

International Journal of Population Data Science

Journal Website: www.ijpds.org



Orthopedic and ophthalmology surgical service forecast modelling in Manitoba: Research approach for a data linkage study

Alan Katz^{1,2,*}, Hannah Owczar¹, Carole Taylor¹, John-Michael Bowes¹, and Ruth-Ann Soodeen¹

Submission History

Submitted:	27/10/2023
Accepted:	04/08/2023
Published:	16/10/2023

¹Manitoba Centre for Health Policy, Dept of Community Health Sciences, Rady Faculty of Health Sciences, University of Manitoba, Winnipeg, MB R3E 3P5 Canada

²Department of Family Medicine, Rady Faculty of Health Sciences, University of Manitoba, Winnipeg, MB R33 0W2 Canada

Abstract

Background

The healthcare system in Manitoba, Canada has faced long wait times for many surgical procedures and investigations, including orthopedic and ophthalmology surgeries. Wait times for surgical procedures is considered a significant barrier to accessing healthcare in Canada and can have negative health outcomes for patients. We developed models to forecast anticipated surgical procedure demands up to 2027. This paper explores the opportunities and challenges of using administrative data to describe forecasts of surgical service delivery.

Methods

This study used whole population linked administrative health data to predict future orthopedic and ophthalmology surgical procedure demands up to 2027. Procedure codes (CCI) from hospital discharge abstracts and medical claims data were used in the modelling. A Seasonal Autoregressive Integrated Moving Average model provided the best fit to the data from April 1, 2004 to March 31, 2020.

Results

Initial analyses of only hospital-based procedures excluded a significant portion of provider workload, namely those services provided in clinics. We identified 500,732 orthopedic procedures completed between April 1, 2004 and March 31, 2020 (349,171 procedures identified from hospital discharge abstracts and 151,561 procedures from medical claims). Procedure volumes for these services are expected to rise 17.7% from 2020 (36,542) to 2027 (43,011), including the forecasted 43.9% increase in clinic-based procedures. Of the 660,127 ophthalmology procedures completed between April 1, 2004 and March 31, 2020, 230,717 procedures were identified from hospital discharge abstracts and 429,410 from medical claims. Models forecasted a 27.7% increase from 2020 (69,598) to 2027 (88,893) with most procedures being performed in clinics.

Conclusion

Researchers should consider including multiple datasets to add information that may have been missing from the presumed data source in their research approach. Confirming the completeness of the data is critical in modelling accurate predictions. Forecast modelling techniques have evolved but still require validation.

Keywords

orthopedic; ophthalmology; surgical service forecasts; data linkage; health policy

*Corresponding Author:

Email Address: alan.katz@umanitoba.ca (Alan Katz)

Introduction

The single-payer universal healthcare system in the province of Manitoba, Canada has long been faced with high wait times for orthopedic and ophthalmology surgeries, which have been exacerbated by the COVID-19 pandemic [1, 2]. These wait times are considered a significant barrier to accessing healthcare and can have negative health outcomes for patients [3–5]. These include increased anxiety and pain, worsened health status and increased recovery time [6]. According to Manitoba Health, wait times can vary month by month and are caused by several factors which include patient choice and condition, the complexity of the treatment, and follow-up care [7].

Wait times in Manitoba are among the highest in Canada. Between 2020 and 2021, wait times for cataract surgeries were the second longest in the country, with only 39% of patients receiving surgery within the 16-week recommended benchmark, compared with the national average of 66%. Just 55% of eligible patients received hip replacement surgeries between April 2020 and September 2021 within the 26-week benchmark, and 38% of eligible patients received knee replacement surgery within the same benchmark [1].

A significant contributor to high wait times in Canada is resource allocation. In the case of most jurisdictions, available funds do not meet all demands for healthcare services. In Canada, patients can expect to wait for services [8]. In the case of orthopedic and ophthalmology procedures, a range of resources are required including trained staff, i.e., surgeons, anesthetists, nurses, and surgical equipment such as artificial joints. Additionally, intensive care beds and other facilities inside of hospital are necessary to support these surgical procedures [9]. The aging nature of the population has also increased demands on healthcare services across Canada [10]. Allocating resources based on population demand is considered a policy goal in many countries [11], however due to limited resources, healthcare managers are forced to set priorities for supplying care based on established healthcare policy goals to maximise impacts on population health [11].

In recent years, Manitoba Health has determined reducing surgical wait times to be a key healthcare policy objective [9, 12]. To assist with planning and to prepare for future resource allocation to meet this policy objective, we developed service forecasts for orthopedic and ophthalmology surgery procedures. The goal of this paper is to demonstrate the potential of using linked administrative data in forecasting service provision to support planning.

Methods

Study setting

The healthcare system in Canada is administered and funded by provincial governments. Healthcare priorities are set in the single payor Canadian system by provinces, and funding for service provisions are determined based on available resources and population need. Both orthopedic and ophthalmology procedures are completed in hospitals and in clinics depending on the procedure type. Whereas hospital services are provided

based on the availability of provincially funded resources such as joint replacement parts and trained staff, clinic-based procedures are controlled by the physicians who provide these services on a fee-for-service basis. While the fee-for-service funding does come from the provincial health department, the health department does not control the availability of these services. The limiting factor in the provision of clinic-based services is the availability of the physician in contrast to hospital-based procedures which are limited by provincial budget allocations for hospital-based nurses, other staff and equipment required for many procedures.

Data sources

Data included in this study are housed in the Manitoba Population Research Data Repository (Repository) located at the Manitoba Centre for Health Policy (MCHP). The Repository is a comprehensive population-based selection of administrative data on the health and social status of residents in Manitoba [13]. Data in the Repository does not contain personal identifying information, but data can be linked across datasets and time at a personal level using scrambled numeric identifiers [13].

In this study, health data and one registry were included. Initially, just procedure codes (CCI) from hospital discharge abstracts were used, which identified in-hospital surgical procedures. However, it was determined that using the procedure codes alone resulted in an incomplete capture of the procedures of interest. While many procedures were completed in facilities that complete and submit hospital discharge abstracts, it became clear that this data source did not include all the relevant procedures. Data from medical claims provided physician billings (tariff codes) for procedures performed outside of hospital or for procedures not resulting in a hospital discharge abstract. Additionally, data from the Provider Registry determined physician specialty. The inclusion of both hospital-based procedure codes and physician billing codes from community practice ensured that all procedures were included. To avoid duplication of procedures, medical billing claims that were also represented by a hospital admission were considered a duplicate and therefore dropped. 97.5% of ophthalmology procedures found in hospital discharge abstracts were linked to a billing claim, along with 83.6% of orthopedic procedures. As not all physicians are paid on a fee-for-service basis, and not all who are paid by alternative means submit shadow billing, it is not expected that 100% of procedures found in a discharge abstract will also show up in a billing claim.

Both hospital discharge abstracts and physician billing data were used to build the forecast models as described below. The COVID-19 period was not included in the development of the models, but forecasts for this period are included, even though they were not achieved due to the pandemic. Procedures provided outside of Manitoba (determined to reflect less than 1% of each category) were excluded.

All Manitobans aged 18 years and above registered for healthcare services for the entire study period were included in the analyses. CCI and tariff codes used in this study were described elsewhere by Katz and colleagues [14].

Forecast models

The monthly patterns of service provision in the training data set (from April 1, 2004 to March 31, 2018) were explored to determine the most appropriate models to describe the data. Seasonal Autoregressive Integrated Moving Average (SARIMA) was determined to be the best modelling approach, which was confirmed on the validation dataset (from April 1, 2018 to March 31, 2020).

Stationary time series data, where statistical properties such as mean, variance, and autocorrelation are all constant over time [15], is relatively easy to predict because we assume that the statistical properties will remain the same in the future as they were in the past. Non-stationary data, such as the monthly patterns of service provision used in this study, which exhibit seasonality and a trend, are unpredictable and cannot be modelled or forecasted without first transforming them into stationary data.

SARIMA models are commonly used for prediction or forecasting series that exhibit trend/seasonality, and therefore, are most useful for short forecast intervals. SARIMA models are usually denoted by $ARIMA(p,d,q)(P,D,Q)_s$, where s represents the seasonal length in the data (e.g. 12 for monthly data), and the lowercase and uppercase notations represent the non-seasonal and seasonal components of the model respectively. These values are referred to as hyperparameters. For instance, p and seasonal P indicate the number of autoregressive terms (lags of the stationary series), d and stationary D indicate the number of differencing that is done to make the time series stationary, and q and seasonal Q indicate the number of moving average terms (lags of the forecast errors). Three models are presented for both orthopedic and ophthalmology procedures: one based on total procedures, another on procedures performed in hospitals, and a third with procedures performed in clinics.

The monthly patterns of service provision were split into a training dataset (April 1, 2004, to March 31, 2018), used for creating the SARIMA models, and a validation dataset (April 1, 2018, to March 31, 2020), which was used to test the model's predictive power. The selected model was then applied to the entire dataset for forecasting purposes.

We employed the Box-Jenkins three-step modelling approach [16] to develop the models in this study. First, we plotted the monthly service provision against time to see if there were any trends or seasonality in our data. We also used the Box-Cox transformation method [17] to determine if any transformations of the data were necessary. The presence of trend/seasonality was corrected for non-stationarity by differencing or logarithmic data transformation. Next, we examined the Autocorrelation Function (ACF) and Partial Autocorrelation Function (PACF) of the differenced data to determine possible models to be estimated. We then fitted models of varying orders of both p and q and used the Schwarz Bayesian Criterion (SBC) and the Mean Absolute Percentage Error (MAPE) to select the most appropriate model for our forecasting purposes.

Our initial intent was to include the projected population estimates for our forecast period stratified by age and sex as input variables in our SARIMA models. However, due to the lack of reliable age and sex projection estimates we used

a multiplier that is based on the actual trend of Manitoba population growth over time. We focused on the trend for those aged 60 and over in the period between 2012 to 2020. We regressed the current population on the past to determine the rate of growth. This rate of growth was used to adjust our annual forecasts as presented in this study. More information on the SARIMA model used in this study is described by Katz and colleagues [18].

Results

Orthopedic surgical procedures

We identified a total of 500,732 orthopedic procedures completed between 2004 and 2020. Of those, 349,171 procedures were identified from hospital (in-patient and day surgery) discharge abstracts with orthopedic CCI codes, and 151,561 procedures were identified using physician billing for procedures not found in hospital discharge abstracts. Orthopedic procedures associated with hospital discharge abstracts are major procedures and include surgeries such as joint replacements. Procedures linked to physician billing codes are minor procedures such as joint injections and casting of fractures. More than one-third of hospital-based surgeries fell into one of three categories: hip replacements, knee replacements, and knee repairs.

Orthopedic service forecasts are presented in Figure 1. Procedure volumes are expected to increase 17.7% from 2020 forecasts (36,542) to 2027 (43,011). As shown in Table 1, much of this growth is due to the forecasted 43.9% increase in clinic-based procedures from 11,081 (95% CI 8,759–12,705) in 2020 to 15,951 (95% CI 3,481–27,418) in 2027. Only a 17.4% increase is forecasted for hospital-based procedures. Table 1 presents the forecasted counts.

Ophthalmology surgical procedures

There were 660,127 ophthalmology procedures completed between April 1, 2004 and March 31, 2020. Less than half (230,717) of these procedures were identified within hospital abstracts with CCI codes. The majority (84%) of hospital-based services were cataract surgeries. The Medical Claims File included an additional 429,410 clinic-based procedures which were incorporated in the models.

As shown in Figure 2, the number of ophthalmology procedures are expected to continue to increase, with the curve increasing slightly in later years of the forecast. The SARIMA models forecasted a 27.7% increase from 2020 (69,598) to 2027 (88,893), with most of these procedures being performed in clinics (from 51,400 to 90,425); see Table 2. Hospital-based procedures are forecasted to increase over the same period (from 17,566 to 23,496) by 33.8%. Table 2 presents the forecasted counts.

Discussion

Within universal coverage healthcare systems there is a need to plan service provisions that meet population needs. However, determining population needs is challenging. While there are

Figure 1: Orthopedic surgical procedures in Manitoba

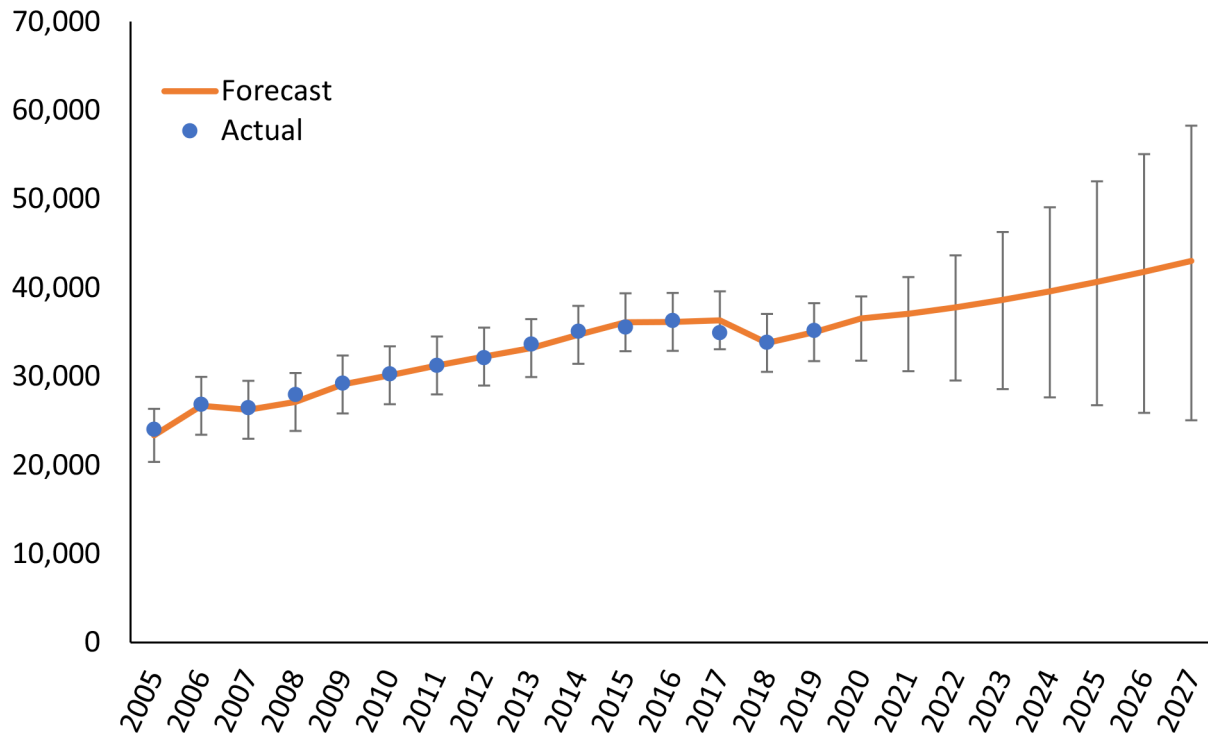


Table 1: Orthopedic procedure forecasts in Manitoba by location of procedure

Fiscal year*	Clinic		Hospital	
	Actual	Forecast (95% CI)	Actual	Forecast (95% CI)
2005	9,153	8,593 (7,103–10,082)	16,287	16,458 (13,931–18,986)
2006	8,010	8,421 (6,796–10,046)	18,832	17,912 (15,385–20,439)
2007	7,712	7,280 (5,654–8,905)	18,755	19,113 (16,586–21,640)
2008	7,576	7,439 (5,814–9,064)	20,377	19,636 (17,109–22,164)
2009	7,766	7,568 (5,943–9,193)	21,454	21,382 (18,855–23,909)
2010	8,223	8,101 (6,476–9,727)	22,045	22,013 (19,486–24,540)
2011	8,779	8,697 (7,072–10,322)	22,447	22,562 (20,035–25,089)
2012	9,208	9,337 (7,712–10,962)	22,887	22,919 (20,392–25,446)
2013	10,003	9,789 (8,163–11,414)	23,628	23,473 (20,946–26,000)
2014	10,641	10,633 (9,008–12,258)	24,436	24,081 (21,554–26,608)
2015	10,814	10,840 (9,215–12,465)	24,735	25,120 (22,593–27,647)
2016	11,103	11,185 (9,559–12,810)	25,188	25,076 (22,549–27,603)
2017	10,709	11,274 (9,649–12,900)	24,204	25,097 (22,570–27,624)
2018	10,340	10,291 (8,666–11,916)	23,500	23,845 (21,318–26,372)
2019	10,781	10,867 (9,242–12,493)	24,393	24,298 (21,771–26,825)
2020		11,081 (8,759–12,705)		25,550 (22,065–27,429)
2021		11,409 (7,927–14,173)		26,160 (21,972–28,703)
2022		11,894 (7,143–15,897)		26,825 (22,125–29,837)
2023		12,494 (6,380–17,822)		27,489 (22,381–30,869)
2024		13,200 (5,631–19,939)		28,140 (22,692–31,820)
2025		14,012 (4,897–22,246)		28,776 (23,035–32,708)
2026		14,929 (4,179–24,740)		29,399 (23,399–33,552)
2027		15,951 (3,481–27,418)		30,012 (23,777–34,361)

*Fiscal Year is from April 1st to March 31st the following calendar year.

CI = confidence interval.

significant issues associated with health service predictions, health system planners need to employ the available tools to meet their mandate.

A key advantage of administrative data in a single-payer system is that it is population based. This provides a significant advantage for future service needs forecasts. This

Figure 2: Ophthalmology surgical procedures in Manitoba

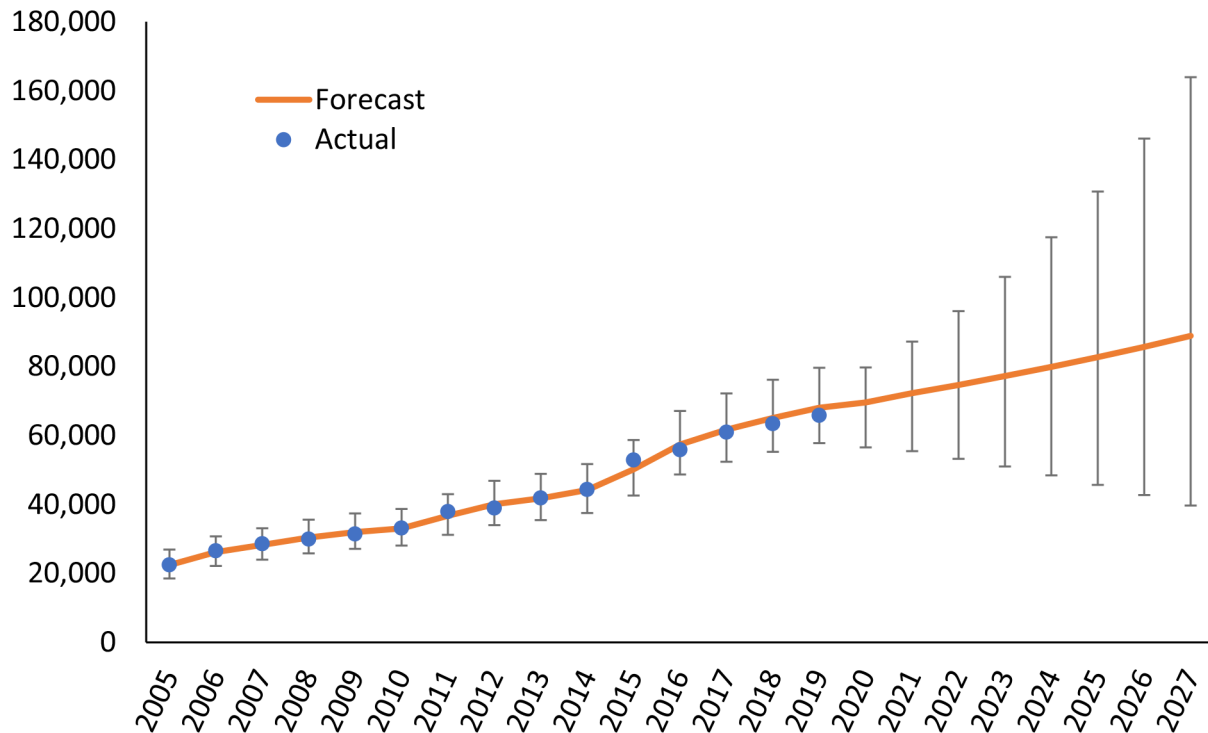


Table 2: Ophthalmology procedure forecasts in Manitoba by location of procedure

Fiscal year*	Clinic		Hospital	
	Actual	Forecast (95% CI)	Actual	Forecast (95% CI)
2005	12,857	12,213 (9,646–15,259)	10,480	10,465 (8,126–13,270)
2006	13,322	13,800 (11,205–16,814)	13,258	11,731 (9,350–14,534)
2007	14,978	14,210 (11,567–17,274)	13,645	13,312 (10,618–16,481)
2008	15,993	16,085 (13,094–19,553)	13,986	14,240 (11,358–17,629)
2009	17,636	17,718 (14,424–21,539)	13,803	14,470 (11,542–17,915)
2010	19,743	19,431 (15,818–23,620)	13,440	14,211 (11,335–17,594)
2011	23,201	23,684 (19,280–28,790)	14,748	14,273 (11,384–17,671)
2012	24,212	25,039 (20,384–30,438)	14,767	14,957 (11,930–18,517)
2013	26,052	25,770 (20,978–31,326)	15,827	15,863 (12,653–19,640)
2014	29,060	28,885 (23,515–35,114)	15,312	15,825 (12,622–19,592)
2015	37,304	35,548 (28,939–43,213)	15,609	16,201 (12,922–20,058)
2016	40,068	42,523 (34,616–51,691)	15,820	16,012 (12,771–19,823)
2017	44,789	45,579 (37,104–55,406)	16,195	16,503 (13,163–20,432)
2018	46,985	48,347 (39,357–58,771)	16,454	16,739 (13,352–20,724)
2019	48,454	49,811 (40,550–60,551)	17,389	17,844 (14,233–22,093)
2020		51,400 (39,371–62,120)		17,566 (13,360–21,359)
2021		53,441 (36,320–71,617)		18,695 (13,560–23,695)
2022		56,025 (32,242–85,870)		19,255 (13,163–25,667)
2023		59,510 (28,162–105,450)		20,106 (13,150–27,805)
2024		64,163 (24,119–132,735)		20,876 (13,080–29,896)
2025		70,426 (20,332–170,765)		21,726 (13,098–32,085)
2026		78,889 (16,889–224,214)		22,589 (13,132–34,327)
2027		90,425 (13,844–300,049)		23,496 (13,199–36,659)

*Fiscal Year is from April 1st to March 31st the following calendar year.

CI = confidence interval.

study demonstrates the importance of adjusting the research approach to fully capture the relevant data prior to developing the models. Using just the procedure codes was found to

miss services done outside of hospital facilities that submit discharge abstracts. While hospital facilities are crucial for many procedures, planning for future service provision needs

to include physicians who also perform services outside of hospitals. Adding medical claims, which provided physician billing, identified a range of procedures performed in clinics and for procedures not resulting in a hospital discharge abstract. This was especially important in capturing ophthalmology procedures, as less than half of these procedures were identified within hospital abstracts.

The forecasted increase in service provision growth is more than twice as high for clinic-based orthopedic procedures than hospital-based procedures. Annual joint replacements in Manitoba are capped by the number of artificial joints purchased by Manitoba Health and limited by the availability of more intensive hospital services. In contrast, clinic-based procedures are largely under the control of the physicians who provide those services. Ophthalmology procedures show a similar pattern with most of the increases being in clinic-based procedures where the broader healthcare system does not yield as much influence on service provision. These system issues, which are highly dependent on provincial funding priorities, have resulted in significant waitlists for the hospital-based procedures included in this analysis.

Previously, service forecast models developed by MCHP have included population forecasts, which recognise that population size and the sex-and-age distribution influence service use [19]. In this study, separate population forecasts were not included in the modelling. The more sophisticated SARIMA models were found to take general population growth into account, but the forecast models presented do include a factor that adjusts for the disproportionate growth of the age groups where the procedures of interest are more frequently provided.

The accuracy of the forecast models in this study is limited as the data do not include backlogs reflected in patients waiting for hospital-based procedures. Forecasts are based on past usage which differs from the actual needs of the population. Wait lists for orthopedic and ophthalmology surgeries are long in Manitoba, indicating that past usage does not meet the population demand for procedures. It is reasonable to expect that provision of services forecasted by the model would result in ongoing wait lists. Addressing the backlog of services that existed prior to the COVID-19 pandemic would require an increase in the number of services provided which would be more than those suggested by the models. Adding wait list information is not possible in the study as the Repository does not include wait list data, and the data that are available are not of sufficient quality to include in forecasts.

An additional limitation of this study is that forecasts are unable to predict changes in medical and surgical practices that could impact whether a surgical procedure is required. Moreover, the models do not consider the reduction in surgical procedures during the COVID-19 pandemic from March 2020 to April 2022, which has increased the already extensive backlog for surgical procedures.

Conclusion

Service provisions for both orthopedic and ophthalmology surgical procedures have grown steadily over the last 15 years. Manitoba faces a growing demand for orthopedic

and ophthalmology surgeries which are highlighted in this study.

Forecast modelling science is a valuable tool for healthcare managers to better prepare and plan for future resource allocation. We chose to end the validation period at the onset of the pandemic, recognising the impact of the pandemic on care provision.

Forecast modelling is a rapidly evolving field with the development of multiple modelling choices created by machine learning, a subset of artificial intelligence. The forecasts presented in this study are based on models with a high degree of predictive accuracy, however the validity of the models depends on the completeness of the data included. It is essential to include all available data and to recognise the limitations of the forecasts based on data availability.

Acknowledgment

The authors acknowledge the Manitoba Centre for Health Policy (MCHP) for use of data contained in the Manitoba Population Research Data Repository under project 2022–001. We also acknowledge Manitoba Health for providing the data. We would like to thank Okechukwu (Oke) Ekuma for his contributions to the analysis and manuscript.

Statement of conflict of interest

The authors have no conflicts of interest to declare.

Ethics statement

We acknowledge the University of Manitoba Health Research Ethics Board for their review of the proposed research project. The Health Information Privacy Committee (HIPC; now replaced by the Provincial Health Research Privacy Committee) was informed of this deliverable. This project is under HIPC/PHRPC #2021/2022-36.

References

1. Canadian Institute for Health Information. Wait times for priority procedures in Canada [Internet]. 2022 May [cited 2022 25]; Available from: <https://www.cihi.ca/en/wait-times-for-priority-procedures-in-canada>.
2. Doctors Manitoba. Surgery & Diagnostic Backlog Dashboard: New Estimates & Progress [Internet]. 2022 Jun. [cited 2022 1]; Available from: <https://doctorsmanitoba.ca/about-us/advocacy-policy/backlog>.
3. Hodge W, Horsley T, Albani D, Barylka J, Belliveau M, Buhrmann R, et al. The consequences of waiting for cataract surgery: a systematic review. CMAJ [Internet] 2007 Apr. [cited 2022 9];176:1285–90. Available from: <https://www.cmaj.ca/content/176/9/1285>. <https://doi.org/10.1503/cmaj.060962>.

4. MacKinnon JC. Wait times in Canada. *Healthc. Manag. Forum* [Internet] 2017 Jul. [cited 2022 5];30:190–2. Available from: <https://journals-sagepub-com.uml.idm.oclc.org/doi/full/10.1177/0840470417700162>. <https://doi.org/10.1177/0840470417700162>.
5. Naimer MS, Aliarzadeh B, Bell CM, Ivers N, Jaakkimainen L, McIsaac W, et al. Specialist wait time reporting using family physicians' electronic medical record data: a mixed method study of feasibility and clinical utility. *BMC Prim. Care* [Internet] 2022 Apr. [cited 2022 6];23:1–14. Available from: <https://pubmed.ncbi.nlm.nih.gov/35392824/>. <https://doi.org/10.1186/s12875-022-01679-x>.
6. Segall RE, Takata JL, Urbach DR. Wait-time reporting systems for elective surgery in Canada: a content analysis of provincial and territorial initiatives. *C. Open* [Internet] 2020 [cited 2022 5];8:E844–51. Available from: https://www-clinicalkey-com.uml.idm.oclc.org/service/content/pdf/watermarked/1-s2.0-S229100262100014X.pdf?locale=en_US&searchIndex=. <https://doi.org/10.9778/cmajo.20200033>.
7. Manitoba Health. Understanding Wait Times [Internet]. [cited 2022 6]; Available from: <https://www.gov.mb.ca/health/waittime/why.html>.
8. Vanberkel PT, Blake JT. A comprehensive simulation for wait time reduction and capacity planning applied in general surgery. *Health Care Manag. Sci.* [Internet] 2007 Dec. [cited 2022 6];10:373–85. Available from: <https://www.proquest.com/docview/227944912/fulltextPDF/D8A65B02295C4BB2PQ/1?accountid=14569>. <https://doi.org/10.1007/S10729-007-9035-6>.
9. Wait times reduction task force. Wait times reduction task force final report [Internet]. 2017 [cited 2022 14]. Available from: <https://www.gov.mb.ca/health/documents/wtrtf.pdf>.
10. Wister A V., Speechley M. Inherent Tensions Between Population Aging and Health Care Systems: What Might the Canadian Health Care System Look Like in Twenty Years? *J. Popul. Ageing* 2015;8:227–43. <https://doi.org/10.1007/s12062-015-9123-1>
11. Mercuri M, Birch S, Gafni A. Using small-area variations to inform health care service planning: What do we “need” to know? *J. Eval. Clin. Pract.* [Internet] 2013 Dec. [cited 2022 25];19:1054–9. Available from: <https://onlinelibrary-wiley-com.uml.idm.oclc.org/doi/epdf/10.1111/jep.12026>. <https://doi.org/10.1111/JEP.12026>.
12. Manitoba Government. Province investing \$50 million to reduce surgical wait times [Internet]. Press Release 2021 Mar. [cited 2022 12]; Available from: <https://news.gov.mb.ca/news/index.html?item=51063>.
13. Smith M, Lix LM, Azimae M, Enns JE, Orr J, Hong S, et al. Assessing the quality of administrative data for research: a framework from the Manitoba Centre for Health Policy. *J. Am. Med. Informatics Assoc.* [Internet] 2018 Mar. [cited 2022 6];25:224–9. Available from: <https://academic.oup.com/jamia/article/25/3/224/4102320>. <https://doi.org/10.1093/JAMIA/OCX078>.
14. Katz A, Taylor C, Ekuma O, Bowes J-M, Soodeen R-A, Owczar H. Orthopedic and Ophthalmology Surgical Projection Models Manitoba Centre for Health Policy [Internet]. Winnipeg: 2022 [cited 2022 27]. Available from: http://mchp-appserv.cpe.umanitoba.ca/reference/SurgModels_Report_Web.pdf.
15. Brocklebank J, David D, Choi B. SAS for Forecasting Time Series. 3rd ed. Cary, NC: SAS Institute Inc; 2018.
16. Box GEP, Jenkins GM. Time series analysis: forecasting and control. San Francisco: Holden-Day; 1976.
17. Box GEP, Cox DR. An analysis of transformations. *J. R. Stat. Soc. Ser. B* [Internet] 1964;26:211–52. Available from: <https://rss.onlinelibrary.wiley.com/doi/10.1111/j.2517-6161.1964.tb00553.x>. <https://doi.org/10.1111/j.2517-6161.1964.tb00553.x>.
18. Katz A, Ekuma O, Bowes J-M, Soodeen R-A, Owczar H. Appendix 3, SARIMA Model Details [Internet]. In: Orthopedic and Ophthalmology Surgical Projection Models. Winnipeg: Manitoba Centre for Health Policy; 2022 [cited 2023 13]. Available from: http://mchp-appserv.cpe.umanitoba.ca/supp/SurgModels_Appendix3_SARIMA_Model.pdf.
19. Katz A, Chateau D, Taylor C, Koseva I. Revisiting Primary Care Provider Projection Models Manitoba Centre for Health Policy [Internet]. Winnipeg: 2020 [cited 2022 19]. Available from: <http://mchp-appserv.cpe.umanitoba.ca/deliverablesList.html>.

Abbreviations

ACF:	Autocorrelation Function
CCI:	Canadian Classification of Health Interventions
HIPC:	Health Information Privacy Committee
MAPE:	Mean Absolute Percentage Error
MCHP:	Manitoba Centre for Health Policy
PACF:	Partial Autocorrelation Function
PHRPC:	Provincial Health Research Privacy Committee
Repository:	Manitoba Population Research Data Repository
SARIMA:	Seasonal Autoregressive Integrated Moving Average
SBC:	Schwarz Bayesian Criterion