CAPITAL HEALTH: FORECASTING DEMAND BEYOND POPULATION GROWTH OF MRI / CT / ULTRASOUND

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Authors: Allison Bouthillier
Amanda Meleshko
Peter Wares

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EXECUTIVE SUMMARY

Over the last several years, the demand for and use of diagnostic imaging has been increasing at a rapid rate in the Capital Health Region. Some of this increase in demand can be attributed to a growing population and changing demographics; however, many of the other factors are less obvious and more difficult to measure. Our goal was to analyze these "other" variables in order to predict their future effect on demand for CT, MRI and US in the Capital Health Region.

Our first stage consisted of both qualitative and quantitative data collection. The factors that we outlined as being the most significant to our project were:

1. **Changes in market share** – Decreases in demand due to machines in other regions
2. **Supply-induced demand –** Increases in demand due to increases in supply
3. **New technologies -** Improvement in technology for CT, MRI and US machines
4. **New treatments -** The development of new procedures and uses for CT, MRI and US machines
5. **Increasing affliction rates -** If Albertans are seeing more injuries or disease per capita
6. **Changing physician behaviours** – Changes in physician attitudes, standard of care, etc.

Due to time constraints and data availability, we were able to perform analysis on four of six factors. The effect of changes in market share was analysed by comparing the rate of Capital Health CT scans provided to residents of the Aspen Health Region before and after they acquired three CT machines. We found that this reduced the amount of Aspen Health Patients coming to Capital Health by close to 30%. A beta test to determine a relationship between change in waitlist times and change in demand failed to produce a clear conclusion, leading us to believe that the relationship is obscured. We calculated a comparison of the number of scans performed per patient over time, which indicated that the number of MRI scans per patient was decreasing while the number of CT scans per patient was increasing. These could be the result of new technology in that less repeat scans are required due to clearer images, but more abnormalities requiring a new scan are found due to higher quality. As well, an analysis of the use of different categories of scan as a percentage of total diagnoses of the corresponding type enabled us to determine an adoption pattern for Cardiac MRI. We found that it took approximately 5 years for it to reach is saturation point, and we think Cardiac CT and Breast MRI will have similar adoption patterns.

Through our qualitative and quantitative analysis, we were also able to rank each factor according to their perceived impact on growth of demand.

PROJECT BACKGROUND

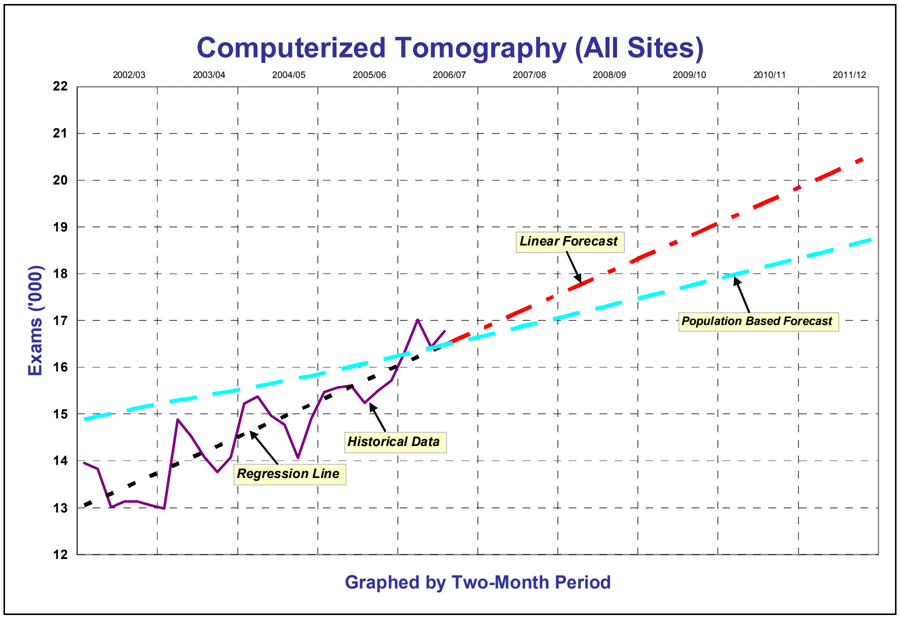
Alberta's Capital Health Region consists of five major and nine smaller sites and serves a population of approximately 800,000 people both within the region (Edmonton and area) and those referred from other regions. Its Regional Imaging Services provides diagnostic, therapeutic and interventional procedures for patients. Of the 8 modalities that perform these services, we were given the task of focusing on only 3 of them: MRI, CT and Ultrasound.

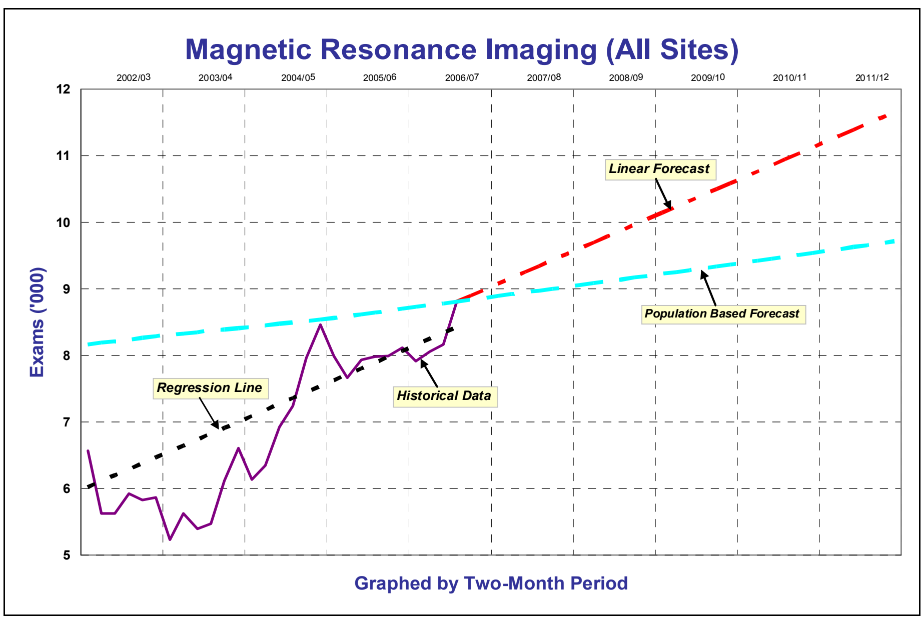
At a value of 40, Alberta has the highest rate of MRI exams per 1,000 population in Canada. The steady increase in volume demanded is raising widespread concerns due to ever growing waitlists for MRI, CT and the start of a concern for US waits. Capital Health feels pressure to improve their services due to physician and public expectations and provincial and federal waitlist targets. With a valid forecast, Capital Health can decide on the appropriate measures to take to begin reducing these long waits, such as adding more machines, increasing the hours of operation of the current machines and doing more outsourcing. Currently, Capital Health has 5 MRI units, 8 CT units and 45 US units.

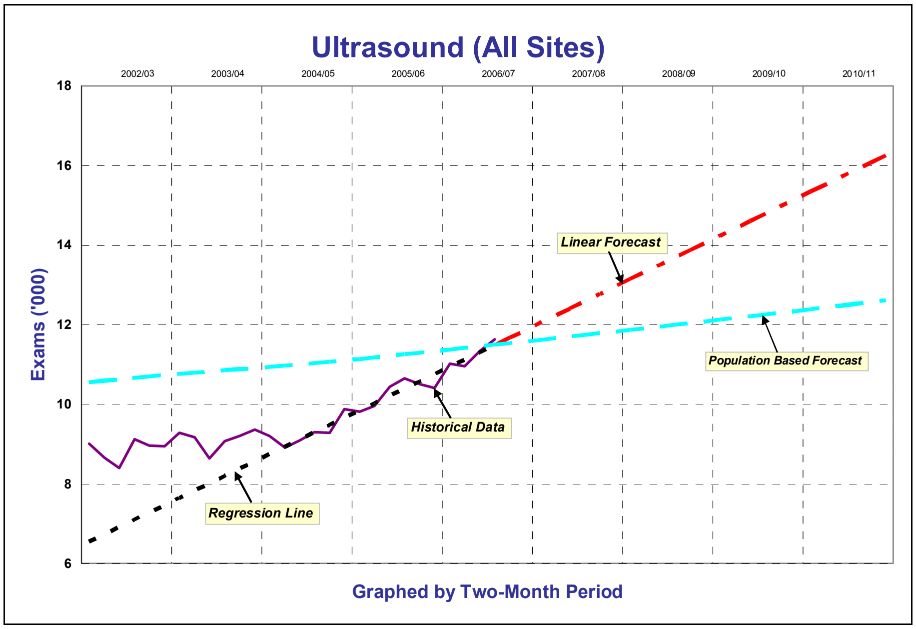
PROBLEM AND SCOPE

Over the last several years, the demand for and use of diagnostic imaging has been increasing at a rapid rate in the Capital Health Region. Some of this increase in demand can be attributed to a growing population and changing demographics; however, many of the other factors are less obvious and more difficult to measure. Our goal was to analyze these "other" variables in order to predict their future effect on demand for CT, MRI, and US in the Capital Health Region. The following (***figure 1***) is a graph of the historic number of scans performed for CT, MRI and US in the Capital Health Region (the purple line), as well as a population-based forecast line (the blue line) as provided to us by Capital Health. While the number of scans performed is affected by many factors such as funding and staff availability, the slope of this line can be considered a rough approximation of an increasing demand due to mounting pressure to increase supply as wait times increase. The black line is a regression of the historical data, indicating the increasing rate of scans, and the red line is an extrapolation of this rate into the future. This red line begins above the black for MRI because Capital Health experts chose the last historical point as the level to begin the regression at, while keeping the slope constant.

Figure 1: Graph of Historic Scan Growth Rate and Population Growth Rate: CT, MRI, US







What we observe is that historically, the rate of scans performed grew at a much higher rate than the region's population growth would have predicted, indicated by the difference in the slope of the black line and the blue line. Our project involved explaining this difference and forecasting what this difference will be in the future by analyzing the factors besides population which contribute to demand for DI scans.

APPROACH & DELIVERABLES

While there are many factors that contribute to the difference in the slope of the regression line, from both the initial advice of our clients and our initial thoughts, our team identified six factors on which to focus our analysis, to either prove or disprove our initial assumptions and to quantify the effect on demand:

1. Changes in market share

- When DI machines are acquired by private providers or in nearby regions, it presumably decreases the number of people seeking scans from Capital Health.

2. Supply-induced demand

- When Capital Health acquires a new DI machine, it affects demand for scans. We predict an increase because in the medical industry, if the supply is there, demand will follow.
- Capital Health is also affected by the current labour shortage in Alberta and is taking steps to increase enrolment for the various programs required to become a technologist for the different modalities.

The current labour shortage is limiting the number of hours that the machines can operate and therefore affecting supply-induced demand.

3. New technologies

- With the improvement in technology for CT, MRI and US machines, we expect to see a decreased number of scans per patient, and thus a slight decrease in demand.
- The new technology will also allow new treatments, increasing demand.

4. New treatments

- The development of new procedures and uses for CT, MRI and US machines affects the number of scans demanded. We would presume that the demand would increase as they can be used by a larger portion of the population.
- This incorporates the effect of procedure adoption rates

5. Increasing affliction rates

- If Albertans are receiving more injuries per capita or disease rates are increasing, it will affect per capita demand per scans.
- The general decline in health in the population is probably the major factor in the number of scans demanded. This is especially due to the aging population.

Furthermore, we realized that during the course of the project we would come across other factors that neither our team nor the client might have initially predicted as being a large contributor to the number of scans requested. In order to comprise a final forecast that will allow for adjustments to be made throughout the five years, we will confer with the experts once again as to its reliability after analyzing both quantitative and qualitative data.

DATA COLLECTION

While we intended to base some of our analysis on numerical calculations and forecasting procedures, the nature of some of the previously mentioned variables made it impossible to reach concrete conclusions as to the degree of their effect. That is where the experts came in. While we realized that nobody could be certain as to the effect of these variables, their experience and expertise were invaluable in getting a general idea of the relative effects of the factors that go into creating demand. Therefore, our data collection involved both qualitative and quantitative data.

Qualitative Data Collection

Through the process of interviews with industry experts from the various hospitals within the Capital Health Region, including Site Directors, Managers and Coordinators for Specialty Imaging, Corporate Directors and Business Support Directors, we added to our knowledge of the situation and uncovered information that we had not previously considered.

1. **Changes in market share**
   a. Although we expected Capital Health's portion of scans to be affected by supply in both the private sector and surrounding health regions, it was mentioned that because private providers are not currently operating at 100% capacity, an increase in their supply would not cause patients to leave the Capital Health waitlist if they have not already done so.

2. **Supply-induced demand**
   a. All of the experts we interviewed agreed that they definitely notice an increase in demand when a new machine is added to their supply, aided by the publicity that surrounds such an event. However, the lag of this increase in demand, and how long it lasts, is uncertain.

3. **New technologies**
   a. A new technology that was brought up in our interviews was the new 64-slice CT scanners, which enable higher-quality scans and a shorter scan time.
   b. MRI and US are also seeing advances in technology which improve the quality (but not necessarily the length) of scans.
   c. Also, Capital Health is replacing many of their US machines in the near future.
   d. Although we expected these higher-quality scans to reduce demand by reducing the number of repeat scans, it was brought to our attention that it just as likely increases the number of scans required because it is more likely to find abnormalities which require a follow-up scan.

4. **New treatments**
   a. The new 64-slice scanner enables Cardiac CT scans, which will increase demand for CT scans due to a broader patient population.
   b. Other relatively new procedures include Gastric CT, Vascular CT, Breast MRI, 3-Dimensional US and Nuchal Translucency US, all of which will increase demand.

c. When asked about adoption rates for these new procedures, it was suggested that there are multiple factors that could affect uptake. While the lengthy wait times for DI machines may influence a physician's tendency to recommend the new procedure over the previously-used method, the forward-thinking attitude of Capital Health in promoting new technologies and the profile of Alberta physicians becoming younger leads us to believe that the procedures will see an adoption rate which is faster than it has been in the past.

5. **Increasing affliction rates**
   a. When asked about population affliction rates, it was mentioned that even if it was determined that more people are receiving a scan, it may be due to an increasing standard of care, or if more people are found to have a certain condition, it had merely gone undetected in the past.

After our interviews, we added another factor to our analysis:

6. **Changing physician behaviours**
   b. Younger physicians are more likely to recommend a DI scan than older physicians. The large number of physicians about to retire and the large influx of younger physicians will likely increase the demand for scans.
   c. There may also be a higher propensity to recommend a scan due to an ever-increasing standard of care as well as liability issues.

Furthermore, we distributed a questionnaire to all of the experts that we met with, as well as a few others, in which we asked them to assign a relative weighting to the factors that we determined influenced the scan volume, to indicate the degree to which they thought the factors contributed to the increase in demand both in the past five years as well as for the upcoming five years. The weightings would indicate how much each factor would explain the difference between the population-predicted scan increase rate and the actual scan increase rate in the past, and how they will explain the difference in the future.

Quantitative Data Collection

We collected large amounts of data including:

A. Historical volume of exams and forecast line based on population growth

This was the starting point to outline the difference between expected volume growth and actual volume growth. From this, we also determined the slope of the lines so that we could adjust them for our forecast. This data, for CT, MRI and US, is shown earlier on in this report in ***Figure 1***.

B. Number of patients on the waitlist each month (CT and MRI)

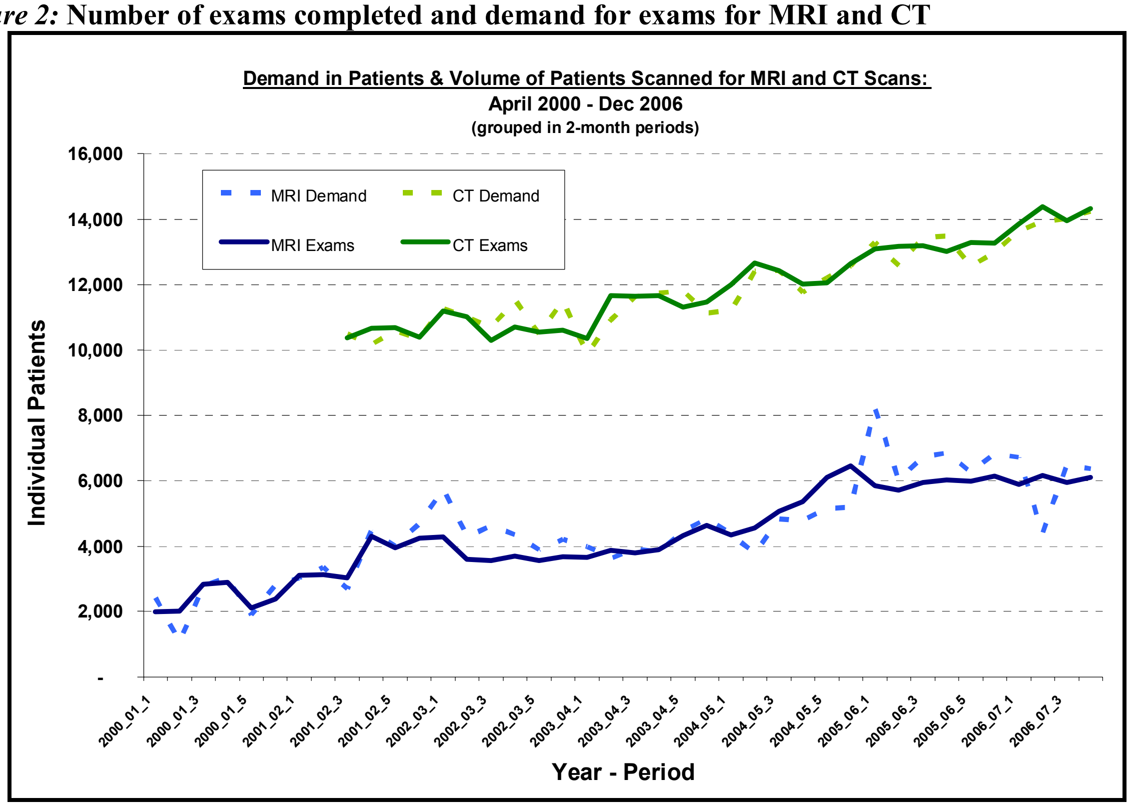
This data is broken down by the category of scan, from Dec 1999 to Jan 2007. This data is further divided by priority and hospital. There is currently no recorded waitlist for Ultrasound.

C. Number of exams completed and number of patients served per month

Using this data, we determined the number of exams per patient for each month.

As suggested by Capital Health and given the data provided, we considered volume of scans completed as a proxy for demand. However, to further analyze demand patterns for the effect of the variables, we also derived demand from waitlist and scan data. To derive the demand for each month we took the next month's number of patients on the waitlist – the number on the waitlist this month + the number of exams completed this month. ***Figure 2*** is a graph of the number of exams completed and demand for exams for MRI and CT. Because the number of scans is a more useful measure of demand, the majority of our analyses use supply and demand measured in scans, and not in individual patients.

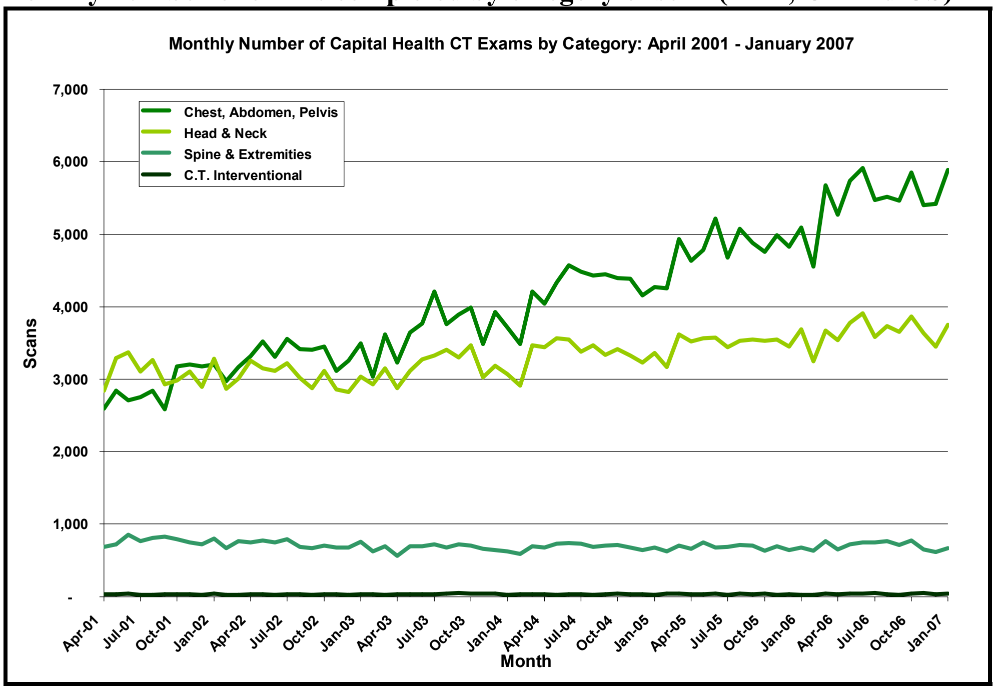
Figure 2: **Number of exams completed and demand for exams for MRI and CT**

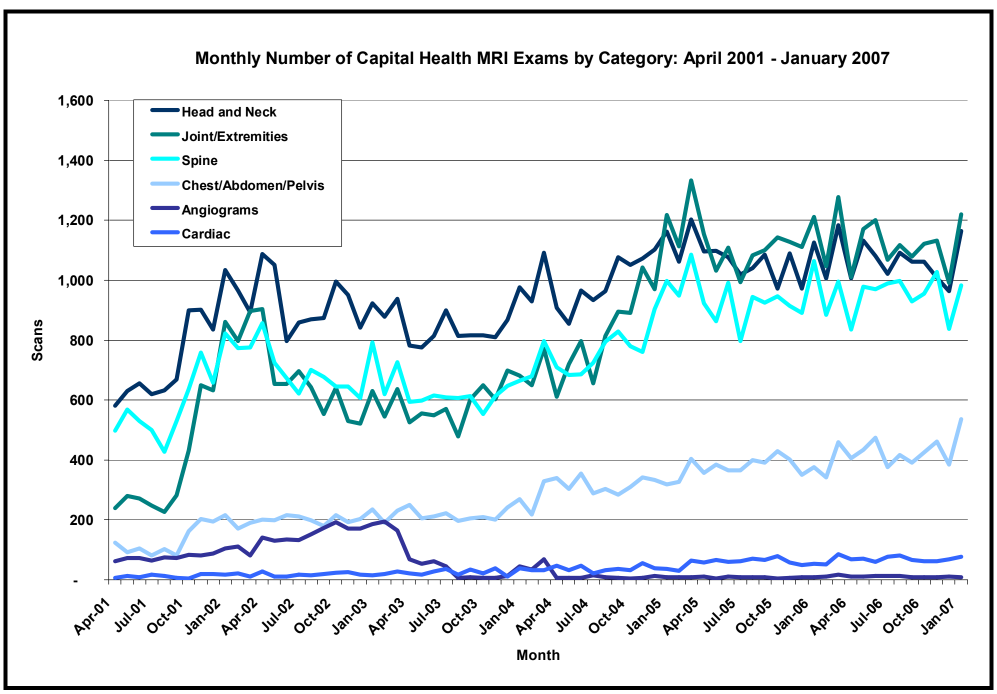


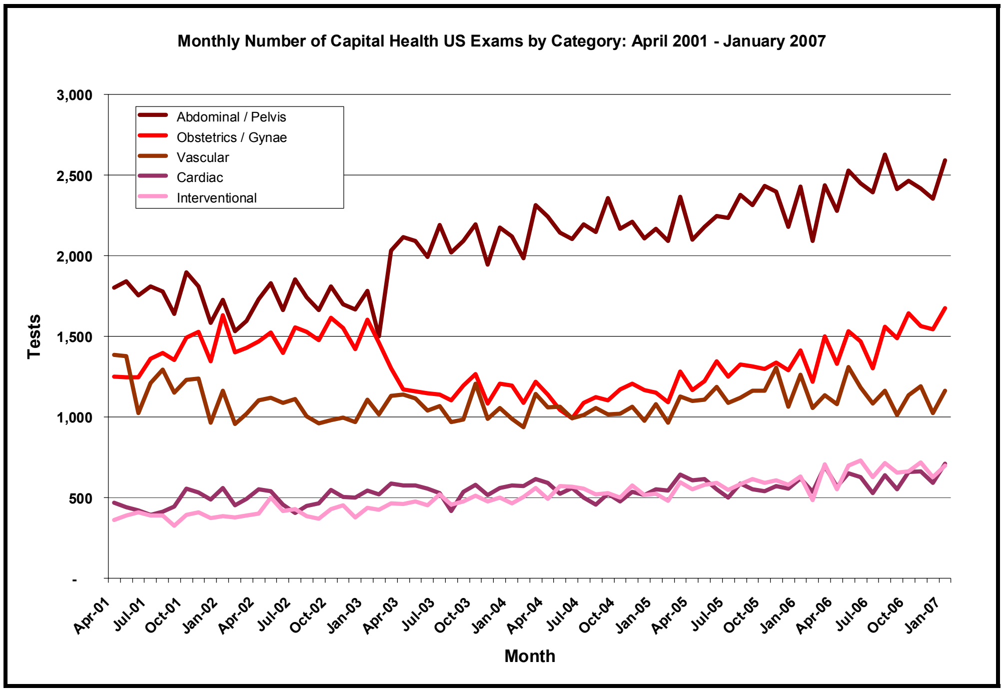
D. Monthly number of exams completed by category of scan (MRI, CT and US)

We graphed this data (***figure 3***) to observe which categories of scans were changing and at what rate, to aid in our analysis of adoption rates of new procedures.

Figure 3: **Monthly number of exams completed by category of scan (MRI, CT and US)**







E. Number and location of all MRIs and CTs in Alberta.

We did additional research to determine the age and year of acquisition of the machines. For Capital Health, this information was provided for most machines. For the other Alberta health regions, we used the National Survey of Selected Medical Imaging Equipment (2006) – from CIHI. The monthly dates of installation for the CT machines in the Aspen Region were provided to us after contacting the region itself. As well, we were provided with the number of each machine that Capital Health plans to install within the next five years. We were unable to learn the dates of any planned machine acquisitions in regions outside of Capital Health.

F. Number of patients served by the Capital Health Region from other parts of Alberta.

This was monthly data from April, 1999 to January, 2007. This data was grouped into the different health regions, and specific information was also provided for Grande Prairie and Fort McMurray, as these were two locations that specifically interested us. Grande Prairie is currently the only other Northern Alberta city besides Edmonton operating an MRI, and Fort McMurray is in the process of obtaining one. This information was also broken down into the reason for requiring treatment, i.e. the ailment of the patient.

DATA ANALYSIS

Forecasting Demand

In order to explain and interpret our results, we first performed a demand forecast on the three modalities. Since we do not have historical demand for US, this forecast is based on exams completed. We did this using Forecast Pro software, conducting holdout analysis to calculate fit and to choose the best forecast method. We used triple exponential smoothing method with a linear trend and additive seasonality indices for all three modalities, which fits the behaviour of the demand. The MAPEs of the holdout forecasts were CT: 5.48%, MRI: 18.3%, and US: 3.34. The output for these forecasts and the holdout forecasts can be found in ***Appendix B***. These forecasts resulted in the following graphs:

***Figure 4*: 5-year Forecast for CT Exam Demand**

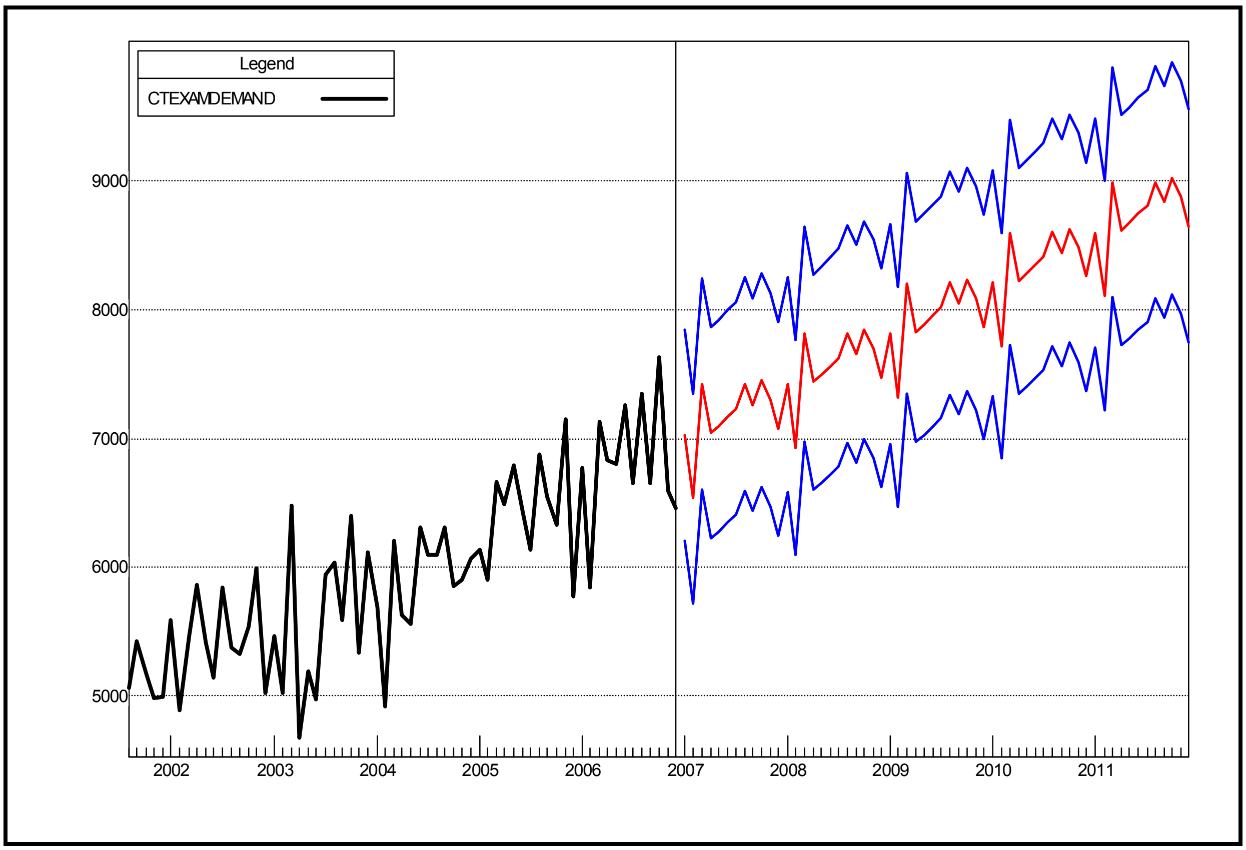


***Figure 5*: 5-year Forecast for MRI Exam Demand**

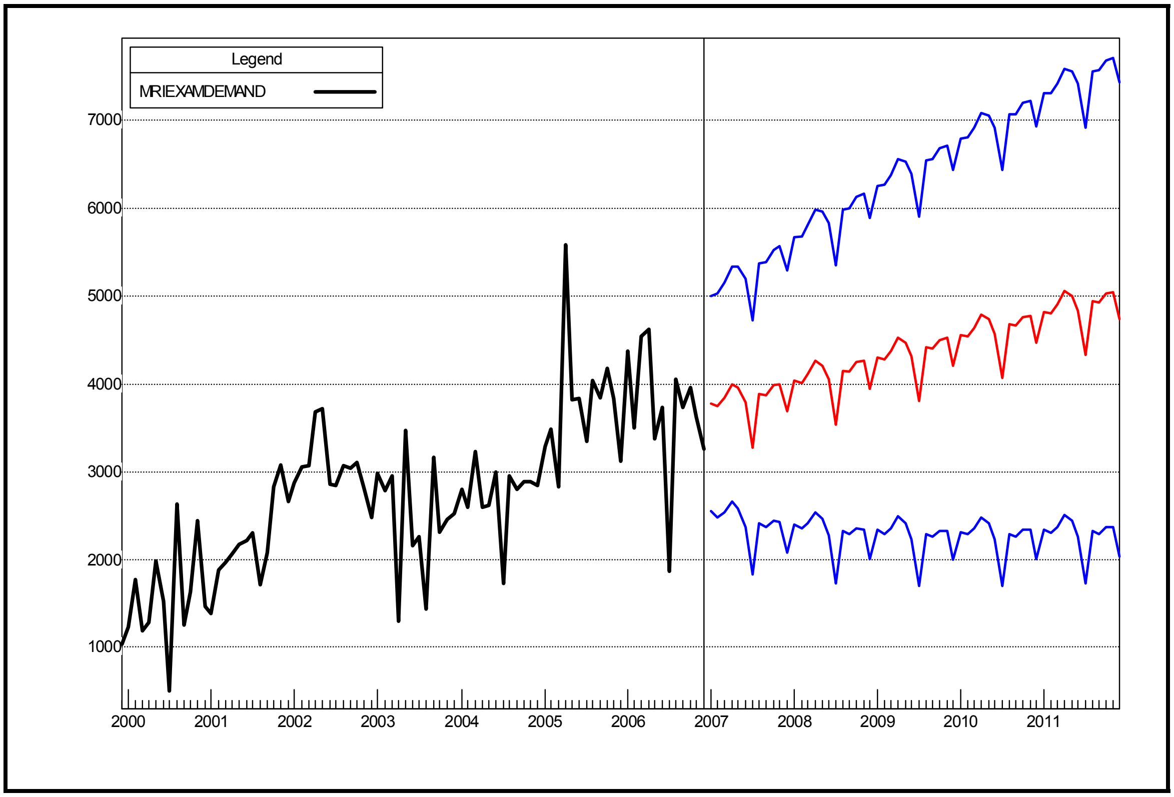
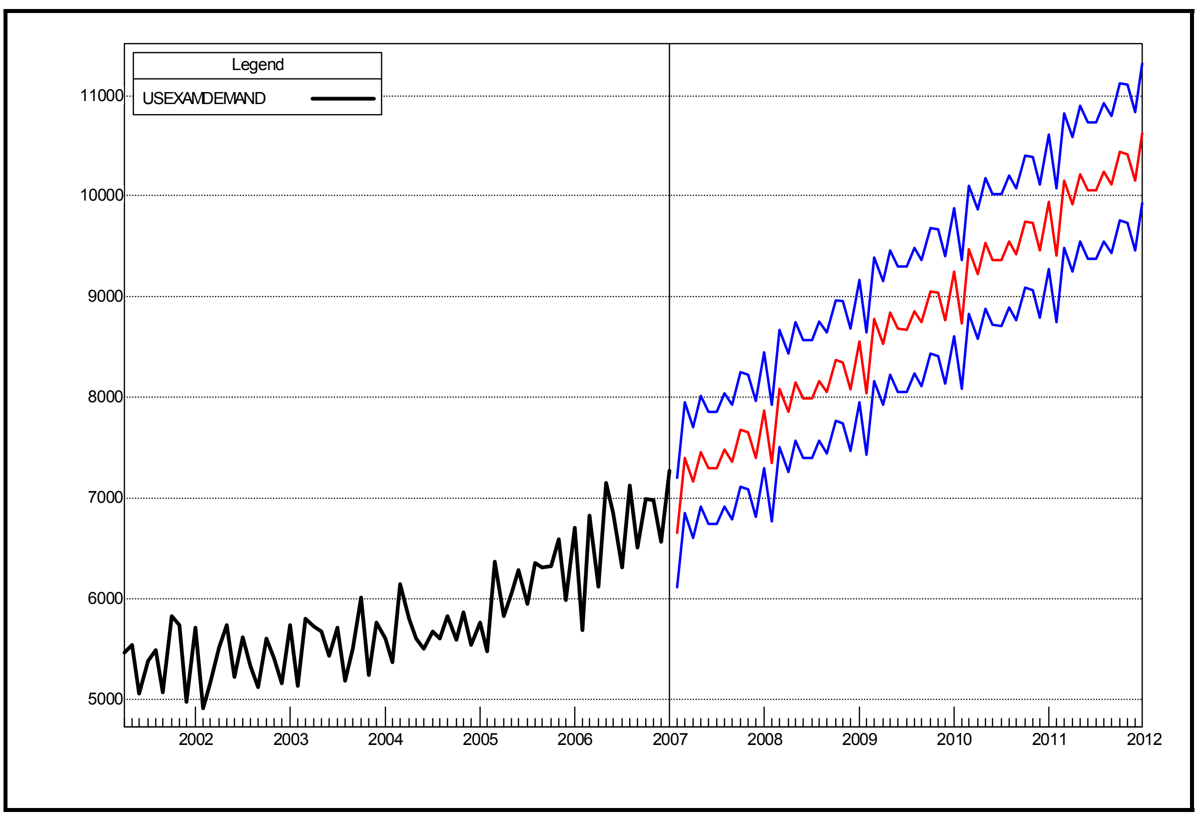


***Figure 6*: 5-year Forecast for US Exams**



These forecasts are only for use as a guideline in our analysis. Using historical demand to forecast future demand does not take into account changes in the multiple factors we mentioned that influence demand.

1. Changes in market share

One of the factors contributing to the increases in demand for diagnostic imaging services in the Capital Health Region is the addition of new machines to other Alberta Health Regions. Capital Health provides services for many other health regions, but this proportion would decrease, lessening the burden of Capital Health, should another region acquire DI equipment.

The analysis we made on this effect is regarding how the addition of new CT machines to the Aspen Health Region affects the influx of patients from this region to Capital Health's DI Services. Aspen Health, which covers the north-central area of Alberta and directly borders the Capital Health Region, acquired one CT scanner in Cold Lake in February 2004, one CT scanner in Hinton in February 2004 and one CT scanner in Westlock in March 2004. We observed a noticeable decline in the influx of CT patients from Aspen Health to Capital Health following the addition of these machines.

To account for the increasing demand for CT scans, ***figure 7*** analyzes this effect as a percentage of total CT scans done by the Capital Health Region. The red line is a simple linear regression of the exams percentage up to Period 6 in 2003, the period before installation of the first and second scanners. Following the installation of the three CT scanners in the Aspen Health Region the percentage values experienced a clear decrease. The annual average percentage of CT scans done by the Capital Health Region for Aspen Health Region residents for years 2002-2006 can be seen in ***figure 8***. The annual average percentage for years up to but not including installation of the 3 new machines, 2002 and 2003, is 8.32%. In addition, the annual average percentage for years after and including installation, 2004 to 2006, is 6.04%. This implies a 27.41% decrease in the number of Aspen Health Region residents coming to the Capital Health Region for treatment as a percentage of Capital Health CT Exams, resulting from the addition of the 3 new scanners in the Aspen Health Region. Another important point is even though the Aspen Region was saturated with CT machines, many patients continue traveling to Edmonton for treatment. As a percentage of pre-installation numbers, 72.6% of Aspen regions residents continue traveling to Edmonton for a CT scan. Furthermore, there is an implication that by adding 3 CT scanners to the Aspen Health Region, Capital Health experienced a 2.28% decrease in total CT demand. On a marginal basis, there was a 0.76% decrease in total CT demand in the Capital Health Region for each CT scanner added in the Aspen Health Region.

Figure 7: **Percentage of Capital Health CT Exams Provided to Aspen Health Residents**

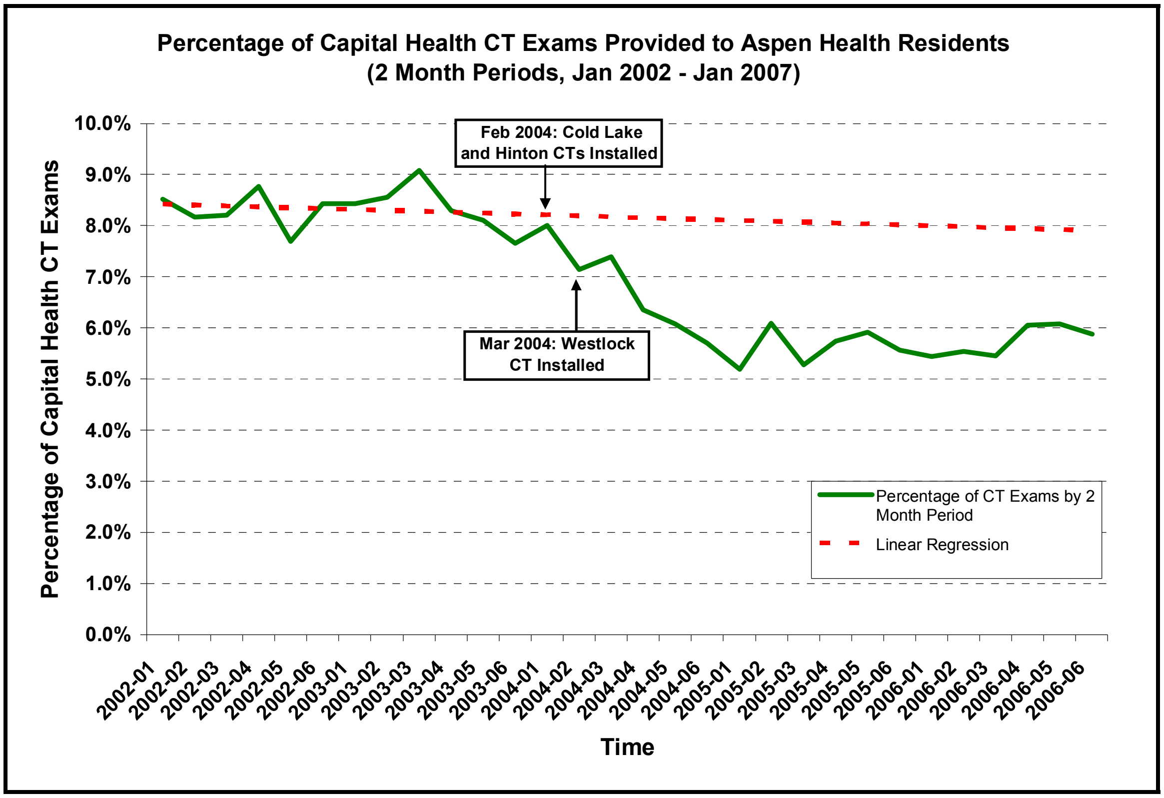


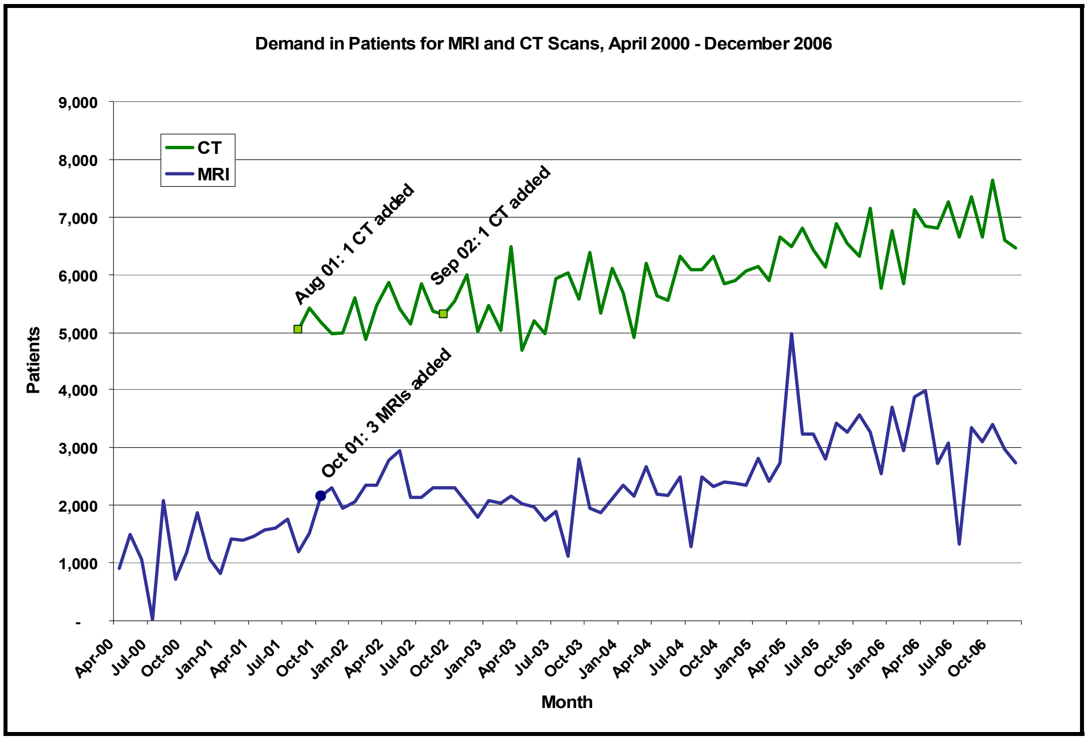
Figure 8: **Annual Percentage of Capital Health CT Scans Provided to Residents of Aspen Health**

Percentage of Total Capital Health CT Scans Provided to Residents of the Aspen Health Region (by Calendar Year)	
Year	**Percentage**
2002	8.29%
2003	8.35%
2004	6.75%
2005	5.63%
2006	5.74%

2. Supply-induced demand

Figure 9 charts the demand for MRI and CT scans, marking the months when new machines were added. This does not include when machines were purchased to replace older machines.

Figure 9: **Demand for MRI and CT and Date of Addition of New Machines**



It was a common perception during our interviews that the addition of supply caused an increase in demand. In order to examine this phenomenon, we performed beta testing for both CT and MRI to quantify the relationship between a change in the wait list times and the subsequent change in demand. As previously mentioned, since no wait list data is available for US exams, this analysis was performed for MRI and CT only. The wait time in days for each priority in any given month was provided to us by Capital Health. In order to better represent the data, we calculated the percentage change in wait time and the percentage change in demand each month. Outliers were identified using the guidelines: Q1 – 1.5*IQR = lower fence (mild outlier), Q1 – 3*IQR = lower fence (extreme outlier) and Q3 + 1.5*IQR = upper fence (mild outlier), Q3 + 3*IQR = upper fence (extreme outlier) (see ***figure 10***). CT and MRI exams are categorized by priority (1, 2, 3, or 4). Category 4 is not included in our analysis because it involves a different type of appointment and therefore does not behave in the same manner as the other types of demand. When analyzing the changes in demand, we noticed differences between the variations of the different classifications priorities. The standard deviation for Priority 2 and 3 were higher for both CT and MRI exams, with Priority 3 having the highest variance. This makes sense because the highest urgency cases (usually inpatients) need to be scanned no matter what the wait time is; whereas the lower urgency cases would perhaps forego scanning should the wait time be too long.

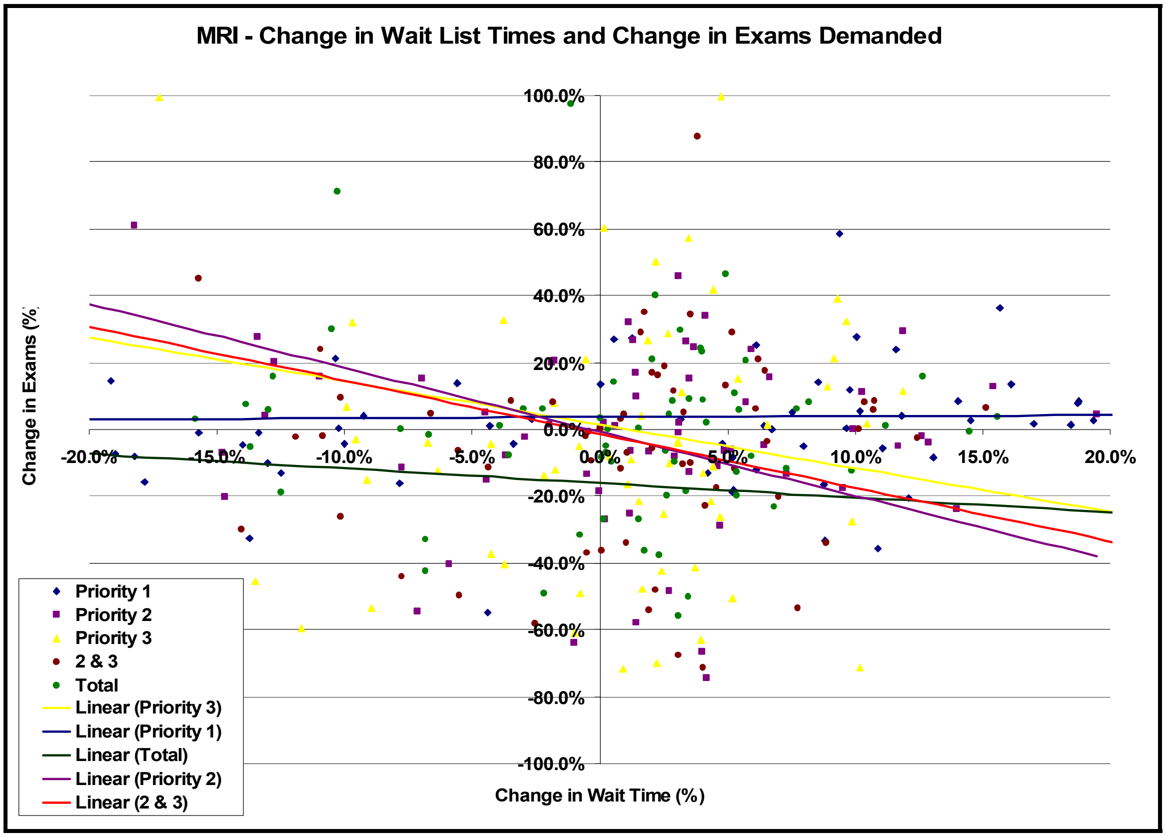
Figure 10: **Quarterly Change in MRI Waits and Demand, Descriptive Statistics, and Outliers**

	Quarterly - % Change									
	Demand - Exams					Wait Times				
Year - Q	1	2	3	2&3	Total	1	2	3	2&3	Total
0102 - 2	0.1%	-2.7%	-5.0%	-3.4%	**-4.2%**	-1.1%	0.9%	-17.9%	1.8%	**4.3%**
0102 - 3	23.5%	71.9%	89.4%	77.1%	**61.7%**	22.5%	67.9%	64.0%	32.2%	**78.8%**
0102 - 4	-1.4%	25.1%	41.9%	30.5%	**20.4%**	0.2%	30.8%	39.2%	7.6%	**37.7%**
0203 - 1	29.9%	16.3%	3.8%	12.0%	**16.7%**	24.8%	-12.8%	-1.2%	6.7%	**-14.3%**
0203 - 2	-19.2%	-18.7%	-12.8%	-16.8%	**-16.2%**	-16.9%	-15.6%	-9.8%	-15.0%	**-16.8%**
0203 - 3	34.3%	-5.8%	-24.6%	-12.1%	**-2.3%**	34.2%	4.3%	-22.9%	32.4%	**4.1%**
0203 - 4	4.5%	5.0%	1.1%	3.9%	**3.8%**	2.5%	5.0%	8.1%	1.4%	**6.3%**
0304 - 1	-18.7%	-22.3%	-18.6%	-21.3%	**-20.4%**	-16.2%	-15.1%	-14.9%	6.5%	**-4.5%**
0304 - 2	-5.0%	5.9%	-5.2%	2.7%	**-1.3%**	-5.6%	7.9%	-1.1%	-0.3%	**11.4%**
0304 - 3	9.5%	7.0%	-6.2%	3.5%	**6.3%**	8.8%	11.1%	-2.5%	1.6%	**6.4%**
0304 - 4	12.0%	3.8%	192.4%	49.5%	**18.4%**	13.8%	14.1%	17.2%	13.1%	**17.4%**
0405 - 1	-3.5%	-6.3%	-48.4%	-26.3%	**-4.9%**	-6.4%	-12.0%	29.5%	-2.2%	**-12.8%**
0405 - 2	-15.1%	-7.9%	3.6%	-4.1%	**-9.0%**	-10.3%	12.1%	21.2%	-9.9%	**11.3%**
0405 - 3	8.0%	23.8%	13.5%	20.1%	**15.4%**	4.8%	7.0%	26.2%	2.9%	**8.7%**
0405 - 4	1.4%	26.5%	-3.6%	16.3%	**11.4%**	2.0%	19.8%	22.1%	5.4%	**20.0%**
0506 - 1	25.1%	20.6%	109.8%	45.6%	**37.9%**	20.3%	-7.6%	-16.6%	16.4%	**-9.7%**
0506 - 2	-1.7%	-10.9%	-29.5%	-18.4%	**-15.1%**	0.6%	-3.4%	-2.6%	-1.0%	**-2.2%**
0506 - 3	-3.9%	-4.1%	10.0%	0.8%	**-1.0%**	-3.2%	4.9%	1.5%	-3.6%	**4.7%**
0506 - 4	4.9%	17.4%	4.2%	12.3%	**11.5%**	3.0%	6.7%	5.0%	4.9%	**5.7%**
0607 - 1	-0.6%	-2.8%	-13.9%	-6.7%	**-5.6%**	0.4%	-2.2%	-4.9%	2.2%	**-1.5%**
0607 - 2	4.3%	-26.9%	-20.3%	-24.7%	**-17.6%**	3.3%	-0.5%	-4.4%	-1.6%	**-0.2%**
0607 - 3	-5.3%	24.7%	8.5%	19.1%	**12.3%**	-3.6%	-0.7%	-5.0%	0.3%	**-0.6%**
Average	4%	6%	13%	7%	**5%**	4%	6%	6%	5%	**7%**
std dev	14%	22%	54%	26%	**19%**	13%	18%	21%	11%	**20%**
n	22	22	22	22	**22**	22	22	22	22	**22**
Quartile 1	-4%	-6%	-14%	-11%	**-5%**	-3%	-3%	-5%	-1%	**-2%**
Quartile 3	9%	20%	10%	18%	**15%**	8%	10%	20%	7%	**11%**
IQR	13%	26%	23%	29%	**20%**	11%	13%	25%	8%	**13%**
Lower Fence (Extreme)	-42.5%	-83.9%	-83.4%	-98.2%	**-65.6%**	-37.3%	-43.2%	-80.4%	-23.4%	**-40.0%**
Lower Fence (Mild)	-23.1%	-45.0%	-48.5%	-54.5%	**-35.5%**	-20.4%	-23.1%	-42.7%	-12.1%	**-21.0%**
Upper Fence (Mild)	28.4%	58.7%	44.5%	62.1%	**44.8%**	24.7%	30.3%	58.0%	18.0%	**29.7%**
Upper Fence (Extreme)	47.8%	97.5%	79.4%	105.8%	**74.8%**	41.6%	50.3%	95.7%	29.2%	**48.6%**

We then plotted these on a scatter plot (***figure 11***) with % change in wait time on the horizontal axis and % change in demand on the vertical axis, in the form of a Beta Test. Realizing that a decrease in wait time may not have an immediate effect on demand, we also examined the data incorporating a 1-period, 2-period, and 3-period lag to see which relationship had the best coefficient of correlation (R^2.) We also analyzed the relationship quarter to quarter, a natural grouping of the data, and with and without outliers.

We anticipated a negative linear relationship, with demand decreasing proportionally as wait time increases. However, it is also possible that as wait times increase more scans are requested due to an increase in publicity. Also, when the wait is long, people may desire to join the list prematurely because they are aware of the lengthy wait times, which would also artificially increase demand when wait times increase. In our analysis, we assumed that the primary negative relationship overpowers the possible positive relationship and therefore focused on finding a negative linear relationship.

***Figure 11*: Beta Test for MRI Wait Times and Demand – Monthly, Outliers Removed**



After fitting linear trend lines to the data and eliminating the trend lines which provided a counter-intuitive positive relationship, we compared the significance (p-values for an f-test) and predictive power (R^2) of the multiple alternative ways of looking at the data. An example of the results for CT is shown in ***figure 12***. The full results for MRI and CT can be found in ***Appendix A***. The p-values that are significant at an alpha of 0.05 are highlighted.

***Figure 12:* P-values and R^2 Values Resulting from Regressions of Data Series**

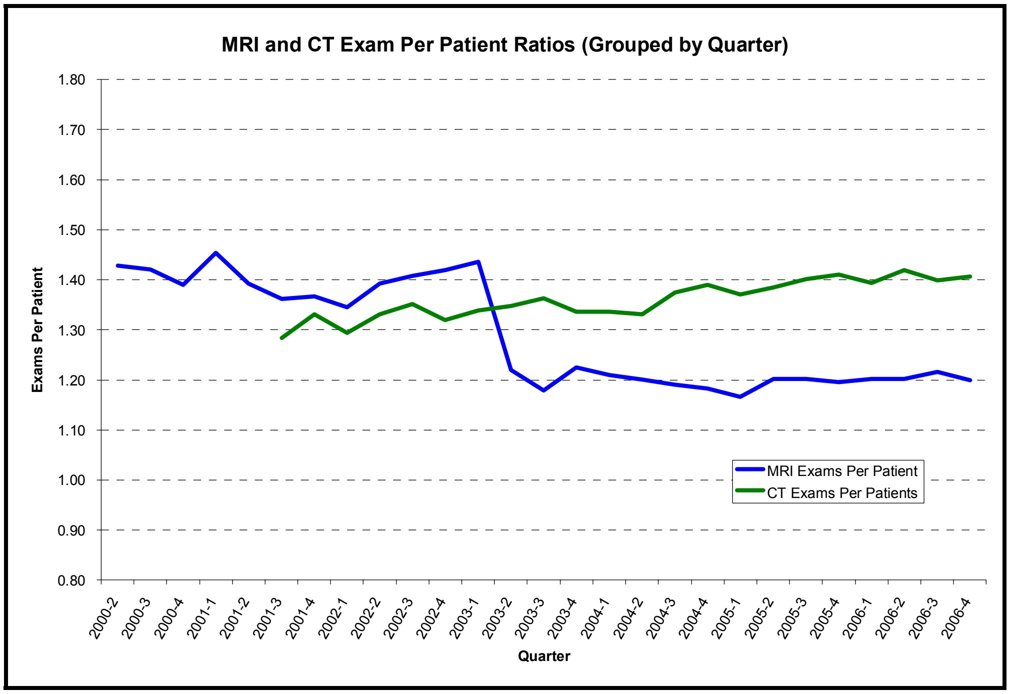
CT											
Monthly Data						Quarterly Data					
Original			Outliers Removed			Original			Outliers Removed		
Priority	P - Value	R Square*	Priority	P - Value	R Square	Priority	P - Value	R Square	Priority	P - Value	R Square
1	0.2621	0.0045	1	0.9303	-0.0168	1	0.7837	-0.0510	1	0.9983	-0.0714
2	0.4551	-0.0071	2	0.6596	-0.0141	2	0.3014	0.0069	2	0.0855	0.1299
3	0.0193	0.0716	3	0.1097	0.0302	3	0.5881	-0.0380	3	0.0981	0.1029
2 & 3	0.1315	0.0211	2 & 3	0.2235	0.0093	2 & 3	0.3073	0.0054	2 & 3	0.3244	0.0020
Total	0.2961	0.0018	Total	0.4244	-0.0061	Total	0.8571	-0.0536	Total	0.9845	-0.0625
Lagged 1 Month			Lagged 1 Month			Lagged 1 Quarter			Lagged 1 Quarter		
Priority	P - Value	R Square	Priority	P - Value	R Square	Priority	P - Value	R Square	Priority	P - Value	R Square
1	0.8524	-0.0161	1	0.4993	-0.0092	1	0.7303	-0.0512	1	0.8001	-0.0714

The results of this analysis were inconclusive. The majority of the regressions revealed an insignificant p-value tested at the $\alpha = 0.05$ level of significance. Those that had a small p-value either had very low explanatory power or presented a positive relationship.

3. New technologies

Figure 13 shows the exam per patient ratio over time. For MRI, the ratio decreases from approximately 1.4 exams per patient in the beginning of 2000 to near 1.2 at the end of 2006. However, for CT, the ratio increases from 1.3 exams per patient to 1.4 over the course of 5 years.

***Figure 13*: MRI and CT Exam per Patient Ratios by Quarter**



4. New treatments

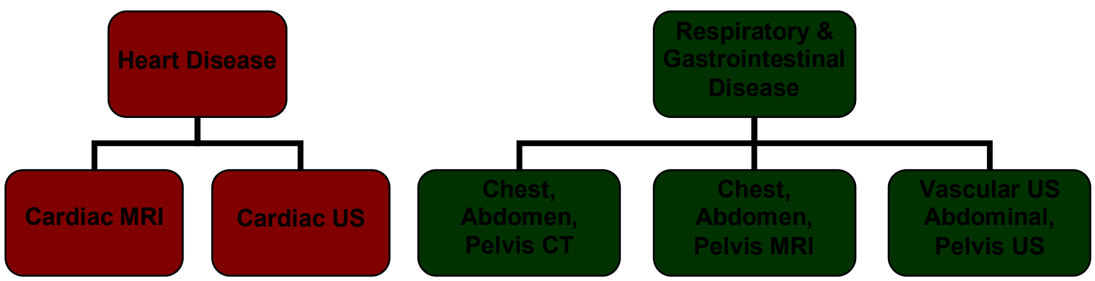
Another effect of the improved technology is the ability to develop and implement new treatments. As a result, this will lead to an increase in demand as more uses are found for the DI technologies. Through our interviews as well as other research, we were able to determine five new procedures which are likely to have an effect on the demand for CT, MRI and US in the coming five years. These are Gastric CT, Vascular CT, Breast MRI, 3-Dimensional US and Nuchal Translucency US. However, the methodology which we used could be applied to the other procedures, as well as any other new treatments as they are developed.

In order to predict the rate at which a new treatment will be demanded, we looked at past data for the adoption rate of previous new procedures. We looked at the number of scans for each modality as a percentage of the total number of cases presenting themselves for a certain category over time. Our ultimate goal was to collect adoption rates for several treatments in order to determine an appropriate rate to apply to the new procedures listed above.

We obtained a total monthly number of cases presenting themselves to Capital Health for care, divided into the following clinical groupings: A) Heart Disease, B) Circulatory Disease, C) Respiratory & Gastrointestinal Disease, D) Reproduction & Genitourinary Disease, and E) Ophthalmic Disease. Each of these is comprised of several diagnosis grouping codes, as can be seen in ***Appendix C.***

The monthly exam data provided to us categorizes the CT, MRI, and US scans performed in a different set of categories. However, there is some overlap. ***Figure 14*** indicates the two primary categories we were able to approximate adequately.

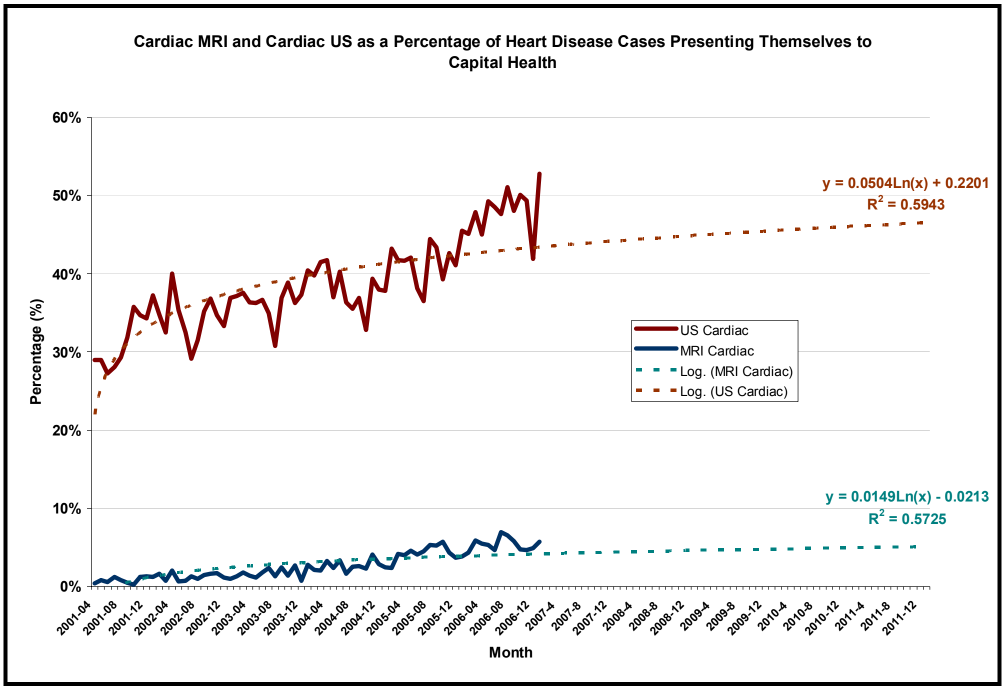
Figure 14: **Available Diagnosis Grouping Codes and Corresponding DI Scan Categories Comprised**



We determined that Ophthalmic US did not have enough exams to warrant further analysis, and judging by the erratic shape of the MRI Angiogram graph, it could not be taken as an example of a standard adoption rate. For reproduction and genitourinary diseases, the categories did not align well.

We plotted the number of exams in the DI categories as a percentage of the total number of diagnoses presenting to Capital Health in the corresponding clinical grouping. Because of the nature of the data, we fitted logarithmic trend lines to the data. This is because the adoption of a new technique would increase rapidly at first, and then gradually slow until reaching a saturation point. We also forecasted this trend line 60 periods (5 years) into the future (***figure 15***).

Figure 15: **US and MRI Exams as a Percentage of Capital Health Cardiac Cases**



Optimally, we would have been able to obtain data going further back in order to see the ramping up effect of many different procedures. However, the only procedure in our data set which essentially began at a diagnosis share of 0 % (just being introduced) was Cardiac MRI (graph shown above). Cardiac MRI increased from 0.4 % of cardiac diagnoses in April of 2001 (first available data point) to 5.7 % in January 2007. ***Figure 16*** indicates the average monthly increase for each fiscal year. The first four years see significant increases, while the last two years see a significant decline in growth. This is as we had predicted, with higher growth early on and less growth as the procedure reaches saturation.

Figure 16: **Average Monthly Increase in Cardiac MRI Usage Rate by Fiscal Year**

Average Monthly Increase in Proportion of Capital Health Cardiac Diagnoses Examined by Cardiac MRI	
Fiscal Year	**Percentage**
2001 - 2002	40%
2002 - 2003	22%
2003 - 2004	26%
2004 - 2005	31%
2005 - 2006	4%
2006 - 2007	4%

5. Increasing affliction rates

In the time frame provided, we were unable to obtain meaningful data regarding the sickness of the Alberta Population over time.

6. Changing physician behaviours

In the time frame provided, we were unable to obtain adequate data regarding the distribution of physicians in the Capital Health Region over time. Had we been able to secure this information, we would have examined a relationship between the average age of physicians and the number of exams demanded.

RESULTS AND DISCUSSION

1. Changes in market share

The Aspen Health Region was the only region for which we were able to calculate the effect of a machine acquisition on future demand coming from that region. This analysis was for CT scans. We found that the number of scans provided by Capital Health to residents of the Aspen Region decreased by 27.41% after the acquisition of three CT scanners in the region. This represents a 2.28% decrease in Capital Health's total demand for CTs. This indicates that while it does reduce the burden on Capital Health when a nearby region acquires a DI machine, the majority of residents will still come to Edmonton for a scan. This may be because smaller urban centers are less likely to have specialists and may only be able to provide treatment for certain conditions.

Our study did not focus on the effect of additional machines in other regions because we were only provided with the number of patients by region of residence beginning in January 2002. Hence, we were unable to analyze the effect of new machines in other areas which installed machines before 2002. A specific area of interest for further studies would be to analyze the effect that the addition of a MRI in Grande Prairie (installed in 2000) had on demand in the Capital Health Region.

To best utilize these findings, it would be necessary to determine which health regions are planning the acquisition of a DI machine and evaluate the number of patients currently being served by Capital Health who come from that particular region. One would then apply the 27% decrease to a forecast of the number served in the upcoming years to determine the effect of the machine acquisition.

While this particular analysis was performed for CT scans, the same type of analysis could be performed for MRI and US scans, which would undoubtedly yield a different proportion of patients who would or would not travel to Capital Health for treatment.

2. Supply-induced demand

Although we tested the relationship between a change in the wait time and the resulting change in demand, we were unable to find any kind of conclusive relationship. We performed a beta test on the data with and without outliers, grouped by month and by quarter, and with a 1, 2 and 3 period lag. The majority of regressions of this data revealed an insignificant p-value tested at the $\alpha = 0.05$ level of significance. Those that did test as being significant proposed a positive linear relationship – the opposite of what the relationship ought to demonstrate, since a higher wait time should discourage demand, and not cause an increase.

We interpret this to mean that there is a more complicated relationship at play here, and there may be one or more factors which cause both demand and wait list to increase or decrease. According to our data, a change in the wait time does not in itself cause an obvious change in demand. While there very well may be a proportion of the population who will seek out a scan when waits are low and shy away from a scan when waits are high, this effect is not shown in our analysis. It may be a weak effect, or it may be obscured by other factors.

3. New technologies

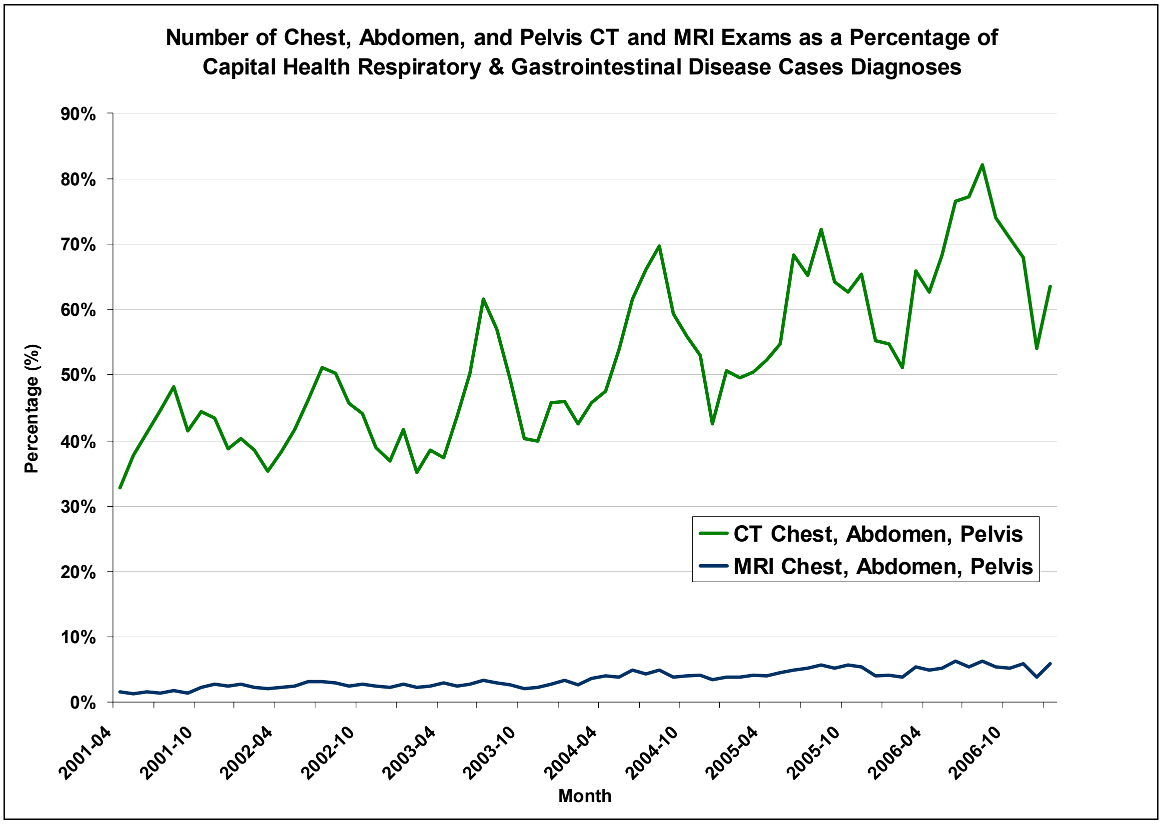
The data showed that the ratio of exams performed per patient decreased for MRI exams from 2000–2006, but increased for CT exams from 2001-2006. This leads us to believe that both of our hypotheses may be in play; the improvement in MRI technology may reduce the number of repeat scans required, but the increasing accuracy of CTs may increase demand because of their ability to find more abnormalities.

4. New treatments

In order to capture the adoption rate of new procedures, we compared the number of scans performed (classified by Scan Category) to the total number of cases diagnosed by Capital Health in the corresponding Diagnosis Grouping Code. This gave us the usage rate of the DI Scan as a percentage of cases presenting with that type of diagnosis.

Of the five new procedures we listed, the two procedures that would likely most closely follow the adoption rate we found would be Cardiac CT and Breast MRI. However, since MRI has a much smaller capacity, has a more difficult supply expansion, and costs more per scan than a CT procedure, it would therefore reach a much lower saturation point than a CT procedure would. We can presume that Cardiac CT will eventually be used on a much higher percentage of cardiac diagnoses than Cardiac MRI. This preference of CT is evidenced when looking at ***figure 17***, indicating that a much higher percentage of Respiratory & Gastrointestinal diagnoses are treated with CT than are treated with MRI.

Figure 17: **CT, US and MRI Exams as a Percentage of Capital Health Respiratory & Gastrointestinal Disease Cases**



Despite this, the ramp-up period may in fact be comparable. We can come to the conclusion that if it follows the same rate of adoption as Cardiac MRI did, the Cardiac CT will have a period of high growth for approximately five years. After that it will reach stability as a percentage of the total cardiac cases that are diagnosed by Capital Health. The adoption rate for Breast MRIs will likely be quite similar to that of Cardiac MRI, although perhaps higher because US is not a popular alternative in this case.

It should also be noted that the adoption of the new procedures will likely lead to cannibalization amongst the different modalities. In this example, the new demand for Cardiac CT will likely reduce the demand for both Cardiac MRI and Cardiac US. Although each modality has its strengths, it is inevitable that there will be some modality switching depending on cost, waitlist and other factors.

5. Increasing affliction rates

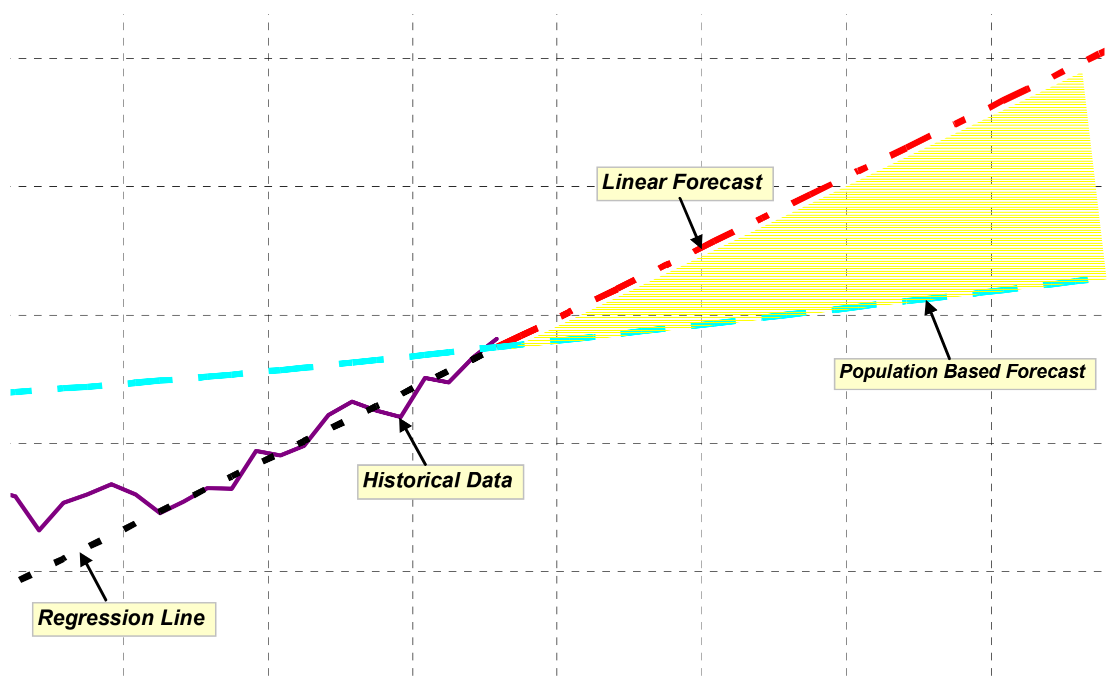
In the time frame provided, we were unable to obtain meaningful data regarding the sickness of the Alberta Population over time. As well, there are numerous factors that would confound this data. If more Albertans are receiving scans, is it due to a general decline in health, a higher standard of care, or a better ability to detect illness? However, this is definitely still a factor in demand for DI scans and warrants further analysis should the opportunity arise.

6. Changing physician behaviours

In the time frame provided, we were unable to obtain adequate data regarding the distribution of physicians in the Capital Health Region over time. It was only through qualitative data collection that we discovered that younger physicians typically have a higher scans requested per patient ratio than older physicians, and therefore we were unable to perform any data analysis or come to any conclusions. A higher standard of care or increased threat of liability would be difficult to define and quantify.

Relative Impact

Taken together, we have been able to develop a very good understanding of the factors which drive demand for CT, MRI and US. The number and complexity of the factors involved makes it nearly impossible to accurately put forth a forecast. However, in order to better anticipate demand in the future, we can classify the multiple factors we have examined here as to their relative effect on the discrepancy between the population-based forecast and the forecast based on past demand. Our value assignments were assigned based on our qualitative data collection, the quantitative analyses we performed and the questionnaires returned by the experts we consulted.



CT

Relative Impact of Factors Contributing to Growth in Demand for CT Scans in the Capital Health Region		
Factor	**%**	**Reasoning**
Change in Market Shares	-5	While this does reduce demand from surrounding regions, this only reduces demand from that region by ~ 30%
Supply-Induced Demand	20	Although we were not able to measure this clearly, an increase in the supply of CT does likely have a significant impact on demand, especially because CT wait lists are decreasing significantly. However, this is likely not as strong an effect as previously perceived.
New Technology	5	As suggested in our analysis, increased technology may increase the number of CT scans demanded per patient, therefore increasing demand
New Treatments	15	Several new CT treatments are on the horizon, but they could take approximately 5 years to come into full force.
Increasing Affliction Rates	40	Increased longevity of the population, an increased ability to detect illness and the increased rate of many afflictions will increase demand for CT significantly
Changing physician behaviours	25	The present generation of physicians relies heavily on diagnostic imaging, and this will only increase with time. The standard of care and patient expectations are also still increasing.

MRI

Relative Impact of Factors Contributing to Growth in Demand for MRI Scans in the Capital Health Region		
Factor	**%**	**Reasoning**
Change in Market Shares	-3%	While this does reduce demand from surrounding regions, in the next five years not many MRIs will be acquired outside of Capital Health, possibly only Fort McMurray. As well, the 30% decrease may be offset by supply-induced demand in the region that acquires the MRI.
Supply-Induced Demand	25	Although we were not able to measure this clearly, an increase in the supply of MRI does likely have an impact on demand.
New Technology	5	While new technology may decrease the number of MRI scans per patient, this effect will likely be negated by the increased demand due to higher quality
New Treatments	10	Several new MRI treatments are on the horizon, but they could take approximately 5 years to come into full force.
Increasing Affliction Rates	40	Increased longevity of the population, an increased ability to detect illness and the increased rate of many afflictions will increase demand for MRI significantly
Changing physician behaviours	23	The present generation of physicians relies heavily on DI, and this will only increase with time. The standard of care and patient expectations are also still increasing.

US

Relative Impact of Factors Contributing to Growth in Demand for US Scans in the Capital Health Region		
Factor	**%**	**Reasoning**
Change in Market Shares	0	Due to the low cost and portability of US machines, many communities outside of the Capital Health Region already possess US machines.
Supply-Induced Demand	5	Although less publicized, an increase in the supply of US does likely have a limited impact on demand.
New Technology	5	Advances in US technology are likely increasing demand slightly
New Treatments	25	News uses for improved US will increase demand, as will modality changes as waits for other DI scans increase.
Increasing Affliction Rates	35	Increased longevity of the population as well as an increase in the birth rate in Alberta both increase demand for US significantly
Changing physician behaviours	30	The present generation of physicians relies heavily on diagnostic imaging, and this will only increase with time. The standard of care and patient expectations are also still increasing.

Taken all the above factors into consideration, Capital Health can now make a more informed decision when it comes to managing supply. Much of the value of this project comes from further understanding the effects of some of the many factors that go into forming demand for CT, MRI and US. This analysis has provided a good basis on which to proceed.

APPENDICES

APPENDIX A: Beta Test Regression Output for MRI and CT

MRI											
Monthly Data						**Quarterly Data**					
Original			**Outliers Removed**			**Original**			**Outliers Removed**		
Priority	**P - Value**	**R Square***	**Priority**	**P - Value**	**R Square**	**Priority**	**P - Value**	**R Square**	**Priority**	**P - Value**	**R Square**
1	0.8508	-0.0140	**1**	0.1395	0.0190	**1**	0.0000	0.9776	**1**	0.0000	0.8985
2	0.1691	0.0131	**2**	0.9438	-0.0178	**2**	0.0001	0.5411	**2**	0.0848	0.1091
3	0.5349	-0.0088	**3**	0.4124	-0.0053	**3**	0.1587	0.0516	**3**	0.0117	0.3114
2 & 3	0.3064	0.0009	**2 & 3**	0.6454	-0.0148	**2 & 3**	0.0047	0.3022	**2 & 3**	0.0070	0.3353
Total	0.8221	-0.0137	**Total**	0.0778	0.0405	**Total**	0.0009	0.4013	**Total**	0.4946	-0.0278
Lagged 1 Month			**Lagged 1 Month**			**Lagged 1 Quarter**			**Lagged 1 Quarter**		
Priority	**P - Value**	**R Square**	**Priority**	**P - Value**	**R Square**	**Priority**	**P - Value**	**R Square**	**Priority**	**P - Value**	**R Square**
1	0.1474	0.0164	**1**	0.3344	-0.0008	**1**	0.1572	0.0552	**1**	0.8520	-0.0739
2	0.9982	-0.0147	**2**	0.0873	0.0350	**2**	0.1263	0.0722	**2**	0.0631	0.1410
3	0.3807	-0.0032	**3**	0.4525	-0.0073	**3**	0.8022	-0.0491	**3**	0.6021	-0.0501
2 & 3	0.7852	-0.0136	**2 & 3**	0.2360	0.0082	**2 & 3**	0.9863	-0.0526	**2 & 3**	0.1268	0.0916
Total	0.9874	-0.0147	**Total**	0.7576	-0.0177	**Total**	0.0728	0.1154	**Total**	0.0095	0.2952
Lagged 2 Months			**Lagged 2 Months**			**Lagged 2 Quarters**			**Lagged 2 Quarters**		
Priority	**P - Value**	**R Square**	**Priority**	**P - Value**	**R Square**	**Priority**	**P - Value**	**R Square**	**Priority**	**P - Value**	**R Square**
1	0.0638	0.0362	**1**	0.0859	0.0320	**1**	0.9208	-0.0550	**1**	0.0163	0.3432
2	0.2203	0.0077	**2**	0.9144	-0.0183	**2**	0.7141	-0.0475	**2**	0.3433	-0.0027
3	0.9057	-0.0147	**3**	0.7131	-0.0151	**3**	0.9664	-0.0554	**3**	0.9237	-0.0761
2 & 3	0.3558	-0.0020	**2 & 3**	0.1943	0.0138	**2 & 3**	0.2597	0.0183	**2 & 3**	0.1531	0.0788
Total	0.8587	-0.0144	**Total**	0.9599	-0.0199	**Total**	0.9951	-0.0556	**Total**	0.5070	-0.0328
Lagged 3 Months			**Lagged 3 Months**			**Lagged 3 Quarters**			**Lagged 3 Quarters**		
Priority	**P - Value**	**R Square**	**Priority**	**P - Value**	**R Square**	**Priority**	**P - Value**	**R Square**	**Priority**	**P - Value**	**R Square**
1	0.3381	-0.0010	**1**	0.0595	0.0422	**1**	0.3447	-0.0031	**1**	0.9980	-0.0909
2	0.0883	0.0289	**2**	0.0747	0.0409	**2**	0.2472	0.0237	**2**	0.9060	-0.0656
3	0.9004	-0.0149	**3**	0.8948	-0.0175	**3**	0.4756	-0.0267	**3**	0.5406	-0.0487
2 & 3	0.3400	-0.0011	**2 & 3**	0.9461	-0.0199	**2 & 3**	0.9827	-0.0588	**2 & 3**	0.0517	0.2040
Total	0.0673	0.0354	**Total**	0.2181	0.0110	**Total**	0.3880	-0.0121	**Total**	0.6463	-0.0513

* Adjusted R Squared

P Value	Threshold	0.05

CT											
Monthly Data						**Quarterly Data**					
Original			**Outliers Removed**			**Original**			**Outliers Removed**		
Priority	**P - Value**	**R Square***	**Priority**	**P - Value**	**R Square**	**Priority**	**P - Value**	**R Square**	**Priority**	**P - Value**	**R Square**
1	0.2621	0.0045	**1**	0.9303	-0.0168	**1**	0.7837	-0.0510	**1**	0.9983	-0.0714
2	0.4551	-0.0071	**2**	0.6596	-0.0141	**2**	0.3014	0.0069	**2**	0.0855	0.1299
3	0.0193	0.0716	**3**	0.1097	0.0302	**3**	0.5881	-0.0380	**3**	0.0981	0.1029
2 & 3	0.1315	0.0211	**2 & 3**	0.2235	0.0093	**2 & 3**	0.3073	0.0054	**2 & 3**	0.3244	0.0020
Total	0.2961	0.0018	**Total**	0.4244	-0.0061	**Total**	0.8571	-0.0536	**Total**	0.9845	-0.0625
Lagged 1 Month			**Lagged 1 Month**			**Lagged 1 Quarter**			**Lagged 1 Quarter**		
Priority	**P - Value**	**R Square**	**Priority**	**P - Value**	**R Square**	**Priority**	**P - Value**	**R Square**	**Priority**	**P - Value**	**R Square**
1	0.8524	-0.0161	**1**	0.4993	-0.0092	**1**	0.7303	-0.0512	**1**	0.8001	-0.0714
2	0.4244	-0.0058	**2**	0.4724	-0.0084	**2**	0.8102	-0.0551	**2**	0.3700	-0.0096
3	0.0958	0.0296	**3**	0.9925	-0.0196	**3**	0.9054	-0.0579	**3**	0.7794	-0.0571
2 & 3	0.1748	0.0143	**2 & 3**	0.8734	-0.0184	**2 & 3**	0.6638	-0.0468	**2 & 3**	0.4379	-0.0233
Total	0.6118	-0.0123	**Total**	0.6193	-0.0133	**Total**	0.5752	-0.0389	**Total**	0.3940	-0.0146
Lagged 2 Months			**Lagged 2 Months**			**Lagged 2 Quarters**			**Lagged 2 Quarters**		
Priority	**P - Value**	**R Square**	**Priority**	**P - Value**	**R Square**	**Priority**	**P - Value**	**R Square**	**Priority**	**P - Value**	**R Square**
1	0.0531	0.0460	**1**	0.5018	-0.0095	**1**	0.7680	-0.0566	**1**	0.8005	-0.0773
2	0.6157	-0.0126	**2**	0.1311	0.0235	**2**	0.5566	-0.0391	**2**	0.6154	-0.0554
3	0.2199	0.0089	**3**	0.1818	0.0161	**3**	0.4803	-0.0289	**3**	0.3568	-0.0060
2 & 3	0.8091	-0.0159	**2 & 3**	0.1959	0.0133	**2 & 3**	0.7909	-0.0577	**2 & 3**	0.9798	-0.0714
Total	0.7135	-0.0146	**Total**	0.3347	-0.0009	**Total**	0.8081	-0.0585	**Total**	0.7132	-0.0608
Lagged 3 Months			**Lagged 3 Months**			**Lagged 3 Quarters**			**Lagged 3 Quarters**		
Priority	**P - Value**	**R Square**	**Priority**	**P - Value**	**R Square**	**Priority**	**P - Value**	**R Square**	**Priority**	**P - Value**	**R Square**
1	0.0798	0.0356	**1**	0.9540	-0.0178	**1**	0.7589	-0.0598	**1**	0.6513	-0.0699
2	0.4456	-0.0070	**2**	0.7111	-0.0159	**2**	0.0564	0.1699	**2**	0.0609	0.2013
3	0.9071	-0.0170	**3**	0.2185	0.0110	**3**	0.0606	0.1630	**3**	0.0541	0.1856
2 & 3	0.7763	-0.0158	**2 & 3**	0.5849	-0.0136	**2 & 3**	0.0740	0.1439	**2 & 3**	0.6274	-0.0568
Total	0.6885	-0.0144	**Total**	0.5732	-0.0125	**Total**	0.3355	-0.0006	**Total**	0.5320	-0.0438

* Adjusted R Squared

P Value	Threshold	0.05

APPENDIX B: Output of Forecast Using Forecast Pro

CT Holdout 12, Forecast 12

```
Forecast Model for CTExamDemand
Additive Winters: Linear trend, Additive seasonality

                      Smoothing     Final
Component              Weight       Value
---------------------------------------------
Level                 0.07068      6515.6
Trend                 0.07300      31.598
Seasonal              0.15650

Seasonal Indexes
-----------------------------------------------------------
January - March                6.2397     -395.55     329.08
April - June                  -76.989     -30.991    -73.536
July - September               101.89      138.97     70.255
October - December             55.471      71.675    -196.52

Within-Sample Statistics
---------------------------------------------------------------
Sample size 53                  Number of parameters 3
Mean 5776                       Standard deviation 585.4
R-square 0.5574                 Adjusted R-square 0.5397
Durbin-Watson 2.369             Ljung-Box(18)=15.12 P=0.3464
Forecast error 397.1            BIC 431.6
MAPE 0.05483                    RMSE 385.7
MAD 315.1
```

CT Holdout 0, Forecast 60

```
Forecast Model for CTExamDemand
Additive Winters: Linear trend, Additive seasonality

                      Smoothing     Final
Component              Weight       Value
---------------------------------------------
Level                 0.06009      6957.8
Trend                 0.05674      32.822
Seasonal              0.15703

Seasonal Indexes
-----------------------------------------------------------
January - March                36.702     -486.47     363.47
April - June                  -45.006     -21.009     18.454
July - September               45.033      201.28     11.779
October - December             164.09     -14.977    -273.34

Within-Sample Statistics
---------------------------------------------------------------
Sample size 65                  Number of parameters 3
Mean 5971                       Standard deviation 698
R-square 0.7018                 Adjusted R-square 0.6922
Durbin-Watson 2.5               Ljung-Box(18)=20.33 P=0.6856
Forecast error 387.3            BIC 416.5
MAPE 0.05299                    RMSE 378.2
MAD 314.6
```

MRI Holdout 12, Forecast 12

```
Forecast Model for MRIExamDemand
Additive Winters: Linear trend, Additive seasonality

                      Smoothing     Final
Component              Weight       Value
---------------------------------------------
Level                 0.26068      3784.9
Trend                 0.01404      28.652
Seasonal              0.09774

Seasonal Indexes
-----------------------------------------------------------
January - March               -7.1505      67.615     4.0920
April - June                   123.58      220.72    -20.016
July - September              -314.95     -18.656    -4.4803
October - December             51.932      92.670    -195.35

Within-Sample Statistics
---------------------------------------------------------------
Sample size 73                  Number of parameters 3
Mean 2613                       Standard deviation 875.8
R-square 0.5774                 Adjusted R-square 0.5653
Durbin-Watson 2.429             Ljung-Box(18)=22.73 P=0.7987
Forecast error 577.4            BIC 617.6
MAPE 0.1834                     RMSE 565.5
MAD 394.1
```

MRI Holdout 0, Forecast 60

```
Forecast Model for MRIExamDemand
Additive Winters: Linear trend, Additive seasonality

                      Smoothing     Final
Component              Weight       Value
---------------------------------------------
Level                 0.25118      3675.5
Trend                 0.01129      21.885
Seasonal              0.12325

Seasonal Indexes
-----------------------------------------------------------
January - March                74.747      34.409     104.44
April - June                   235.23      165.42    -19.906
July - September              -553.80      41.300     6.7599
October - December             85.647      78.602    -252.85

Within-Sample Statistics
---------------------------------------------------------------
Sample size 85                  Number of parameters 3
Mean 2769                       Standard deviation 936.9
R-square 0.6127                 Adjusted R-square 0.6032
Durbin-Watson 2.471             Ljung-Box(18)=19.64 P=0.646
Forecast error 590.2            BIC 626.9
MAPE 0.1779                     RMSE 579.6
MAD 408.2
```

US Holdout 12, Forecast 12

```
Forecast Model for USExamDemand
Additive Winters: Linear trend, Additive seasonality

                    Smoothing     Final
Component            Weight       Value
---------------------------------------
Level               0.15310      6433.6
Trend               0.16883      57.043
Seasonal            0.23000

Seasonal Indexes
-----------------------------------------------------------
January - March             129.10      -308.92      237.81
April - June                60.854       103.20     -74.755
July - September            11.881      -39.108     -77.514
October - December          130.05       58.141     -230.74

Within-Sample Statistics
-----------------------------------------------------------
Sample size 58                   Number of parameters 3
Mean 5655                        Standard deviation 399.5
R-square 0.632                   Adjusted R-square 0.6186
Durbin-Watson 2.443              ** Ljung-Box(18)=78.4 P=1
Forecast error 246.7             BIC 266.9
MAPE 0.0334                      RMSE 240.3
MAD 190.6
```

US Holdout 0, Forecast 60

```
Forecast Model for USExamDemand
Additive Winters: Linear trend, Additive seasonality

                    Smoothing     Final
Component            Weight       Value
---------------------------------------
Level               0.08248      7018.0
Trend               0.23624      57.486
Seasonal            0.21116

Seasonal Indexes
-----------------------------------------------------------
January - March             163.10      -417.58      265.48
April - June               -31.056       213.32     -9.1143
July - September           -69.362       56.207     -119.63
October - December          143.90       65.647     -260.91

Within-Sample Statistics
-----------------------------------------------------------
Sample size 70                   Number of parameters 3
Mean 5834                        Standard deviation 569.4
R-square 0.7979                  Adjusted R-square 0.7919
Durbin-Watson 2.491              ** Ljung-Box(18)=67.7 P=1
Forecast error 259.8             BIC 278.4
MAPE 0.03461                     RMSE 254.2
MAD 203.9
```

APPENDIX C: Components of Clinical Groupings as Provided by Capital Health

Clinical Groupings:
Reported separately and broken into groups as follows, using the diagnosis grouping codes from PH_DX_GRP_DESC_ICD_9 (for 1999/2000 to 2001/2002), and PH_DX_GRP_DESC_ICD_10 (for 2002/03 to January 2007).

A) Heart Disease
- Heart Disease (excluding IHD)
- IHD
- *Other Heart Disease*

B) Circulatory Disease
- Other Circulatory Disease

C) Respiratory & Gastrointestinal Disease
- Malignant Neoplasm, Respiratory & Intrathoracic Organs
- Malignant Neoplasm of Trachea, Bronchus, & Lung
- Malignant Neoplasm of Female & Male Breast
- Acute Upper Respiratory Infections
- Pneumonia & Influenza
- Other Acute Lower Respiratory Infections
- Other Diseases of the Upper respiratory Tract
- Chronic Lower Respiratory Diseases
- Lung Disease Due to External Agents
- Other Respiratory Diseases Principally Affecting the Intersitium
- Suppurative & Necrotic Conditions of the lower Respiratory Tract
- Other Diseases of the Respiratory System
- Diseases of the Digestive System
- Severe Acute Respiratory Syndrome (SARS)
- *Other Respiratory & Gastrointestinal Disease*

D) Reproduction and Genitourinary Disease
- Malignant Neoplasm of Female & Male Genital Organs, Urinary Tract (excl prostate & cervix)
- Malignant Neoplasm of Cervix
- Malignant Neoplasm of Prostate
- Diseases of Genitourinary System
- Complications of Pregnancy, Childbirth & Puerperium
- Certain Conditions Originating in Perinatal Period
- Disorders Related to Length of Gestation and Fetal Growth
- Certain Conditions Originating in Perinatal Period
- Congenital Malformations, Deformations, & Chromosomal Abnormalities
- *Other Reproduction and Genitourinary Disease*

E) Ophthalmic Disease
- Disorders of the Eye and Adnexa
- *Other Ophthalmic Disease*

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