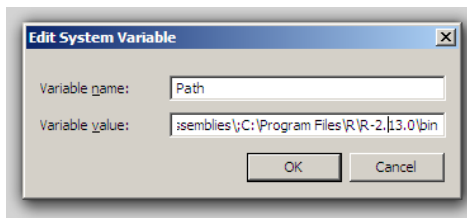


3. Click Environment Variables.



4. In the second list, Edit the Path variable.

5. Scroll to the end of the value and add a ';' and the path of the R bin directory.



6. Now, copy the Sweave.sty file to the folder where you will be processing the Sweave documents. If you used the standard installation, Sweave.sty can be found in *C:\Program Files\R\R-2.13.0\share\texmf\tex\latex*

7. The environment should now be ready to process Sweave files. For example, the following file, caisis.Snw, can be processed into a pdf with two commands:

```
> R CMD Sweave caisis.Snw
> pdflatex caisis.tex caisis.pdf
```

```
% caisis.Snw
% This example query is not necessarily correct.

\documentclass[a4paper]{article}

\SweaveOpts{echo=true}

\begin{document}

<<echo=false,results=hide>>=
options(SweaveHooks = list(fig = function() par(mfrow=c(2,2))))

library(RODBC)
channel <- odbcConnect("CAISIS", uid="caisisr", pwd="yourpwd", case="tolower")
z <- sqlQuery(channel, "select * from diagnostics where DxType = 'Screening' and
DxResult <> 'Normal' and DxDate > '2009-01-01' and DxDate < '2010-01-01'")
odbcClose(channel)
@

There were \Sexpr{length(z$DiagnosticId)} abnormal screenings in 2009.

\end{document}
```

# APPENDIX B: Caisis Entity Relationship Diagram

(Please zoom in to see more details in this diagram – Diagram from Caisis website)



## APPENDIX C: R, Latex and Batch Snapshot

```
ScreenToReport_RCodes.R
checkEmpty <- function(arg)
{
  if (length(arg$TOTAL) == 0)
  {
    arg = rbind (arg, data.frame(TOTAL = "0", waitTime = 0, QuarterNumber = 0, YEAR = 0 , Id = 0))
  }
  return(arg)
}

library(RODBC)
library(qcc)

channel <- odbcConnect("Caisis", uid=user, pwd=pass, case="tolower")

Prove <- sprintf("select Cast(B.YEAR As VARCHAR (8)) +''+CAST(B.QuarterNumber as VARCHAR(8)) as TOTAL, B.WaitTime, B.QuarterNumb

PR <- sqlQuery(channel, Prove)

PR = checkEmpty(PR)

Prov1 = aggregate(PR[,2], list( PR[,1]),quantile, probs = c(.90))

Prov3 = aggregate(PR[,2], list( PR[,1]),median)

Prov <- data.frame(i = 1:length (Prov1$x), Prov1$x)

Prov5 <- data.frame(i = 1:length (Prov3$x), Prov3$x)

Prov2 = aggregate(PR[,2], list( PR[,3], PR[,4]),quantile, probs = c(.90))

pdf(file = "C:\\LatexReports\\Library\\Style\\bin\\NS.pdf", heigh=4.3, width=8)
```

R snapshot

```
Latex_ALCodes.R
latexReport = paste(latexReport , "\\vfill", sep=" \n");

latexReport = paste(latexReport , "\\begin{block}{}", sep=" \n");

latexReport = paste(latexReport , "\\centering", sep=" \n");

latexReport = paste(latexReport , "\\includegraphics[width=1.0 \\textwidth]{../bin//All.pdf}\\par", sep=" \n");

latexReport = paste(latexReport , "\\end{block}", sep=" \n");

latexReport = paste(latexReport , "\\vfill", sep=" \n");

latexReport = paste(latexReport , "\\end{frame}", sep=" \n");

latexReport = paste(latexReport , "\\title {COMMENTS PAGE}" , sep="\n");

latexReport = paste(latexReport , "\\begin{frame}{\\LARGE Comments:}", sep=" \n");

latexReport = paste(latexReport , "\\end{frame}", sep=" \n");

latexReport = paste(latexReport , "\\end{document}", sep=" \n");

write(latexReport, file = reportFile);

command = "pdflatex";
command = paste(command, reportFile, sep=" ");
system(command);

file.remove(list.files(pattern=".aux"));
file.remove(list.files(pattern=".log"));
file.remove(list.files(pattern=".nav"));
file.remove(list.files(pattern=".toc"));
```

Latex snapshot

```

echo ##### Input Parameters #####
echo year ^<^ - %1 > data.R
echo year1 ^<^ - %2 >> data.R
echo Indicator ^<^ - ^"%3^" >> data.R
echo ins ^<^ - ^"%4^" >> data.R
echo user ^<^ - ^"%6^" >> data.R
echo pass ^<^ - ^"%7^" >> data.R
echo yearq ^<^ - %8 >> data.R
echo year1q ^<^ - %9 >> data.R
echo ##### Input Parameters #####
echo save.image(^"%4%,Rdata^") >> data.R
del C:\Users\Administrator\Desktop\Reports\%3\%4%3%1%2.pdf
R CMD BATCH data.R
R CMD BATCH C:\LatexReports\RCodes\%3_RCodes.R
R CMD BATCH C:\LatexReports\LatexCodes\Latex_%5.R
del /Q *.RData *.Rout *.R
del C:\LatexReports\Library\Style\RData
del C:\LatexReports\Library\Style\bin\*.pdf
del C:\LatexReports\LatexCodes\*.Rout
del C:\LatexReports\RCodes\*.Rout
XCOPY C:\LatexReports\Library\Style\*.pdf "C:\Users\Administrator\Desktop\Reports\%3%"
del C:\LatexReports\Library\Style\*.pdf
goto :done
:done
echo Report generated.
echo on
:end

```

Batch file snapshot

## APPENDIX D: Acceptance Letter

Nova Scotia Breast Screening Program  
603L - 7001 Mumford Rd.  
Halifax, NS B3L 2H8  
P: (902) 473-3960  
F: (902) 473-3959  
www.breastscreening.nshealth.ca



---

August 22, 2011

Dr. Grace Paterson, PhD  
Assistant Professor, Health Informatics  
Room 2L-C2 Tupper Building, Dalhousie University  
Halifax, NS, Canada B3H 4H7

**Subject: Husam Alqatami's Internship**

Dr. Paterson,

This letter is to indicate that Husam Alqatami has completed all requirements for his internship with the Nova Scotia Breast Screening Program (NSBSP). Husam's focus and dedication to his internship proved to be extremely valuable for the NSBSP. His work will become a major part of a valuable tool used on a regular basis at the NSBSP.

If you have any questions or would like to discuss the NSBSP's experience with MHI interns, please do not hesitate to contact me.

Sincerely,

Theresa Foley  
Program Manager  
Nova Scotia Breast Screening Program  
603L - 7001 Mumford Rd  
Halifax, NS B3L 2H8  
P: (902) 473-3956  
F: (902) 473-3959

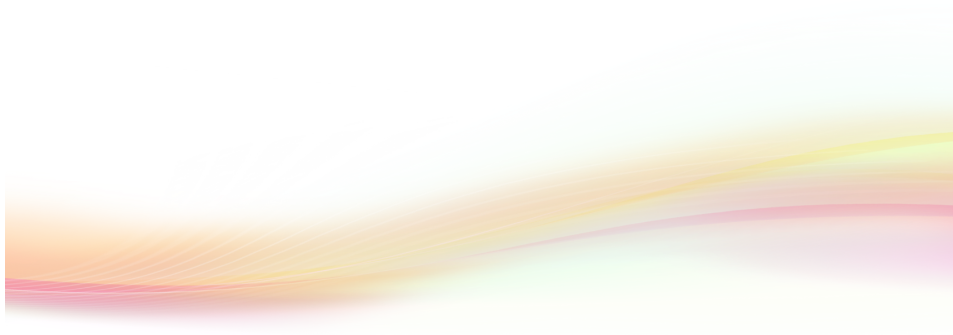
## **APPENDIX E: Plan Table**

# Wait-Time Reporting for NS Breast Screening Program

## **Plan Table**

### **Submitted by:**

Abdulhady Habash  
Husam Alqatami



## Plan Table

<b>Tasks</b>	<b>Start Date</b>	<b>Objectives/ Deliverables</b>	<b>Duration</b>
Planning	May 9	<ul style="list-style-type: none"> <li>• Download and get familiar with software (R + Latex)</li> <li>• Familiarity with database</li> <li>• Weekly meetings with Ryan or whenever meeting is needed</li> </ul>	10 days
Requirement definition	May 20	<ul style="list-style-type: none"> <li>• Define application type (Web App. Or Desktop App).</li> <li>• Define performance indicators</li> <li>• Define national targets</li> <li>• Define software-programming language.</li> <li>• Define the way to connect the results from R system with Latex</li> </ul>	20 days
Programming	9 June	<ul style="list-style-type: none"> <li>• Select needed parameters from database</li> <li>• Define needed statistical methods and apply them on the data</li> <li>• Draw graphical representation of the results</li> <li>• Prepare report template</li> <li>• Flag abnormal results in the report</li> </ul>	30 days
Integration & testing	10 July	<ul style="list-style-type: none"> <li>• Finalize software prototype</li> <li>• Test the software and compare the results with previous reports done manually by Ryan</li> <li>• Present the software to the supervisors.</li> <li>• Collect feedback</li> <li>• Apply feedback if need it</li> </ul>	25 days
Installation & acceptance	5 August	<ul style="list-style-type: none"> <li>• Deliver final edition of the system and install it on hospital system</li> <li>• Showcase</li> <li>• Deliver final report</li> </ul>	14 days

# APPENDIX F: WTRG User Guide

## Wait Time Report Generator-User Guide

Reporting Tool

User Name:  Password:  Test Connection

Time Period

From:  To:

Indicators

Screening  Diagnostic  
 Workup  Image to Core  
 Screen to Report  Screen to Core  
 Report to Workup  Core to Surgery

Sites

All Sites  Lower Sackville  
 Nova Scotia  Mobile2  
 Amherst  Mobile3  
 Antigonish  Mobile4  
 Bridgewater  New Glasgow  
 Dartmouth  Sydney  
 Halifax  Truro  
 Kentville  Yamouth

Get Report

- Enter user name and password that were created in step "ODBC Connection" In Installation guide
- Password is case sensitive
- Press on "Test Connection" button
- A message box will determine whether connection test passed or not.

Reporting Tool

Breast Screening Program  
Wait Time Report Generator

Time Period

From: 2007 Q1 To: 2008 Q1

Indicators

Screening  Diagnostic  
 Workup  Image to Core  
 Screen to Report  Screen to Core  
 Report to Workup  Core to Surgery

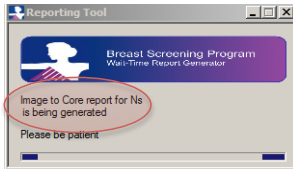
Sites

All Sites  Lower Sackville  
 Nova Scotia  Mobile2  
 Amherst  Mobile3  
 Antigonish  Mobile4  
 Bridgewater  New Glasgow  
 Dartmouth  Sydney  
 Halifax  Truro  
 Kentville  Yamouth

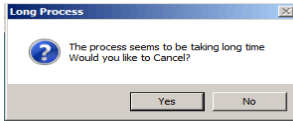
Get Report

- 1- Enter start and end year and quarter time period.  
Notes:
  - Starting year can't be less than 2007
  - Time period has to include at least 4 quarters.
- 2- Screening and Diagnostic indicators aren't working yet. Modification to database has to be made in order to enable them.
- 3- Core to Surgery indicator doesn't work properly because there isn't enough data yet in database. (Don't use it on sample data)
- 4- Choose "All Sites" to generate one report for all sites, or pick individually if needed.
  - Note that you can pick only one option at a time

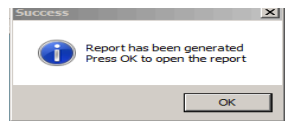




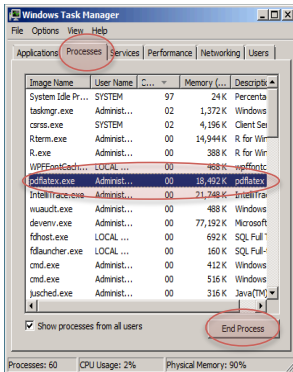
- Name of indicator and site will be displayed on loading page.
- Please **Do Not** close this form if you need to cancel the process. Process will be still working in the background and it might slow your PC.



- If the process is taking long time (more than 3 minutes), Long Process message will appear in case user wanted to cancel.



- Once report is generated, a success message will appear
- Press OK button to open report.
- Reports will be saved in "Reports" folder in the Desktop.



- In rarely occasion, if the program is not acting normal and taking more time than usual, please follow these steps:
  - o Hold ctrl+ alt and press delete
  - o Choose "Start Task Manager"
  - o Click on Processes tab
  - o Find "pdflatex.exe"
  - o Click on End Process button
- Success message might appear, please close it.

## **Glossary & Nomenclature**

**NSBSP.** Nova Scotia Breast Screening Program

**CMB.** Central Mammography Booking

**MIS.** Mammography Information System

**DRS.** Diagnostic Reporting System

**SQL.** Structured Query Language

**RODBC.** Open Database Connectivity for R

**SPC.** Statistical Process Control

**SAS.** Statistical Analysis Software

**P90.** 90<sup>th</sup> percentile

**QE.** QE II Health Centre

**DG.** Dartmouth General

**CQ.** Cobequid Health Centre

**HC.** Halifax Clinic

**Mammo.** Mammogram Procedure

**U/S.** Ultra Sound Procedure

**Core.** Core Biopsy

**WTRG.** Wait Time Report Generator

## Declaration

I, the undersigned, hereby declare that the work contained in this report is my own original work and has not previously in its entirety or in part been submitted at any university for a degree.

\_\_\_\_\_  
Husam Alqatami

\_\_\_\_\_  
Date