Enhancing Patient Care: Machine Learning's Role in Reducing Wait Times for Medical Procedures

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***Abstract*—The healthcare system faces a critical challenge with extended wait times for medical procedures, significantly impacting both patients and healthcare professionals. While increasing funding and hiring more doctors may seem like effective solutions, these approaches are often impractical due to various constraints. This research examines the factors driving medical procedure wait times in Canada, specifically in British Columbia, Nova Scotia, and Quebec, highlighting the urgent need to address delays caused by resource limitations. By leveraging machine learning techniques—including random forest methods, k-means clustering, and linear regression—alongside statistical models such as bar graphs, correlation matrices, and z-score normalization, the study, conducted in both Python and R Studio, identifies key contributors to these delays. Based on the findings, a strategic approach to physician hiring is proposed, emphasizing the optimization of seniority levels. Specifically, the study recommends capping the hiring of entry-level doctors at 18% and senior-level doctors at 5%, while increasing the absolute population of entry-level physicians by 27% and reducing the physician-to-100,000 population ratio by 2%, which could lead to a 15% reduction in wait times. By addressing the complexities of medical procedure delays, this research aims to enhance the efficiency and fairness of surgical care delivery.**

***Index Terms*—Canadian medical system; clustering; medical wait times; decision trees; medical care analysis**

I. INTRODUCTION

The duration patients wait for surgical procedures is a key measure for assessing the effectiveness and availability of healthcare systems. In Canada, there is often more demand for timely surgeries than resources available, resulting in extended wait times that can substantially impact patient well-being and public health in general. It is crucial for policymakers, healthcare professionals, and patients to comprehend the factors that lead to these wait times.

Despite concerted efforts to enhance operational efficiency within the healthcare sector, significant disparities in wait times for surgical procedures continue to exist among various provinces and territories in Canada. These variations stem from a complex interplay of factors such as differences in healthcare infrastructure, the distribution of medical personnel, patient demographics, and the allocation of resources. Rectifying these discrepancies necessitates thoroughly examining the root causes and adopting tailored interventions to streamline the provision of surgical services.

The main goal of this research project is to examine the waiting periods for a range of surgical procedures in diverse Canadian provinces, including **British Columbia**, **Nova Scotia**, and **Quebec**. The aim was to pinpoint the primary elements impacting these wait times using an extensive dataset encompassing patient characteristics, surgery types, and healthcare resource metrics. This analysis sought to reveal important patterns and fluctuations that can provide valuable insights for policymakers and contribute to enhancements in surgical wait times on a national scale.

This research seeks to answer several critical questions:

1) What are the average **wait times** for different types of surgeries across the 3 Canadian provinces, and what practices contribute to these differences?
2) How do factors such as the ratio of **medical professionals** to the population, healthcare infrastructure, and patient demographics influence surgical wait times?
3) What is the ratio of **seniority levels** for physicians that achieve the lowest wait times?

Machine learning tools—including the random forest method, k-means clustering, and linear regression—were employed alongside statistical models such as bar graphs, correlation matrices, and z-score normalization. Data analysis and insight extraction were conducted in Python and R Studio. The findings will highlight the current state of surgical wait times across Canadian provinces and provide actionable recommendations for healthcare policymakers and administrators who aim to reduce wait times and enhance patient care.

The paper contains an overview of existing literature on surgical wait times, detailed descriptions of the datasets used and methodology, presenting the findings, and discussing their implications for healthcare policy and practice. This comprehensive analysis aims to contribute to ongoing efforts to enhance the efficiency and equity of surgical care in Canada.

The remainder of this paper is organized as follows: the next section discusses Related Work and the Methods employed. This is followed by the Data section, which addresses the relevance of the data. In the Analysis section, we present the preliminary findings from the data. The Discussion section reviews these findings. Finally, we conclude with the Conclusion and Future Work sections.

II. RELATED WORK | METHODS

Marshall et al. [1] conducted a unique study that focused on the increase in long wait times for physicians and the impact these wait times have on healthcare workers. The researchers analyzed surveys sent to Nova Scotia physicians in which physicians were asked about the challenges experienced due to these long wait times and whether they had any suggestions for improving the wait times. This study saw that 22% of the responses mentioned that they had to work outside their expertise because of the long wait times, resulting in longer treatment times and potentially lower quality treatments. The participants suggested that more trained physicians are needed to reduce Canada's long wait times issue, highlighting the importance of changes to the way physicians are hired in Canada.

Expanding on this issue Liddy et al. [2] analyzed wait times from primary care clinics across Canada, focusing on the wait times between referral and appointment. The study took wait time information from 22 primary care clinics across seven provinces. They were able to conclude the median national wait time of 78 days. They also found that Saskatchewan and British Columbia maintained the shortest waits while New Brunswick and Quebec had the longest. Reinforcing the disparities in healthcare access across Canada and the need for region specific changes.

Similar issues were found Cole et al. [3] focused on urological surgery patients to try and identify bottlenecks and find factors for identifying wait times. The researchers looked at 322 charts of patients undergoing surgery and studied certain data points to find predictors for wait times. Through this data, the researchers determined an average wait time of 75 days. Their analysis also showed that 47% of the wait time is accounted for in the time from referral to decision. The study strongly emphasized this factor because, generally, this period is not recorded or considered when looking at wait time reduction policies. Emphasizing the inefficiencies within the referral process and how it should be considered when looking to improve wait times.

Taking a broader approach, Naiker et al. [4] examined articles from significant health databases in search of patterns or similarities between the articles to find a more effective means of combating long wait times in Australia. The 152 articles that were investigated showed three significant factors contributing to wait times: resource alignment, operational efficiency, and process improvement. This research suggests that focusing on these three areas would result in the most considerable improvement in wait times.

Jaakkimainen et al. [5] researched the wait times from referral to appointment with a physician. The study focused on data from the Electronic Medical Record Administrative Data Link Database and included wait times and the personal characteristics of each patient, such as age and socioeconomic status. According to the study, patients' personal characteristics have no relationship with wait times. They were able to find the median wait times for both medical and surgical specialists and concluded that their findings showed much longer wait times than those presented by governmental sources. According to the researchers, this discrepancy is most likely due to the exclusion of waiting after a referral for an appointment.

Finally, Stanfinski et al. [6] thoroughly investigated the methods that positively improve wait times from decision to treatment. The study examined interviews, studies, and documents from 17 countries to identify consistent factors for improving wait times. Multiple reviewers properly vetted the records, with duplicates and non-eligible records removed. The analysis revealed eight approaches that displayed strong evidence for positive wait time improvement, with the strongest approach being targeted funding.

This research focuses primarily on the impact of the seniority level of physicians on wait times, with additional analysis of population ratios, cases, and physicians. These factors are often not considered when studying medical wait times, so little research has been conducted on these relationships. As a result, this analysis provides a unique insight into the factors that potentially impact medical wait times.

III. Data

This section looks into the data that was used for this analysis. It covers how the original datasets were cleaned and manipulated to create the final datasets. Finally, it covers the overall structure of the cleaned datasets.

A. Original Datasets

Two datasets were used for this analysis of surgical wait times across Canada. The first evaluated surgical wait times from 2008 to 2022 across British Columbia, Quebec, and Nova Scotia are based on comprehensive data from provincial health databases and hospital records. Data was taken from Canada Expenditure Data (1975-2023) [7], Canada Physician Data and Population (1971-2022) [8], and Canada Priority Procedure Wait Time Data (2008-2023) [9]. Additionally, detailed reports on BC Surgical Wait Times (2009-2023) [10], along with practitioner services and expenditures by local health authorities and specialties [11], provide an in-depth understanding of healthcare resources and expenditures impacting surgical wait times.

The second data set used more recent data, Canada's expenditure data (1975-2024) [12], Canada's physician data and population (1971-2023) [13], and wait times priority procedures in Canada (2013-2023) [14]. This second data set evaluated wait times across all provinces, with added expenditure columns for each province. This allowed for further evaluation of the factors affecting surgical wait times across Canada.

B. Data Structure

In this analysis, 17 dimensions were utilized, each playing a crucial role in shaping the findings and conclusions, as shown in Table I. These dimensions encompass key factors such as physician seniority and wait times for essential surgeries across the three provinces.

For the second data set, 24 dimensions were used and evaluated. This data set is similar to the original, with a few new notable columns. The population ratio is the number of physicians over 100,000 in each province. Various types of spending include drug, public health, administration, other institutions, and professional and additional health spending, seen in Table II.

TABLE I: DESCRIPTION OF VARIABLES USED IN DATASET 1

Code	Definition
Year	Fiscal year of data recording (2008-2022).
Province	Province where data was recorded (British Columbia, Quebec, Nova Scotia).
Health Region	Specific regions within each province.
Surgery Type	Types of surgeries recorded.
Wait Times (50th Percentile)	Median wait times for surgeries.
Wait Times (90th Percentile)	90th percentile wait times for surgeries.
Number of Cases	Total number of cases for each surgery type.
Number of Physicians	Total number of physicians for each surgery type.
New Graduates (0-5 years)	Number of physicians with 0-5 years of experience.
Graduates (6-20 years)	Number of physicians with 6-20 years of experience.
Graduates (21-35 years)	Number of physicians with 21-35 years of experience.
Graduates (>36 years)	Number of physicians with more than 36 years of experience.
Population	Total population served in each health region.
Total Expenditure	Total spending on all specialist categories from the Surgery Type column across the three provinces for different fiscal years.
Hospital Expenditure	Total spending on all specialists by health region in the three provinces for different fiscal years.
Physician Expenditure	Total spending on physicians in all specialist categories across the three provinces for different fiscal years.

C. Data Cleaning and Integration

Initial examinations of the dataset involved identifying missing values, resolving inconsistencies, and correcting formatting errors that obscured the integrity of the information. Once each dataset was cleaned, they were linked to their respective dataset. This involved merging records from diverse datasets using shared identifiers, such as year, province, health region, and type of surgery. This resulted in the two datasets necessary for the analysis.

D. Creation of Final Dataset

Two new columns were created using binning.

1) **Graduates**: Physicians were categorized according to their experience level.
2) **Wait Time**: The waiting times were sorted into two groups: the 50th percentile and the 90th percentile. The 50th percentile is the average wait time for all the data that 50% of the data fit into. The 90th percentile represents the average wait time below which 90% of the data points fall to better analyze the outliers.

TABLE II: DESCRIPTION OF VARIABLES USED IN DATASET 2

Code	Definition
Province	Province the data was recorded.
Health Region	Specific region within each province.
Year	Fiscal year of data recording (2008-2023).
Surgery Type	The type of surgery recorded.
Wait Times (50th Percentile)	Median wait times for surgeries.
Wait Times (90th Percentile)	90th percentile wait time for surgeries.
Number of Cases	Total number of cases for each type of surgery.
Specialty	Specialty of Physicians.
Number of Physicians	Total number of Physicians for each type of surgery.
New Graduates (0-5 years)	Number of graduates with 0-5 years of experience.
Graduates (6-20 years)	Number of graduates with 6-20 years of experience.
Graduates (21-35 years)	Number of graduates with 21-35 years of experience.
Graduates (>36 years)	Number of graduates with more than 36 years of experience.
Population	Population within each province of that year.
Population Ratio	The ratio of physicians to the 100,000 population within each province.
Hospital Spending	Yearly hospital spending within each province.
Other Institution Spending	Yearly spending on other institutions within each province.
Physician Spending	Yearly spending on physicians within each province.
Other Professionals	Yearly spending on other healthcare-related professionals.
Drug Spending	Yearly spending on drugs within each province.
Public Health Spending	Yearly public health spending within each province.
Administration Spending	Yearly administration spending within each province.
Other Health Spending	Yearly spending outside of other spending columns.
Total Spending	Yearly total spending within each province.

E. Binning Process:

Wait times were grouped into different categories based on their frequency. Each category represented a particular range of wait times, improving analysis of the frequency of different wait times in different areas.

Categorizing graduates based on their experience levels using binning highlighted the impact of experience on surgical wait times. Each category represented a cohort of graduates with a five-year range of experience, enabling examination into how these varying levels of experience affect the attainment of shorter surgical wait times.

F. Final Dataset Description

The first dataset comprises records of over 10,000 surgical procedures performed in three Canadian provinces. The second dataset contained over 6,000 records of wait times across all provinces and health regions. These are a comprehensive collection of crucial information, including the year of the surgery, the province where it was carried out, the specific type of surgery, and the corresponding wait times. Initial analysis extracted summary statistics illustrating the distribution of key variables and the disparities observed across various regions.

IV. Analysis and Methodology

This section discusses the methodologies used to evaluate each research question outlined in the Introduction.

A. Question 1. Wait times across provinces

All surgical procedures were compared during the examination rather than focused on specific operations. Bar graphs were used to present the average wait times in the 90th percentile for all surgeries across the three provinces, as shown in Figure 1. This figure shows that Quebec has the highest average wait times, followed by Nova Scotia and British Columbia.

In the second dataset, another bar graph was used to visualize the mean wait time between the provinces depicted in Figure 2. The study focused on British Columbia, Quebec, and Nova Scotia to gain more accurate insight. This graph shows that Nova Scotia has the highest average wait times of the 90th percentile. Quebec is the second highest, and British Columbia has the lowest, similar to Figure 1. A correlation matrix was constructed on all features to better understand the relationships within the data visualized in Figure 3. This data set only compared the average wait times between the three provinces.

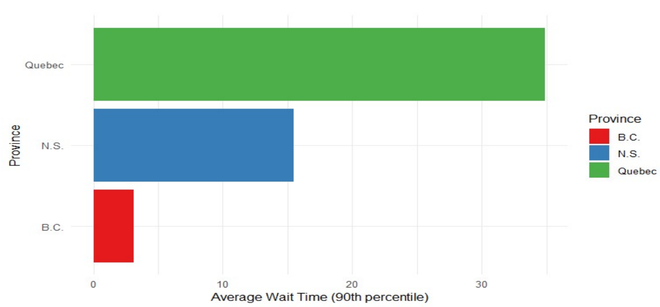


Fig. 1. Average Wait Time by Province Across All Surgery Types Dataset 1

B. Question 2. The effect of external factors

The Random Forest method was used as a regression tool to determine the factors most influential when predicting waiting times for all surgeries. The random forest method creates multiple decision trees and uses the average of the results to make the final decision tree. This is a more robust tool than decision trees because it is less likely to overfit the data [15]. An essential step in this analysis was determining the five regions with the longest and shortest wait time. This was

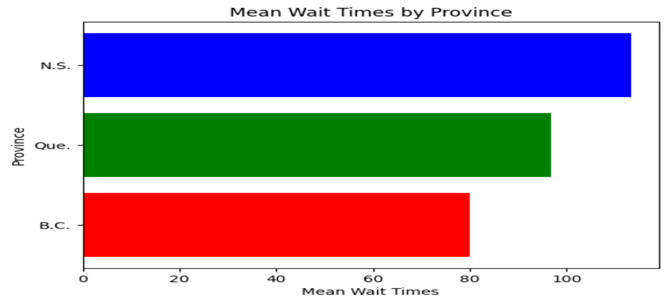


Fig. 2. Average Wait Time by Province Across All Surgery Types Dataset 2.

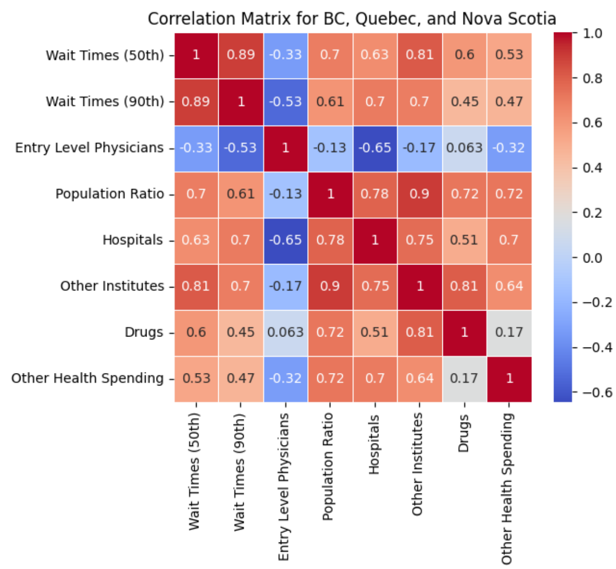


Fig. 3. Surgical Wait Time Correlation Matrix for BC, Quebec, and Nova Scotia Abbreviated for Formatting

done to narrow the focus on the regions of significance. Data from those key regions was used for the rest of the analysis.

Key factors analyzed included population, number of cases, number of physicians, and how many of each type of Doctor was employed in that region. Before running the algorithm, data was split into training and testing data with a 0.7 ratio for training data and a random seed. Feature importance was determined using importance scores for each feature. To predict wait times based on the features present in the dataset.

In the second dataset, z-score normalization was used on the data given by:

$$Z = \frac{X - \mu}{\sigma} \tag{1}$$

where:

- Z: The Z-score, which represents the number of standard deviations a value X is from the mean.
- X: The value for which the Z-score is being calculated.
- μ: The mean of the dataset.
- σ: The standard deviation of the dataset.

This equation is used to bound the values in each column between -1 and 1. This prevents scale from affecting future predictions. To predict values of wait times in the 50th percentile, Linear regression with backward elimination was used. The three provinces were analyzed to predict wait time data for the 50th percentile. Linear regression is a statistical analysis tool used to predict the value of the dependent variable. Backward elimination is a variable selection procedure that considers all independent variables and removes each variable that does not meet the criterion for elimination. The criterion for elimination in this analysis was having a p-value more significant than the 5% threshold. Z-score normalization is where the original value has the mean subtracted from it and then divided by the standard deviation to put it between 1 and -1 so that all values will have equal scaling [16]. After creating a model, the predicted changes to reduce the wait times using minimizing calculations and inverse transforms were performed.

C. Question 3. Seniority level of physicians

The analysis conducted for question 2 found that the wait time for medical services was significantly influenced by the ratio of the experience level of doctors to the total number of doctors in each region. For example, the ratio of entry-level doctors to the total number of doctors in an area was particularly influential. K-means clustering was employed to visually represent the dataset's variations to better understand these differences. K-means clustering allows the grouping of the data so that data points within each group are more similar than data points in other groups. This process involves the initial random placement of cluster centers, followed by the random assignment of each data point to a specific cluster. Subsequently, the algorithm iterates to minimize the distance between the data points and the cluster centers by reassigning points and adjusting the center positions [17].

After analyzing the importance scores using the random forest method, it was identified that the abundance of each doctor category in the area was the most crucial factor, as depicted in Figure 4. Subsequently, clustering was conducted based on the proportion of different types of doctors (e.g., entry-level, intermediate-level, mid-level, and senior level) relative to wait times for all surgical procedures. Establishing the decision boundary and cluster centers aimed to determine the optimal number of each type of doctor required to minimize wait times in different health regions.

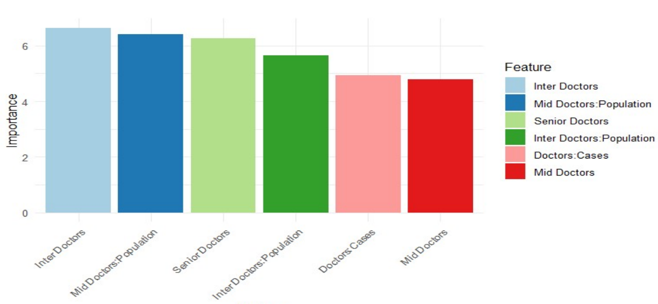


Fig. 4. Six Most Important Features in Determining Wait Times

Similarly, in the second dataset, the ratio and experience of physicians were an influential factor when predicting wait times of the 50th percentile. Specifically, entry-level and senior physicians were the most influential factors when predicting wait time. The physician-to-population ratio was also found to be a very important factor.

The coefficient values were taken to calculate the percentage change of the independent variables, found in Table III. The normalized values of the average value were calculated in each column of the independent variables using 1. The minimize function in the Scipy library was used to determine the changes necessary to find a specific value from the linear regression equation. The target value was determined as 75 days because of the average wait time in Sweden for hip surgeries since it has a very low average wait time with a similar system to Canada [18]. The results gave normalized values of the independent variables necessary to reach this number, which was converted using 1. Equation 1 was adjusted to revert the data back to its original scale.

These results found the percentage change based on the original means of the new values. Showing that the linear regression equation could be used to predict necessary changes to lower wait times.

V. Discussion | Evalution

This section will analyze and discuss the results for each research question using advanced analytical tools and methodologies. Each question is addressed separately in the following sections..

A. Question 1. Wait times across provinces

This initial analysis from Figure 1 suggests that the shortest wait times may predominantly originate from B.C. This prompts further exploration into what unique factors in B.C. may differentiate it from the other provinces. The results from the second dataset appeared to confound these findings as well.

The findings from the correlation matrix created from the second dataset in Figure 3, show results with negative correlations of -0.33 and -0.53 for entry-level physicians with wait times of the 50th and 90th percentile, respectively. The physician population ratio has a high positive correlation of 0.7, with hospitals at 0.63, other institutions at 0.81, drugs at 0.6, and other health spending at 0.53. This provides evidence that the ratio of physicians to population and these areas of spending have strong relationships with wait times in both the 50th and 90th percentiles. These findings indicate potential predicting factors of wait times. Overall, the second dataset positively correlated with the overall physician population ratio, spending on hospitals, drugs, other institutions, and other health spending. With negative correlations with entry-level physicians. These findings show that certain age groups could have an effect on lowering wait times across provinces, while spending in certain areas may not lower wait times.

B. Question 2. Effect of external factors

After comprehensively analyzing the chosen features and their impact on wait times, the random forest method was

TABLE III. LINEAR REGRESSION RESULTS

Dependent Variable:	Wait Times (50th Percentile)					
R-squared:	0.756					
Adjusted R-squared:	0.738					
F-statistic:	42.36					
Prob (F-statistic):	1.25e-12					
	coef	std err	t	P>|t|	[0.025	0.975]
Constant	96.6855	2.751	35.149	0.000	91.130	102.241
New Graduates (0-5 years)	-32.9924	4.909	-6.720	0.000	-42.907	-23.078
Graduates (>36 years)	29.2295	4.887	5.982	0.000	19.361	39.098
Physician-Population Ratio	23.0773	2.776	8.314	0.000	17.471	28.683

used for prediction. This method proved to be effective and relatively accurate in forecasting wait times. The performance metrics evaluated included Mean Absolute Error (MAE), Mean Squared Error (MSE), and R-squared value (RSQ). MAE represents the average difference between the predicted and actual wait times. MSE is similar to MAE but squares the differences, giving more weight to larger disparities. RSQ serves as a measure of how well the regression line can predict the actual data values [19]

TABLE IV. PERFORMANCE METRICS OF RANDOM FOREST REGRESSION CLASSIFIER

Metric	Combined (C)	Shortest (S)	Longest (L)
Wait Time (WT)	12.76	3.16	49.47
MAE	4.23	2.24	17.88
MSE	47.77	16.54	413.26
RSQ	0.87	-0.10	0.25

The analysis was initially conducted separately for the five regions with the shortest wait times, the five regions with the longest wait times, and the combined dataset for the shortest and longest wait time regions. The results are in Table IV.

We analyzed the wait times in the combined dataset and obtained the following results:

The average wait time for the combined dataset was 12.76 days. The average for the shortest wait times was 3.16 days; it was 49.47 days for the longest. The MAE values were low across all columns, indicating minimal error in the predictions.

The MSE for the combined data was 47.77, which is relatively high compared to the mean value. For the shortest wait times, the MSE was 16.54, suggesting good accuracy. However, the MSE was significantly high for the most extended wait times at 413.26, indicating substantial error for the most significant values.

The RSQ value for the combined dataset was 0.87, meaning the predictions accounted for 87% of the variance. For the shortest wait times, the RSQ value was -0.1, indicating a poor fit. For the longest wait times, the RSQ value was 0.25, showing that the model explained 25% of the variance but did not represent the data well.

After analyzing the data, it was found that the combined dataset produced the most accurate results and the highest RSQ. As a result, it was decided to concentrate on the combined model and dataset for further analysis. The MAE value was favorable, representing a low percentage of the average wait time for the combined dataset (33%). This indicates that the error is acceptable and the model's predictions are reliable. While the MSE is relative to the values in the dataset, the calculations revealed that it is only 27% of the squared average wait time. This suggests there may be some more significant errors, but overall, the model's performance is satisfactory. Furthermore, the high RSQ value demonstrates that the regression model effectively captures underlying patterns in the data and serves as a strong predictor of wait times.

During the study, it was crucial to thoroughly evaluate this method. The data derived from this method played a critical role in the third part of the analysis. Fine-tuning was performed to enhance the precision of this method and guarantee the utilization of the most precise information.

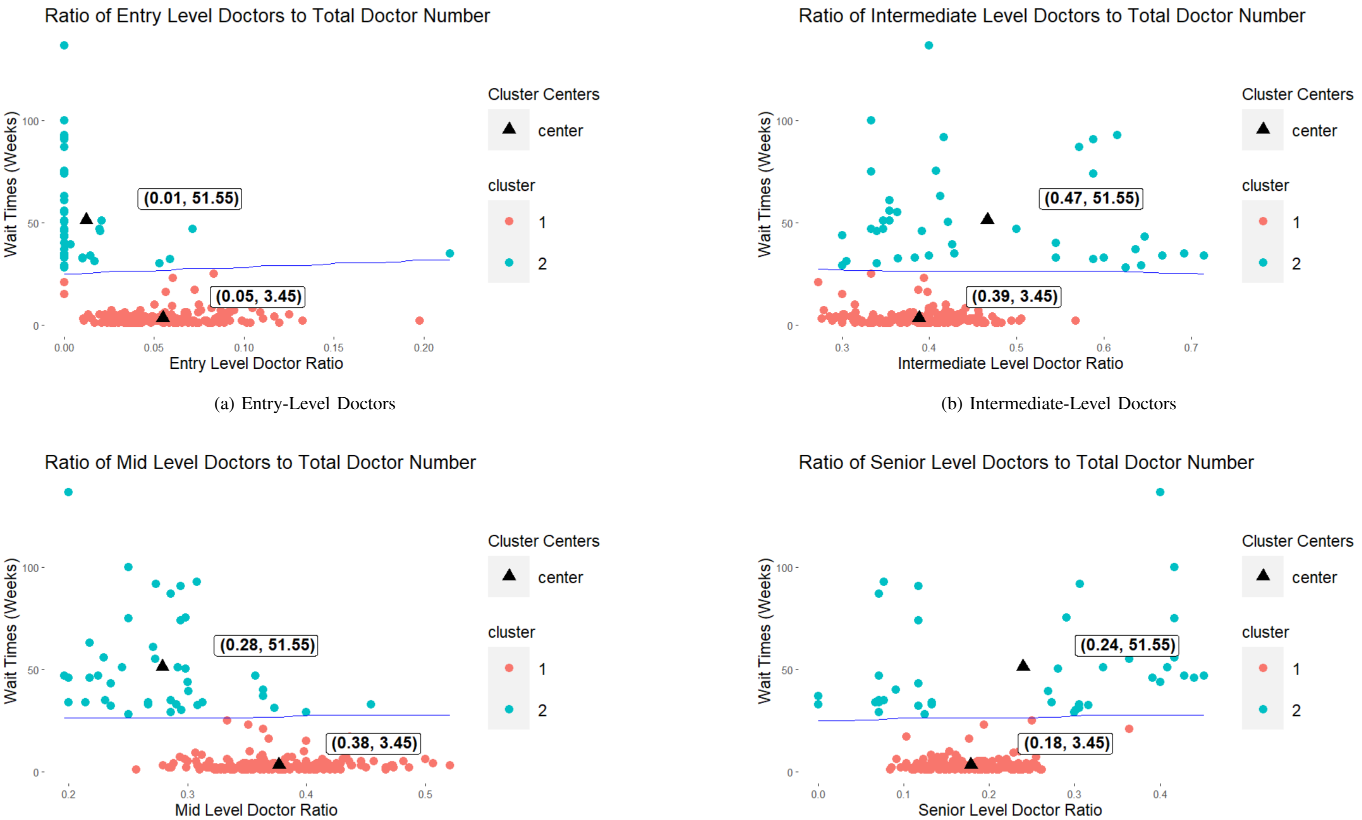
It was found that linear regression produced the best results for the second dataset. After normalization on the dataset, a regression equation was run using backward elimination to produce the results in Table III With an RSQ of 0.756 and an adjusted RSQ of 0.738, this model accounts for 74% of the variance in the dependent variable in the dataset, with the independent variables suggesting this model is a good fit. The model is statistically significant with a high F-statistic of 42.36 and a low p-value of 1.25 e-12. This data shows that this model is significant, and the findings are relevant.

C. *Question 3. Seniority levels of physicians*

In this analysis, the random forest model was used to determine the importance scores for each variable when predicting wait times. The results showed that there were four distinct features within the dataset. Specifically, the seniority level ratio among physicians employed in the healthcare region was a significant factor. Among these four features related to the ratio of doctor types to the total number of doctors, the top 7 features were observed, ranked by importance, and included the ratios of various doctor types. Interestingly, the intermediate and mid-level doctor ratios were essential in predicting wait times.

To expand on the analysis, k-means clustering was conducted on the ratio of doctors within each experience level. The clustering was performed on entry-level, intermediate-level, mid-level, and senior-level doctors and wait times. The resulting clusters are visually represented in figures 5a, 5b, 5c, and 5d.

The clustering analysis grouped healthcare regions into long and short wait time clusters based on physician ratios, with centroids calculated to determine the optimal proportion of doctors at each experience level. Figure 6 visualizes these



(a) Entry-Level Doctors

(b) Intermediate-Level Doctors

(c) Mid-Level Doctors

(d) Senior-Level Doctors

Fig. 5. K-Means Clustering of Doctors and Wait Times Across Different Levels.

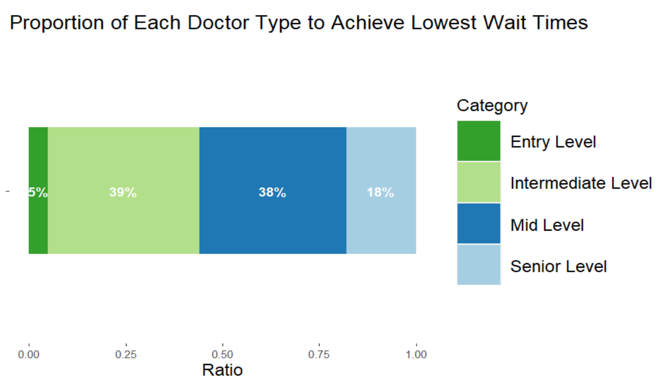


Fig. 6. K-means clustering of senior level doctors and wait times.

proportions within the short wait time cluster, highlighting the importance of recruiting doctors in strategic ratios rather than simply increasing overall numbers.

This insight supports the concept of a "magic ratio", where healthcare regions with shorter wait times maintain a specific balance of physician experience levels. Adhering to this ratio is expected to reduce wait times, while deviations significantly increase delays for critical procedures. To optimize workforce planning, healthcare facilities should limit the combined hiring of entry-level and senior-level doctors to 25% of total staff capacity, ensuring a balanced distribution that enhances accessibility and efficiency

Using the model created by the second dataset in Table III, it can be seen that three columns are the most significant in predicting wait times in the 50th percentile. Entry-level graduates have a negative correlation coefficient of -32, senior physicians have a positive correlation coefficient of 29, and the physician-population ratio is 23. This information shows that as the number of entry-level graduates increases, the wait times decrease within the provinces. While the senior physicians and physician-population ratio increases, the wait times across the provinces also increase. From this, an increase in entry-level graduates with a freeze on senior-level physicians could help reduce the physician-population ratio and thus decrease the wait times across the provinces. The next step in the analysis was to evaluate the optimal percentage change in the independent variables to reach optimal wait times. Using the median wait time of hip surgeries in Sweden gathered from the OECD [18] of 75 days, this was used as a target to determine the percentage change needed to reach this value. After minimizing the model with the constraint that senior-level doctors cannot be lowered, the inverse transform of the results is performed, and the percentage change is calculated. It was found that for entry-level graduates, a 27.22% increase and a -2.7% decrease in the physician-population ratio would reduce the predicted wait times to the target 75 days. Upon examination, it is essential to consider the factors contributing to this phenomenon. This analysis suggests that physicians just starting their careers or nearing the end of their professional journey may exhibit decreased efficiency in patient care. However, the abundance of new physicians could help reduce wait times due to external factors such as their ability to develop new skills to accommodate new issues within the healthcare system. It is reasonable to expect new doctors to be less efficient, as they are still in the learning phase and refining their skills. On the other hand, doctors with 35 or more years of experience would have developed the expertise and protocols necessary to care for many patients efficiently. While they may outperform new doctors, they do not appear as effective as mid-career and seasoned doctors. This indicates that these more experienced doctors may be operating at a reduced level due to additional factors. With continued worries about a straining healthcare system, maintaining a manageable physician-population ratio may be critical to prevent further issues arising from the ever-increasing wait times for surgeries across the provinces.

It is crucial to emphasize the significance of hiring experienced doctors with less than 35 years of experience since graduation. Most of the workforce should comprise middle- and intermediate-age groups to ensure patients receive timely and efficient care.

VI. Conclusion and Future Work

This paper focuses on the factors influencing wait times for medical procedures in Canada, specifically analyzing data from British Columbia, Nova Scotia, and Quebec over several years. The research identified a significant link between wait times and the seniority levels of physicians. To address this, the paper suggests strategic hiring practices in healthcare facilities: limit entry-level doctors to 18% and senior-level doctors to 5%. Additionally, increasing the number of entry-level physicians by 27% and reducing the physician-to-100,000 population ratio by 2% could potentially decrease wait times by 15%. The study aims to improve the efficiency and fairness of surgical care in Canada by thoroughly examining wait times and their contributing factors.

This research provides a limited look at the relationship between physicians' seniority, physician-population ratios, and wait times for medical procedures, based on a small sample from three provinces. To better understand how physician seniority affects wait times, the study should include data from more provinces and territories across Canada. More specific details on surgeries and their wait times are necessary. By expanding the data, we can analyze wait times for specific procedures and identify ways to reduce delays, particularly for high-priority or high-volume cases. Linking types of surgeries to relevant physicians can highlight areas in Canadian healthcare that need improvement. Additionally, applying advanced machine learning and statistical methods can enhance the findings and lead to stronger conclusions.

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