|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | | | | | |
|  | BAN 240 Capstone Project**Reducing Waiting Time in Canada’s Healthcare: The Power of Data Analytics.** | | | |  |
|  |  | | |  | |
|  | |  |  | | | |
|  | | **Group 2:**  **Dio Elikem T. Tay**  **Solomon Ayotunde Olayode**  **Omowunmi Arinola Bamgbelu**  **Ozoemena Nwamadi**  **Micheal Delos Santo** |  | | | |

Table of Contents [0](#_Toc142829571)

[Executive Summary 3](#_Toc142829573)

[Introduction 4](#_Toc142829574)

[Current Status 5](#_Toc142829575)

[Literature Review 6](#_Toc142829576)

[What are the challenges of Physicians & Nurse Practitioners? 8](#_Toc142829577)

[Emotional work 8](#_Toc142829578)

[Overview of Canada’s Healthcare System 10](#_Toc142829579)

[Legislation 10](#_Toc142829580)

[Healthcare Providers 12](#_Toc142829581)

[Primary Healthcare Providers 12](#_Toc142829582)

[Secondary Healthcare Providers 12](#_Toc142829583)

[Challenges in Canada’s Healthcare Sector 13](#_Toc142829584)

[Queuing Model 14](#_Toc142829585)

[Non-Integrated IT System 14](#_Toc142829586)

[Fee-for-Service Model 14](#_Toc142829587)

[Data Collection and Methodology 15](#_Toc142829588)

[Analysis, Result, and Interpretation 18](#_Toc142829589)

[Data Preprocessing 18](#_Toc142829590)

[Wait time by Medical Procedures (Fig 2) 19](#_Toc142829591)

[Implications 21](#_Toc142829593)

[Potential consequences of Wait Time 22](#_Toc142829594)

[Conclusion 22](#_Toc142829595)

[Recommendation 22](#_Toc142829596)

[Implications for Business Analytics Managers 24](#_Toc142829597)

[Works Cited 26](#_Toc142829598)

## Executive Summary

The Canadian healthcare system continues to face challenges with long wait times for medical services, negatively impacting patient outcomes and satisfaction. However, the emergence of Big Data and Data Analytics offers promising opportunities to address these issues and improve the effectiveness of healthcare delivery. This research focuses on how data analytics can be used to manage waiting times for appointments, consultations, diagnosis, referrals, treatments, and prescriptions in Canada's healthcare system. The current state of waiting times in Canada's healthcare system is extensively documented in the annual reports by the Fraser Institute, a trusted healthcare research organization. The 2021 report highlights an increase in waiting times for medically necessary treatment compared to the previous year, with the median waiting time between referral and treatment reaching a record high of 25.6 weeks. Significant variations are observed across provinces and specialties, underscoring the need for efficient healthcare delivery (Fraser Institute).

Extant literature review reveals the detrimental effects of extended waiting times, including increased pain, suffering, and mental anguish for patients. The economic costs are also significant, as patients often have to forgo wages while awaiting treatment. Big data analytics has shown promise in revolutionizing healthcare delivery by enabling better clinical decision-making, enhanced patient outcomes, reduced costs, and improved efficiency and productivity. Cloud-based big data analytics, in particular, can help manage patient data, streamline operations, and reduce waiting times (Belle et al., 2016; Raghupathi & Raghupathi, 2014; Low et al., 2011). We posit that establishing a centralized database for health information would enable efficient sharing of patient data across healthcare systems, leading to improved coordination and reduced redundant data gathering. Predictive analytics such linear regression and logistics regression models and machine learning algorithms can be utilized to forecast patient flow, optimize resource allocation, and identify bottlenecks in the healthcare delivery process. Cloud-based big data analytics can enable real-time data analysis and informed decision-making. Overcoming barriers such as data privacy, data security, and the need for skilled personnel is essential to successfully implement these solutions.

## Introduction

In healthcare, the timely delivery of medical services is of paramount importance to ensure optimal patient care. However, long wait times have been a recurring issue in Canada's healthcare system, making it harder to get timely treatments and services. Recent developments in big data and data analytics have demonstrated tremendous promise for revolutionizing a variety of industries, and the healthcare industry is no different. This study is to investigate how big data and data analytics may help the Canadian healthcare system cut waiting times. Decision-makers, which includes physicians and nurses can choose between treatments, forecast the course of major health events, and make long-term plans thanks to the ability to quickly examine correct data. Over the past 18 months, this has been more crucial than ever. Despite these obstacles, big data may revolutionize processes, produce deeper insights to help healthcare providers improve waiting times, enhance the quality of treatment, and optimize workflows and operations when it is used securely, ethically, and legally and when data sources are integrated.

The objective of this research is to evaluate how waiting times for appointments, consultations, diagnosis, referrals, treatments, and prescriptions can be managed with the aid of data analytics. This study is focusing on wait times for diagnostic imaging (CT scan and MRI). We seek to get insights into the elements influencing the present situation and suggest viable remedies for improvement by utilizing historical data and doing in-depth analysis.

The industry will be thoroughly analyzed in this report, with a focus on the difficulties faced by doctors and nurse practitioners both during and after COVID-19. It will examine the historical analysis of the number of doctors and nurse practitioners and the causes of the current situation

in the wait times for CT scan and MRI diagnostic imaging. With the help of this study, we hope to highlight the value of data analytics in addressing waiting time issues and provide tactics to improve healthcare productivity.

The sections that follow in this paper will delve into the background of the sector, evaluate the research issues surrounding the management of waiting times, research methodology, analysis, and offer insights into the potential remedies provided by data analytics.

## Current Status

As the healthcare landscape continues to evolve, a crucial issue at the forefront of discussions in Canada's healthcare system is waiting times for healthcare procedures. With Canada's healthcare identified as a system defined by waiting for treatment, strategies are continually being sought to address and reduce these times. This project investigates the potential of big data and data analytics in reducing these waiting times, contributing to a more efficient and patient-centric healthcare system.

The current state of waiting times in Canada's healthcare system is extensively documented in annual reports by the Fraser Institute, a trusted source in healthcare research. In the 2021 report, "Waiting Your Turn: Wait Times for Health Care in Canada," the Institute pointed out that waiting times for medically necessary treatment have increased compared to the previous year. The median waiting time between referral from a general practitioner and receipt of treatment rose from 22.6 weeks in 2020 to 25.6 weeks in 2021. This is significant, as it represents the longest wait time recorded in the survey's history, 175% longer than in 1993, when it was just 9.3 weeks (Fraser Institute). The significant variation is also seen across provinces and specialties. Ontario has the shortest total wait time at 18.5 weeks, while Nova Scotia has the longest at 53.2 weeks. Patients waiting for neurosurgical procedures experience the most extended wait times at 49.2 weeks. In contrast, those awaiting radiation treatments begin treatment in just 3.7 weeks (Fraser Institute). There are two crucial segments to the total waiting time: from a referral by a general practitioner to consultation with a specialist and from consultation with a specialist to the point of receiving treatment. In 2021, these segments saw increased wait times compared to the previous year, raising concerns about the system's efficiency and patient outcomes (Fraser Institute).

## Literature Review

The implications of these extended waiting times are significant and harmful. As the Fraser Institute's report suggests, they can cause increased pain, suffering, and mental anguish. Sometimes, they may result in poorer medical outcomes, turning potentially reversible conditions into chronic or permanent disabilities. The economic cost is also considerable, as patients often need to forgo their wages while waiting for treatment (Fraser Institute).

Furthermore, the Canadian Institute for Health Information (CIHI) provides more specific data on organ transplants in Canada. Their data highlights the stark reality of wait times in the context of organ transplants, with the number of patients waiting for a transplant significantly outnumbering the number of transplants performed in 2022 (CIHI).

The gravity of the waiting time issue in Canada's healthcare system underscores the need for innovative solutions. A growing body of literature suggests that big data and data analytics could be vital to addressing this issue. Big data refers to the vast amounts of data that can be collected, stored, and analyzed, while data analytics involves using specialized systems and software to analyze this data. For example, in their 2016 paper "Big Data Analytics in Healthcare: Promise and Potential," authors Belle, Thiagarajan, Soroushmehr, Navidi, Beard, and Najarian argue that big data analytics can revolutionize healthcare delivery. The authors suggest that the ability to analyze large and complex datasets can lead to better clinical decision-making, enhanced patient outcomes, reduced healthcare costs, and improved efficiency and productivity.

Another study by Raghupathi and Raghupathi in 2014, titled "Big data analytics in Healthcare: overview and Perspective," highlights the transformative power of big data analytics in healthcare. The authors argue that healthcare organizations that harness the power of big data analytics can improve service delivery, optimize efficiency, reduce cost, and improve the quality of care. Additionally, they argue that big data analytics can help healthcare organizations to predict epidemics, cure diseases, improve the quality of life, and avoid preventable deaths.

In the context of waiting times, the potential of big data analytics is considerable. By leveraging these technologies, healthcare providers can better predict patient flow, optimize resource allocation, and identify bottlenecks in the healthcare delivery process. This could significantly reduce waiting times and improve patient outcomes.

For example, a study by Low, Chen, and Wu in 2011 titled "Understanding the determinants of cloud computing adoption" suggests that cloud-based big data analytics could help healthcare organizations better manage patient data, streamline operations, and ultimately reduce waiting times. The authors argue that cloud computing's scalability and flexibility could enable healthcare providers to quickly analyze large datasets, generate insights, and make real-time data-driven decisions.

However, the adoption of big data analytics in healthcare is challenging. Issues such as data privacy, data security, and the need for skilled personnel are significant barriers that must be addressed. Additionally, the quality of the data collected is crucial, as good data quality can lead to accurate analysis and potentially harmful decisions.

In conclusion, the potential of big data and data analytics to reduce waiting times in Canada's healthcare system is significant. While there are challenges to be overcome, the benefits of these technologies, as evidenced by the literature, suggest that they could play a key role in addressing the waiting time issue and transforming healthcare delivery in Canada. Therefore, stakeholders in Canada's healthcare system must invest in these technologies and explore their potential to improve patient outcomes and reduce waiting times.

number in each cell represents the number of measures in each theme that are above, the same as or below The Commonwealth Fund average of 11 countries. (Table1)

**Timely Access to Care**

Canada continues to perform below the international average for timely access to patient care. Most Canadians (93%) have a regular doctor or place of care, but they generally report longer wait times for medical care than adults in comparable countries. One possible reason for longer waits here is that Canadians consult with physicians more often than people in other countries. Only 43% of Canadians report that they were able to get a same- or next-day appointment at their regular place of care the last time they needed medical attention — the lowest percentage of all countries. Only 34% of Canadians report that they could get care on evenings or weekends without going to an emergency department. However, after-hours access is closer to the international average (43%) in some provinces such as Ontario and Alberta. Canadian patients are generally not seeing improvements in timely access to primary care over time. This is contrary to what primary care physicians reported in The Commonwealth Fund’s 2015 survey. Canadians visit emergency departments more often than people in other countries and wait longer for emergency care; Canada has the highest proportion of patients waiting 4 or more hours during a visit. Reported wait times for specialists and non-emergency surgeries in Canada are also the highest among the 11 countries, with all provinces showing significantly longer waits for specialists.

### What are the challenges of Physicians & Nurse Practitioners?

### Emotional work

Nurse practitioners (NPs) go through emotional ups and downs when providing treatment, which can be heartwarming or intimate. Building patient trust and helping them when they are in need are essential. Preventing these emotions from having an impact on one's daily life is the problem.

**Varying Hours:** Although nurse practitioners appreciate flexible schedules, these can provide difficulties. Work-life balance and personal life are impacted by irregular shifts, lengthy hours, and night work. One of the biggest obstacles in nursing is presented by this.

**Working with People:** Healthcare requires interactions with people, just like customer service. Managing the concerns, emotions, and family dynamics of a diverse patient population presents difficulties for nurse practitioners (NPs). Complexity is increased by patient mistrust or health concerns. A key barrier for NPs is navigating between many personalities and emotions.

**Power imbalance and hierarchy:** Healthcare is characterized by a pervasive dynamic of power and hierarchy between nurses, nurse practitioners (NPs), and physicians. The independence and power of decision-making of NPs may be hampered by this hierarchical structure. Due to previous hierarchies, colleagues may micromanage, lack trust, or contest clinical judgements.

**Not being able to help everyone:** Nurse practitioners (NPs) are driven to support patients' healing, but it can be difficult for them to accept that they can't help everyone. Accepting this reality while being committed is essential**.**

**Meeting the demands of a growing population**

Hospital Analytics for Improved Operations: In Ontario, ageing and growing populations put a strain on emergency departments (EDs), forcing hospitals to work towards better patient care and shorter stays. However, obstacles including long-term care transfers, bed shortages, and ED bottlenecks make it difficult to accomplish this goal.

Long-Term Care (MOHLTC), helping hospitals make decisions that are cost-effective.

**Improving compliance efficiency:**

Administrative burdens increase as a result of the requirement to submit reports to numerous funding agencies and regulatory organisations. For instance, the Canadian Institute of Health Information mandates data collection for specific patient classifications, such as those who attend the ED or who are having a day operation. Weekly, monthly, or quarterly relevant activity reports are required from hospitals. 54 Community Care Access Centres (CCACs) were recently combined into 14 Local Health Integrated Networks (LHINs), as part of a long-term attempt to improve long-term care funding and patient treatment. However, hospitals must abide by legal requirements that LHINs provide yearly reports to the government that include audited financial statements.

Key operational metrics are also tracked through funding-based programmes including the Ontario MOHLTC, the Health Based Allocation Model (HBAM), and the Quality Based Procedures (QBP).Unfortunately, many hospitals have a variety of operating systems where data is stored, which makes it challenging to meet these statutory reporting requirements. In order to ensure data integrity and speed up the rate at which stakeholders may access it, a complete analytics and reporting platform should incorporate data management technology. The intention is to equip hospital staff with the tools they need to focus more on data analysis and less time gathering and compiling it.

## Overview of Canada’s Healthcare System

The Canada Health system is a publicly funded health care system that provides universal coverage for basic medical services on a need basis. The system covers health services that are medically necessary, including disease prevention, diagnosis, treatment of injury, illness or disability (Ferguson 3)

Health coverage is financed through taxes collected by the Federal and Provincial governments. Provinces may also require their residents to pay a premium, depending on the level of taxable income, to supplement finances received from the federal government.

The responsibilities for Canadian healthcare are shared between the Federal, provincial, and territorial governments. The federal government is mainly concerned with providing funding for health services while the provincial and territorial governments control the delivery, regulation, and licensing of health care.

## Legislation

The Canada Health Act provides the legislative framework for administering Publicly Health Insurance. The Act establishes the conditions and criteria that must be met by provincial/territorial governments to receive financial support from the Federal government. The Canada Health Act underpins 5 principles that guide the delivery of health care by the different government level. The principles are highlighted and explained as follows:

**Public Administrations**: Health plan must be administered and operated by the provincial/territorial government or their agencies with no profit-motive.

**Comprehensiveness**: This suggests all medical necessary services by health care practitioners and institutions must be publicly funded by the provincial/territorial government.

**Universality**: Health insurance covered must be provided to all insured persons on uniform terms and conditions.

**Accessibility**: All insurance person must have reasonable access to medically necessary hospital and physician services without barriers (financial or otherwise)

**Portability**: Provides for continuity of health insurance coverage when the insured persons change locations within Canadian provinces/territory or travel outside of Canada. Approval may however be required for some health services required outside of Canada.

**Administration and Industry Operators**

The administration of Canada Health Care is primarily through the provincial and territorial governments. Each province/territory manages and delivers health care services through the health departments in its respective jurisdiction. The operators of Canada’s healthcare system include various stakeholders at different levels of administration. The operators include the federal government, the provincial/territorial government, the health department, the regional health authorities, and the healthcare providers.

**The federal government**: The arm of government is responsible for formulating and administering the national policies for the Canadian healthcare system under the guidance of the Canada Health Act. Their roles include providing financial support to provinces/territories as well as funding the delivery of primary and supplementary services to certain groups of people; First Nations people living on reserves, Inuit, serving members of the Canadian Armed Forces, eligible veterans, inmates in federal penitentiaries and some group of refugee claimants (Government of Canada).

**The provincial and territorial governments**: These control the delivery, regulation, and licensing of health care. They deliver Canadian healthcare services through the provincial/territorial health insurance plan which covers medically necessary services. In addition to the funds received from the Federal government, the essential medical services are financed through insurance premiums paid by the resident, depending on the level of taxable income. These finances are also used to offer supplementary health benefits to low-income residents and senior citizens (Government of Canada). Services covered under the supplementary (or extended) health insurance include prescription drugs outside hospitals, medical equipment, and appliances (e.g., ambulance), dental, optometry, and Physiotherapy services. Other than the aforementioned group, the cost of supplementary health benefits is funded out-of-pocket or through extended health insurance that is self-enrolled by the individual or funded by the employer of the affected individuals.

**Health Departments**: Each province and territory have its own health department that is responsible for managing and coordinating healthcare services. They oversee healthcare planning, policy development, resource allocation, and regulation of healthcare providers within their jurisdiction. Healthcare departments collaborate with other stakeholders to ensure the delivery of accessible and quality care.

**Regional Health Authorities**: Some provinces have established regional health authorities or health boards to oversee healthcare delivery in specific geographical areas. These authorities manage and coordinate healthcare services within their regions, including hospitals, clinics, and long-term care facilities.

## Healthcare Providers

These are doctors, nurses, specialists, pharmacists, and other allied health professionals. These professionals work in public hospitals, clinics, and private practices to deliver medical services and care to patients. There are different levels of healthcare providers, and they are primary, secondary, and supplementary healthcare providers.

## Primary Healthcare Providers

Primary healthcare providers: These comprise nurses, nurse practitioners, physicians, family doctors, dietitians, physiotherapists, and social workers. They are the first point of contact for primary health care services and ensure continuity of care by coordinating the transfer of patients for specialized service.

## Secondary Healthcare Providers

These provide specialized services not covered under primary health care. They represent community hospitals and facilities through which long-term care, home care, and chronic or palliative care are delivered to patients. The cost of these services cost borne by the provincial/territorial govt, except for room and board.

Supplementary or allied health professionals: These play a vital role in Canada’s healthcare system, working alongside physicians, nurses, and other providers to deliver a wide range of specialized healthcare services. They encompass a diverse range of disciplines and specializations, including but not limited to physiotherapy, occupational therapy, speech-language pathology, diagnostic imaging, medical laboratory technology, respiratory therapy, psychology, patient and rehabilitation.

## Challenges in Canada’s Healthcare Sector

The following are some of the challenges identified in the Canadian healthcare system.

Growing population and changing demography: Canada’s population is growing so fast due to its novel immigration program. Recently, Statistics Canada reported Canada’s population reaches 40 million, explaining the Canadian number rose by over a million in 2022 (2.7% annual population growth, the highest since 1957). Further, the agency estimated that 25% of the Canadian population will age 65 years and above by 2030 (Statistics Canada). The growing population and the considerable change in Canada demography imply a likely demand increase for healthcare with consequent surge in government finances for basic medical coverage.

**Shortage of Medical Personnel Waiting Time**

The red tape associated with the medical licensure of health professionals trained outside of Canada as well as the growing population have created a huge shortage of qualified medical personnel to meet with the growing demand for medical service. For instance, Statistics Canada “reported that 14.5% of Canadians aged 12 and older (circa 4.6 million) did not have regular health care provider”. This situation was further deepened by the unprecedented demand for medical treatment during the COVID-19 pandemic, resulting in a backlog of unattended non-emergency health cases after the pandemic.

## Queuing Model

The healthcare system currently operates on an individual queueing model where patients wait in a single queue for specialist treatments (Ferguson 6). With the primary healthcare providers as the first point of contact, a patient with a non-emergency health issue must first meet a general practitioner who then refers the patient to the diagnostic facility or to a specialist who determines if the patient needs to undergo a medical procedure. Each of these meeting points will require a patient to line up before being attended to, and therefore prolong the waiting period.

## Non-Integrated IT System

The lack of integration of health IT facilities poses another problem to the system. Presently, each province utilizes a stand-alone IT system that does not communicate with other systems (Ferguson 8). In this situation, patients’ medical records cannot be shared easily between systems, resulting in more time for gathering redundant patient information before administering treatment.

### Fee-for-Service Model

As Canada’s healthcare system is publicly funded, general practitioners and specialists are compensated on a fee-for-service basis. Under this arrangement, the practitioners are paid a pre-determined amount for each patient visit. This model could unethically incentivize general practitioners and specialists to deliberately maintain a long patient waiting list and maximize their earnings or hedge it against unexpected cancellations and decrease demand for healthcare service. (Ferguson 9).

of internationally trained practitioners in response to the shortage of medical personnel in these provinces (Atlantic). A similar approach can be implemented in other provinces to address the shortage of medical doctors and specialists.

**Co-Funding for Basic Medical Coverage**: Apart from the co-funding which applies to provinces/territories by way of premium, co-funding for basic medical coverage can be introduced across provinces to reduce the financial burden of basic medical services on the government. A varying ratio of co-funding can be adopted across provinces based on certain socio-economic parameters. This will encourage the responsible use of basic medical services as individual patients will now have to share in the resulting cost.

**Empowerment of Allied Medical Professionals**- To support the capacity of the current Health Care system, the regional medical agencies can promote initiatives that empower and increase the job functions of auxiliary professionals (e.g., nurses, physician aids, occupational therapist) to include drug prescription, ordering of diagnostic imaging and patient treatment. A specialized assessment and on-the-job supervision can be introduced to achieve this. While this initiative could pose some ethical and medical risks to the profession, the risks can however be minimized by additional level of quality control and supervision procedures.

## Data Collection and Methodology

**Dataset Description**

The dataset used in this project is titled "Wait Times for Priority Procedures in Canada (2023)". It is sourced from the Canadian Institute for Health Information (CIHI) as an Excel file (https://www.cihi.ca/sites/default/files/document/wait-times-priority-procedures-in-canada-2023-data-tables-en.xlsx). This dataset was chosen because it provides comprehensive and reliable data relevant to the project's objectives, particularly about wait times for various priority procedures in different provinces and territories of Canada.

The dataset includes multiple variables such as the type of procedure, the province where the procedure was performed, the patient's priority level, and the wait time in weeks. These variables enable the analysis of the differences in wait times across various procedures, provinces, and priority levels, directly aligning with the project's objectives.

**Data Collection Method**

The data collection method used by the Canadian Institute for Health Information (CIHI) is not explicitly described in the provided dataset. However, based on standard practices in health information collection, it can be inferred that the data likely comes from various hospitals and healthcare centers across Canada. These institutions typically have systems for recording and reporting data related to procedures performed, including wait times. This collected data is then compiled and organized by the CIHI, providing a comprehensive overview of wait times across the country.

**Data Type and Justification**

The dataset comprises primarily quantitative data, expressed in numbers and graphs and analyzed through statistical methods. For instance, the wait times are numerical values representing the number of weeks a patient waits for a procedure. Quantitative data allows for precise measurements and statistical insights, which is crucial for the project's goal of analyzing and comparing wait times across different contexts.

This dataset aligns with the project's objectives because it provides specific, measurable data on wait times for priority procedures across different regions of Canada. This allows for a comprehensive analysis of the current state of wait times in Canada's healthcare system and the identification of potential areas for improvement.

**Methodology**

Our methodology for this project involves a positive and participatory approach supported by existing data on wait time within the Canadian healthcare system. The data for our analysis comprises quantitative and qualitative data that speaks to the subject and identifies it as a significant problem. While our qualitative data would be obtained through a literature review, the quantitative analysis would be based on wait time data available on Canadian Institute for Health Information (CIHI) website. The quantitative data explores the wait times for priority procedures across Canada (CIHI). We have chosen this dataset because it aggregates the wait time data of some individual specialist procedures and surgeries received from provincial representatives by CIHI. Further, the dataset includes the most recent 6-month data spanning between April 2022 to September 2022 and the comparative periods since 2008. Additionally, the dataset is structured and organized to provide median wait time across provinces for the following procedures and surgeries:

* Hip replacement, Knee replacement, Hip fracture repair, Cataract surgery, Radiation therapy, Coronary artery bypass graft (CABG), Magnetic resonance imaging (MRI), Computed tomography (CT scan)
* Cancer surgery (5 body sites: bladder, breast, colorectal, lung and prostate). Other metrics included in the data, apart from the median wait times are:
* 90th percentile: 1 out of 10 patients waited this many days (or hours) or more before receiving care.
* Volumes for all procedures
* The proportion of patients that received their procedure within the benchmark time frame (where applicable) CIHI and provinces have validated the dataset to ensure its accuracy before publication by CIHI.

**Limitation of Scope**

The scope of our analysis will be limited to the procedures mentioned earlier within the Ontario province only. Our choice of Ontario as the focus province is informed by its relative population size, representing 39% of Canada's population. Accordingly, the outcome of our analysis for Ontario will give a sense of wait time incidences in other provinces.

### Analysis, Result, and Interpretation

We approach our analysis of this project from qualitative and quantitative perspectives. Whilst our qualitative analysis is based on review of other literatures supporting our research questions and conclusions, the quantitative approach involves exploration of wait time dataset for priority medical procedures, obtained from the Canadian Institute of Health Information (CIHI). The dataset contains aggregates of wait time data of some individual specialist procedures and surgeries that are received from provincial representatives from 2008 to 2022. The wait time of medical procedures that are captured in the dataset include hip and knee replacement, hip fracture repair, cataract surgery, radiation therapy, coronary artery bypass graft (CABG), magnetic resonance imaging (MRI) scan, computed tomography (CT) scan, and five (5) body sites of cancer surgery- bladder, breast, colorectal, lung and prostrate.

## Data Preprocessing

The above-name dataset was obtained, reviewed, and wrangled in Excel before uploading on a Data Analytic platform, Tableau, for analysis and visualization. We, however, observed some missing fields in the dataset but we do not deem the missing fields material enough to change the outcome of our analysis.

Our initial analysis reveals that diagnostic imagining (i.e., CT and MRI scans) has the largest volume of procedures compared to others. Accordingly, we explored these procedures to understand the causes of wait time for CT and MRI scans. Further, we note cataract surgery ranks 3rd on the volume count but no further analysis is made on this. Though CT scan was the most significant procedure based on volume. Nonetheless considering the the fact that heart diseases is the 2nd leading cause of death in Canada (Public Health Agency of Canada 2022) and MRI is the most reliable diagnostics procedure for cardiovascular diseases, we understood its analytical significance and elected its data as our preferred dataset.

**Volume of Medical Procedures in Canada. (No Fig 1. )**

|  |
| --- |
|  |

## Wait time by Medical Procedures (Fig 2)

## 

|  |  |
| --- | --- |
| Per the visual on Fig 2, the wait time for the procedures indicated in the chat increased YoY from 2021, except CT scan. The wait time for MRI scan increased by 10 days from 45 days in 2021 to 54 days in 2022, while CT scan wait time remains flat at c. 20 days between these periods. |  |

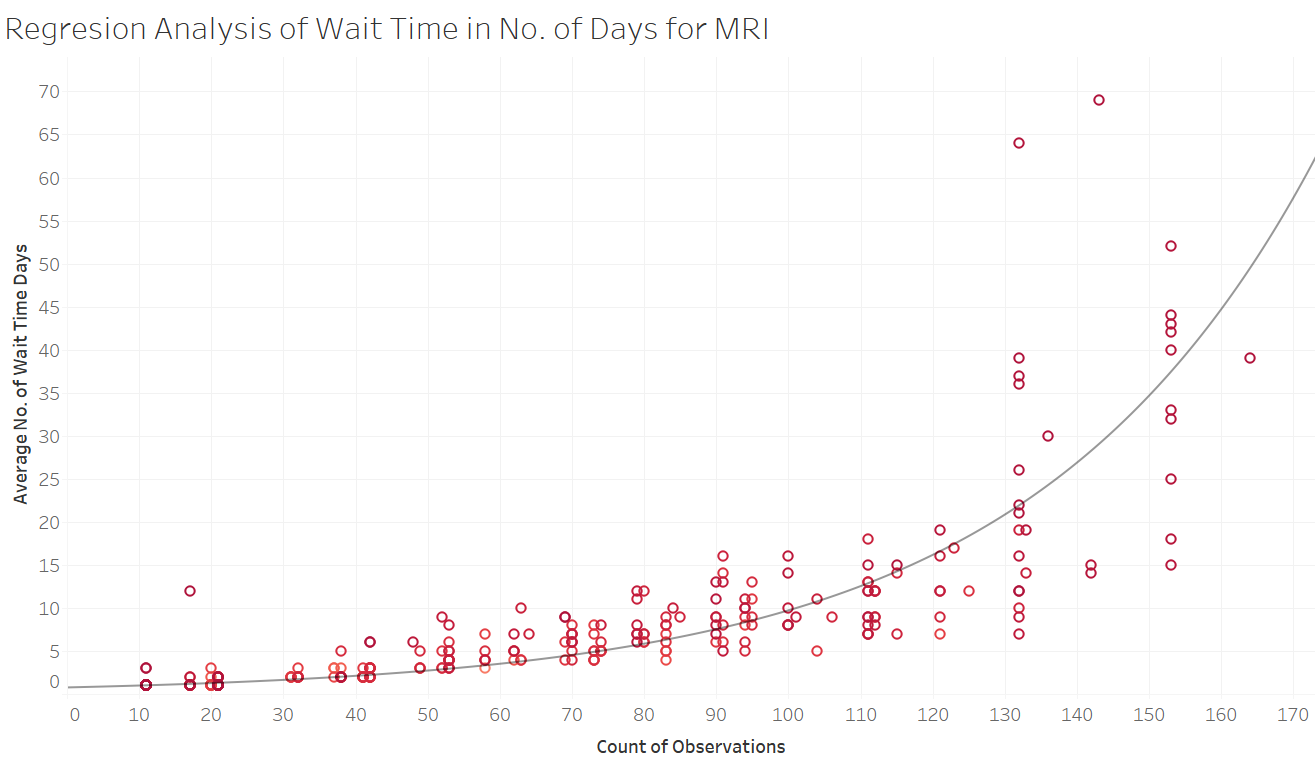
Increased Wait Time in Canada Caused by Shortage of Medical Personnel and Diagnostic Imaging Facility. Canada is confronted with insufficient number of physicians and MRI scanning facility. This was established by the number of doctors and MRI scanning facility per population index when compared with other OECD countries.

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

Per the tables above, Canada was outperformed by 16 countries on the number of physicians per pop. Index, including Portugal, Norway, Spain, Germany etc despite its relatively larger spend on healthcare sector. Similarly, Japan, US, Australia, Germany and 12 other countries are ahead of Canada with respect to number MRI scanning facility per 1m pop. ratio.

Predictive Analytics:

Based on the CIHI dataset of MRI volumes across Canada and the times from spanning 2008 -2023, we sought to predict the outlook of the wait time, whether it will improve and worsen. We deployed the power of data analytics specifically predictive analysis by running a regression analysis in Tableau using volumes of wait time as Predictor and wait time as dependent variable or the outcome. Our regression analysis revealed there is an exponential relationship between the predictor and the dependent variable. We fitted a linear regression model but it was not the best fit

Fig 3: Regression Analysis

to the observations. The observations were best fitted by an exponential regression model with an R squared value of 0.91. An R-squared value of 0.91 signifies that the model explains about 91% of the variance in the data, indicating a strong fit. This means the model's predictions closely match the actual data, capturing underlying trends. However, approximately 9% of the variability remains unexplained, which might be due to factors not accounted for or random fluctuations. While the high R-squared value suggests reliability, considering other factors and assessing the model's applicability is important.

## Implications

This model suggest that underlying trends of between MRI volumes and wait time over a 14 years period point to a wait crisis which is likely to worsen further in exponential proportion if decisive steps are not taken. This appears a very plausible prediction considering the build -up of the wait time before the Covid-19 Pandemic which got worsened during the pandemic and are likely to further deteriorate due sequels of the covid-19 pandemic.

## Potential consequences of Wait Time

The Fraser Institute’s research has repeatedly showed that wait times for medical procedures could have some grave consequences with likely risk of aggravating potentially reversible conditions to irreversible (Barua). Other side effects of prolonged wait time are ‘increased pain, suffering and mental anguish” Further, Moir and Barua (2022) quantified the cost of wait time per Canada patient to be worth c.$2,848 in 2021, if estimated based on normal work hours, and c. $8,706 “if all hours of the week (excluding eight hours of sleep per night) were considered.” (Barua)

## Conclusion

**The Canada wait time for CT and MRI scans has increased since the pandemic, and this was partly caused by shortage of medical personnel and backlog request created by C-19. The fiscal and health authorities must therefore rise to urgently address the increasing wait time to prevent a serious health crisis in the country.**

## Recommendations

To address the rising wait time in Canada’s healthcare, we have put forth the following recommendation to reduce the wait time for CT and MRI scans.

**Maintenance of a centralized system for the management of patient waiting list and assigning specialists**- In contrast to the siloed waiting list of individual specialists, the Canadian Medical Association in conjunction with the Federal Government can implement a centralized database for managing the patient waitlist and allocating queuing patient to specialist/facilities with more capacity or freer medical appointment schedules. The centralized system should be designed to provide update on specialists appointment schedules and enable the system assign a waiting patient to specialist/facility based on the capacity and specialist availability. The benefits of this include efficient accessibility of medical services, reduced waiting time and maintenance of centralized database for effective administration of health care.

**Review of the Medical license requirements to accommodate international medical practitioners.** Presently, the licensing of medical practice is characterized with restrictive registration against internationally trained medical practitioner. The current system requires them to write multiple medical exams before being licensed while there is a huge capacity shortfall in the system. British Columbia, Alberta and Nova Scotia however, recently reviewed its license registration to fast-track the licensure of internationally trained practitioners to address shortage of medical personnel in their provinces (Altlantic, 2023). A similar approach should be encouraged and implemented in other provinces, to address the personnel supply gap in the system.

**Empowerment of Allied Medical Professionals-** To support the current medical capacity in healthcare, the Medical Association in collaboration with the government can promote initiatives that empower and increase the job functions of auxiliary professionals (e.g. nurses, physician aids, occupational therapist) to include drug prescription, ordering of diagnostic imaging and patient treatment. A specialized assessment and on-the-job supervision can be introduced to achieve this. While this initiative could pose some ethical and medical risks to the profession, the risks can however be minimized by additional level of quality control and supervision procedures (Ferguson).

**Co-Funding for Basic Medical Coverage**: Apart from the co-funding which applies to extended health insurance, co-funding for basic medical coverage can be introduced across provinces to reduce the financial burden of basic medical services on the government. A varying ratio of co-funding can be adopted across provinces based on certain socio-economic parameters. This will encourage responsible use of basic medical services as individual patient will now have to share in the resulting cost.

## Implications for Business Analytics Managers

The following are the implications of this research project for a business analytics manager. As a business analytics manager reviewing the wait time for medical services in Canada, the following are the key implications of this review;

1. Identifying Bottlenecks: Through the analysis, the manager can identify the specific points in the healthcare system where wait times are prolonged, such as appointment scheduling, diagnostic tests, specialist referrals, or surgical procedures. This information is crucial for targeting areas that require improvement.
2. Resource Allocation: Analyzing wait times can help in optimizing resource allocation. By understanding the demand and capacity for medical services, we can allocate resources more efficiently, such as doctors, nurses, hospital beds, and medical equipment, to reduce wait times.
3. Cost Management: Prolonged wait times can lead to higher costs for patients, healthcare providers, and the overall healthcare system. Reducing wait times can help manage costs by preventing complications from delayed treatments and reducing the need for emergency interventions.
4. Patient Satisfaction: Long wait times can negatively impact patient satisfaction and experience. Improving wait times can enhance patient satisfaction, leading to better patient retention and positive word-of-mouth referrals.
5. Health Outcomes: Extended wait times may result in worsening health conditions for patients. Reducing wait times can improve health outcomes by providing timely access to medical services, leading to better treatment outcomes and reduced morbidity.
6. Compliance and Regulations: In some regions, there might be regulations or government targets related to maximum allowable wait times for certain medical procedures. Ensuring compliance with these standards is essential, and analytics can help track and report progress.
7. Identifying Trends and Patterns: By analyzing historical data, the manager can identify trends and patterns in wait times, enabling me to make data-driven decisions for implementing interventions and improvements.
8. Benchmarking: The manager can compare wait times in different healthcare facilities or across regions to identify best practices and areas for improvement. Benchmarking against high-performing facilities can provide valuable insights into potential strategies to reduce wait times.
9. Forecasting Demand: Utilizing predictive analytics, the manager can forecast future demand for medical services, allowing for proactive planning and resource management to prevent potential surges in wait times.

Overall, as a business analytics manager, the review of Canada’s wait time is critical for driving data-informed decisions that can lead to substantial improvements in reducing wait times for medical services, resulting in enhanced patient care and overall operational efficiency within the healthcare system. Top of Form

# Works Cited

Atlantic, CTV News. "Nova Scotia nursing college sees influx of applicants after fast-tracking licensing." 16 May 2023. *CTV News.* <https://atlantic.ctvnews.ca/nova-scotia-nursing-college-sees-influx-of-applicants-after-fast-tracking-licensing-1.6400630>.

Barua, Mackenzie Moir and Bacchus. "Waiting Your Turn, Wait Times for Healthcare in Canada." 2022.

CIHI. *Canadian Institute for Health Information*. 17 November 2022. <https://www.cihi.ca/en/health-workforce-in-canada-in-focus-including-nurses-and-physicians/overview-impacts-of-covid-19-on>.

Belle, Ashwin, Raghavendra Thiagarajan, S. M. Reza Soroushmehr, Fatemeh Navidi, Daniel A. Beard, and Kayvan Najarian. “Big Data Analytics in Healthcare: Promise and Potential.” Health Information Science and Systems 4.1 (2016): 3.

Canadian Institute for Health Information (CIHI). "Organ transplants in Canada: Donations and need." CIHI, 2022, [www.cihi.ca/en/organ-transplants-in-canada-donations-and-need](http://www.cihi.ca/en/organ-transplants-in-canada-donations-and-need). Accessed 27 June 2023.

Drummond D., Sinclair D., et al. Troubles in Canada’s Health Workforce: The Why, the Where, and the Way out of Shortages. Commentary 630, C.D Howe Institute, November 2022.

Ferguson, Sarah Lord. “Supply and Demand in the Canadian Healthcare System”. Sage Publication, 2022.

Ferguson, Sarah Lord. *Supply and Demand in the Canadian Healthcare System*. City: SAGE Publications, 2022.

Fraser Institute. "Waiting Your Turn: Wait Times for Health Care in Canada, 2021 Report." Fraser Institute, 15 Dec. 2021, [www.fraserinstitute.org/studies/waiting-your-turn-wait-times-for-health-care-in-canada-2021-report](http://www.fraserinstitute.org/studies/waiting-your-turn-wait-times-for-health-care-in-canada-2021-report). Accessed 27 June 2023

Government of Canada. “Canada’s Health Care System”. September 17, 2019 (<https://www.canada.ca/en/health-canada/services/health-care-system/reports-publications/health-care-system/canada.html>

[**https://sk-sagepub-com.libaccess.senecacollege.ca/cases/supply-and-demand-in-the-canadian-healthcare-system**](https://sk-sagepub-com.libaccess.senecacollege.ca/cases/supply-and-demand-in-the-canadian-healthcare-system)**.**

https://www.cbc.ca/news/politics/canadian-doctor-struggle-to-get-licensed-1.6890254#:~:text=Canada%20is%20grappling%20with%20a,they%20need%20to%20practice%20here.

<https://www.cihi.ca/en/podcast/dr-judy-morris-canadas-health-workforce-crisis#:~:text=Canada%20is%20facing%20an%20unprecedented,large%20cohort%20entering%20retirement%20age>.

<https://www.news-medical.net/health/What-is-Telemedicine.aspx>

<https://www.statcan.gc.ca/en/subjects-start/population_and_demography/40-million>

Low, Chinyao, Ya-Yueh Chen, and Mingchang Wu. “Understanding the Determinants of Cloud Computing Adoption.” Industrial Management & Data Systems 111.7 (2011): 1006-1023.

Morris, Judy. “Canada’s Health Workforce Crisis. Canadian Health Information Podcast”. Canadian Institute for Health Information. October 21, 2022.

[Primary health care providers, 2019 (statcan.gc.ca)](https://www150.statcan.gc.ca/n1/pub/82-625-x/2020001/article/00004-eng.htm)

Raghupathi, Wullianallur, and Viju Raghupathi. “Big Data Analytics in Healthcare: Overview and Perspective.” Journal of Medical Systems 40.2 (2014): 1-6.

Statistics Canada. “Canada's population reaches 40 million”. June 19, 2023

Statistics Canada. “Primary Health Care Providers, 2019”. October 22, 2020.

Tasker, John P. “Canadian-born family doctor struggles to come home through a wall of red tape”. Morning Brief. CBCNews, June 28, 2023.

Thomas, Liji. “What is Telemedicine”. News Medical Life Science, January 18, 2023,