

COVID-19 and the duration of operating room procedures in Ontario: a population-based retrospective study

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Background: Studies have estimated that a large backlog of procedures was generated by emergency measures implemented in Ontario, Canada, at the onset of the COVID-19 pandemic, when nonessential and scheduled procedures were postponed. Understanding the impact of the COVID-19 pandemic on the time needed to perform a procedure may help to determine the resources needed to tackle the substantial backlog caused by the deferral of cases. The purpose of this study was to examine the duration of operating room (OR) procedures before and after the onset of the COVID-19 pandemic to inform planning around changes in required resources.

Methods: A population-based, retrospective cohort study was conducted using Ontario Health Insurance Plan claims data and other administrative health care data from Apr. 1, 2019, to Sept. 30, 2020. Statistical analysis was conducted using multivariate regression, with procedure duration as the outcome variable.

Results: Results showed that the average duration of nonelective procedures increased by 34 minutes during the COVID-19 period and by 19 minutes after the resumption of scheduled procedures. Controlling for physician, patient and hospital characteristics, and the procedure code submitted, procedure duration increased by 12 minutes in the nonelective COVID-19 period and by 5 minutes when scheduled procedures resumed, compared with the pre-COVID-19 period.

Conclusion: Procedures may take longer in the COVID-19 period. This will affect wait times, which had already increased because of the deferral of procedures at the beginning of the pandemic, and will have an impact on Ontario's ability to provide patients with timely care.

Contexte : Selon des études, on estime que la mise en place des mesures d'urgence en Ontario (Canada) au début de la pandémie de COVID-19, qui ont entraîné le report de toutes les interventions planifiées et non essentielles, a mené à l'accumulation d'un retard important des interventions chirurgicales. Comprendre l'incidence de la pandémie de COVID-19 sur le temps nécessaire pour réaliser une intervention pourrait aider à déterminer les ressources requises pour s'attaquer à cet arriéré considérable. Le but de cette étude était d'observer la durée des interventions en salle d'opération avant et après le début de la pandémie de COVID-19 pour mieux planifier les changements aux ressources nécessaires.

Méthodes : Une étude de cohorte rétrospective populationnelle a été menée à l'aide des données sur les réclamations médicales soumises au Régime d'assurance-santé de l'Ontario et d'autres données administratives sur les soins de santé du 1^{er} avril 2019 au 30 septembre 2020. L'analyse statistique a été réalisée au moyen d'une régression multivariable, où la durée de l'intervention constituait la variable dépendante.

Résultats : Les résultats ont montré que la durée moyenne des interventions non urgentes a augmenté de 34 minutes durant la période de restrictions associées à la COVID-19, et de 19 minutes après la reprise des interventions planifiées. En tenant compte de variables comme les caractéristiques du médecin, du patient et de l'hôpital ainsi que des codes d'acte soumis, le temps moyen des interventions a augmenté de 12 minutes pendant la période de restrictions associées à la COVID-19 pour les interventions non urgentes et de 5 minutes après la reprise des interventions planifiées comparativement à la période précédant la COVID-19.

Conclusion : Les interventions peuvent prendre plus de temps en contexte de COVID-19. Cela influencera les temps d'attente, qui ont déjà augmenté en raison du report des interventions au début de la pandémie, et aura des répercussions sur la capacité de l'Ontario à fournir aux patients des soins dans des délais raisonnables.

On Mar. 11, 2020, the World Health Organization (WHO) declared COVID-19 a global pandemic.¹ Since then, 90% of countries have reported an interruption in essential health services caused by both demand- and supply-side factors.² The most reported supply-side factor was cancellation of elective, or scheduled, services to preserve capacity in response to the novel coronavirus. In Ontario, Canada, on Mar. 15, 2020, the Ministry of Health (MOH) asked hospitals to scale down nonessential and scheduled procedures.³ On Mar. 19, 2020, the MOH required that delivery of these services stop or be substantially reduced;⁴ these procedures were resumed on May 26, 2020.⁴ As a result of this restriction, fewer surgeries were performed during the pandemic, and recent literature has estimated a large backlog of procedures generated by the cessation of scheduled services that is estimated to take several months to clear.^{5,6} Postponement of procedures and delays in treatment may substantially reduce the quality of life of affected patients and may have an impact on other health outcomes.⁷

As the province resumes postponed services, the time needed to tackle the substantial wait lists will depend on many interrelated factors and will determine the resources required. However, there is a lack of research on the impact of COVID-19 on factors that may affect wait times and other aspects of clinical care. One factor may be an increase in the time needed to perform a procedure, attributable to COVID-19 hospital protocols or changes in procedure and patient case mix. Longer procedure durations may result in a smaller total number of procedures being performed if operating room (OR) days are not lengthened. This would further increase wait times. If OR days are lengthened, there would be substantial cost and human resource implications that would need to be accommodated.

The objective of this study was to examine and quantify the impact of COVID-19 on the duration of OR procedures using health care administrative claims data from Ontario, Canada. Specifically, we explored the impact of COVID-19 on the duration of procedures performed, first, in a period where only essential or nonelective procedures could be performed in Ontario because of restrictions on health care services relating to COVID-19, and second, in a period where these restrictions were lifted and scheduled procedures were allowed to resume.

METHODS

Study design and setting

We performed a population-based, retrospective study of OR procedures in Ontario, Canada, performed between Apr. 1, 2019, and Sept. 30, 2020, to assess the hypothesis that procedure times increased at the onset of the COVID-19 pandemic. We compared outcomes during the prepandemic period of Apr. 1, 2019, to Mar. 14, 2020,

with 2 separate COVID-19 periods. In the first period (Mar. 15, 2020, to May 25, 2020), defined in this study as the COVID-19 nonelective period, only nonelective procedures were performed because of the Ontario government's requirement that health care capacity be preserved in response to the novel coronavirus. The second period, defined in our study as the COVID-19 elective period, started when scheduled services were resumed on May 26, 2020, and ended on the last date of our study period, Sept. 30, 2020. Data were collected for all OR procedures, including surgical and endoscopy services, performed by a physician (excluding those performed by anesthesiologists or surgical assistants) and billed with an anesthesia time unit indicating that the services were performed in an OR. In an encounter, the physician could bill under more than 1 procedural fee code. For convenience of analysis, we defined a main procedure for each encounter, which was identified by the highest billed amount. The sample of fee codes was restricted to those billed in both the pre-COVID-19 and COVID-19 periods in the claims data. We excluded cancelled procedures, procedures involving multiple physicians and potentially erroneous claims (e.g., the procedure time billed was a negative value).

Data sources

Data were obtained from the MOH under a data-sharing agreement with the Ontario Medical Association. The primary data source for this study was the Ontario Health Insurance Plan (OHIP) database, which tracks claims paid for physician billings for all publicly insured health services in Ontario. The OHIP data were combined with other administrative health care data sets including the Corporate Provider Database for physician demographic data and the Registered Persons Database for patient demographic data.

Estimating procedure duration

Data on procedure duration, the key outcome variable, were obtained from OHIP claims data using codes submitted by anesthesiologists. These codes are expressed in total service units (set-up and duration), where duration units are expressed in 15-minute increments and are based on the total amount of time the anesthesiologist spends with the patient in the OR, beginning when the anesthetic is administered and ending when the patient is safely in postoperative care.⁸ The anesthesia time was determined for the same physician-patient encounter from the code submitted by the anesthesiologist. The anesthesia time, based on total anesthesia service units, was then linked to the main procedure by physician-patient encounter to determine the duration of each procedure, which was converted into the corresponding time value in minutes (e.g., 2 anesthesia units equals 30 min).

Covariates

The data included physician-level, patient-level and hospital-level covariates that may influence procedure duration. Physician-level covariates were age, sex, geographic location and specialty. Patient-level covariates were age, sex and a measure of the complexity of patients' health needs derived from the Canadian Institute for Health Information (CIHI) Population Grouping Methodology (known as the CIHI Pop Grouper).^{9,10} More information on the CIHI Pop Grouper is available in Appendix 1 at www.canjsurg.ca/lookup/doi/10.1503/cjs.011521/tab-related-content. Hospital-level covariates included hospital size.

Statistical analysis

Descriptive analyses were conducted comparing average procedure durations in the pre-COVID-19 and COVID-19 periods. Statistical analysis was conducted using multivariate regression. The outcome variable, procedure duration, was analyzed at the fee code level. The key explanatory variables were an index variable for the COVID-19 period, which classified procedures performed before Mar. 15, 2020, as pre-COVID-19 procedures (index variable value of 0) and procedures performed on and after Mar. 15, 2020, as COVID-19 procedures (index variable value of 1), and an index variable identifying procedures performed in the COVID-19 nonelective period. This term was included to measure the change in procedure duration separately for the 2 COVID-19 periods compared with the pre-COVID-19 period. Five different models of the multivariate regression were analyzed controlling for different sets of covariates. Model 1 was an unadjusted model, while Model 2 included fee code level effects, specified by dummy variables for each fee code in the data, analyzing average duration for the same fee codes before and after the onset of COVID-19. Model 3 controlled for physician characteristics, Model 4 added patient characteristics, and Model 5 included all covariates, all controlling for month of year. Physician age, patient age and hospital size were expressed in quartiles. Descriptive statistics on physician and patient demographic characteristics are included in Appendix 1. Standard errors were adjusted for clustering at the physician level.

Additional sensitivity analyses and falsification tests (method for evaluating the validity of the impact of COVID-19 on procedure duration) were conducted. First, we restricted the sample of fee codes across all periods to those that were billed in the COVID-19 nonelective period. Second, we adjusted for patient condition at the time of surgery captured by anesthesia and premium billing codes in the data (see Appendix 1). From these codes, we were able to identify and restrict the

analysis to procedures on patients with life-threatening, incapacitating systemic disease, patients with severe, activity-limiting disease, moribund patients, patients requiring emergency surgery within 24 hours of OR booking, and patients requiring trauma procedures.

We also identified and restricted the analysis to patients who were in an emergency department within 7 days before their procedure, and to procedures performed during evenings or nights (after hours) and weekends or holidays. Additional analyses restricted procedures to those performed by physicians and hospitals active in both periods. We also considered the sensitivity of the results to the precise definition of the COVID-19 start date by conducting analyses on 3 alternative start dates and performing a falsification experiment by considering only the pre-COVID-19 period and randomly assigning a start date for the pandemic. Analysis was also done by procedure type on the basis of specialty and duration quartiles defined in the pre-COVID-19 period. The impact of COVID-19 was also estimated on the basis of the number of anesthesia time units, instead of time in minutes. Lastly, we included month index variables to estimate the change in procedure duration for each month of the COVID-19 period. All analyses were conducted using Stata 15 (StataCorp) and SAS version 9.4 for Windows (SAS Institute).

RESULTS

We identified 1 295 509 main OR procedures performed by 8968 physicians between Apr. 1, 2019, and Sept. 30, 2020. The distribution of procedure durations before and during the COVID-19 pandemic shows a shift to longer times during the COVID-19 period (Figure 1): the share of procedures with shorter durations (< 75 min) was higher in the pre-COVID-19 period than in the COVID-19 period, which had a higher share of procedures with longer durations (> 75 min) up until around 360 minutes. The average unadjusted procedure duration increased sharply after Mar. 14, 2020, when the MOH asked hospitals to scale down nonessential and scheduled procedures to preserve capacity in response to COVID-19 (Figure 2). There was a gradual decrease in procedure duration coinciding with the resumption of scheduled procedures, but the unadjusted average procedure duration remained longer in the months during the pandemic compared with before the pandemic.

There was a substantial drop in the number of physicians who performed procedures, the number of patients and the number of hospitals where procedures were performed in the COVID-19 period (Table 1). There were large unadjusted differences in average procedure duration between the 2 periods, with greater unadjusted differences in the COVID-19 nonelective period, overall and by selected physician, patient and hospital characteristics (Appendix 1, Table A2).

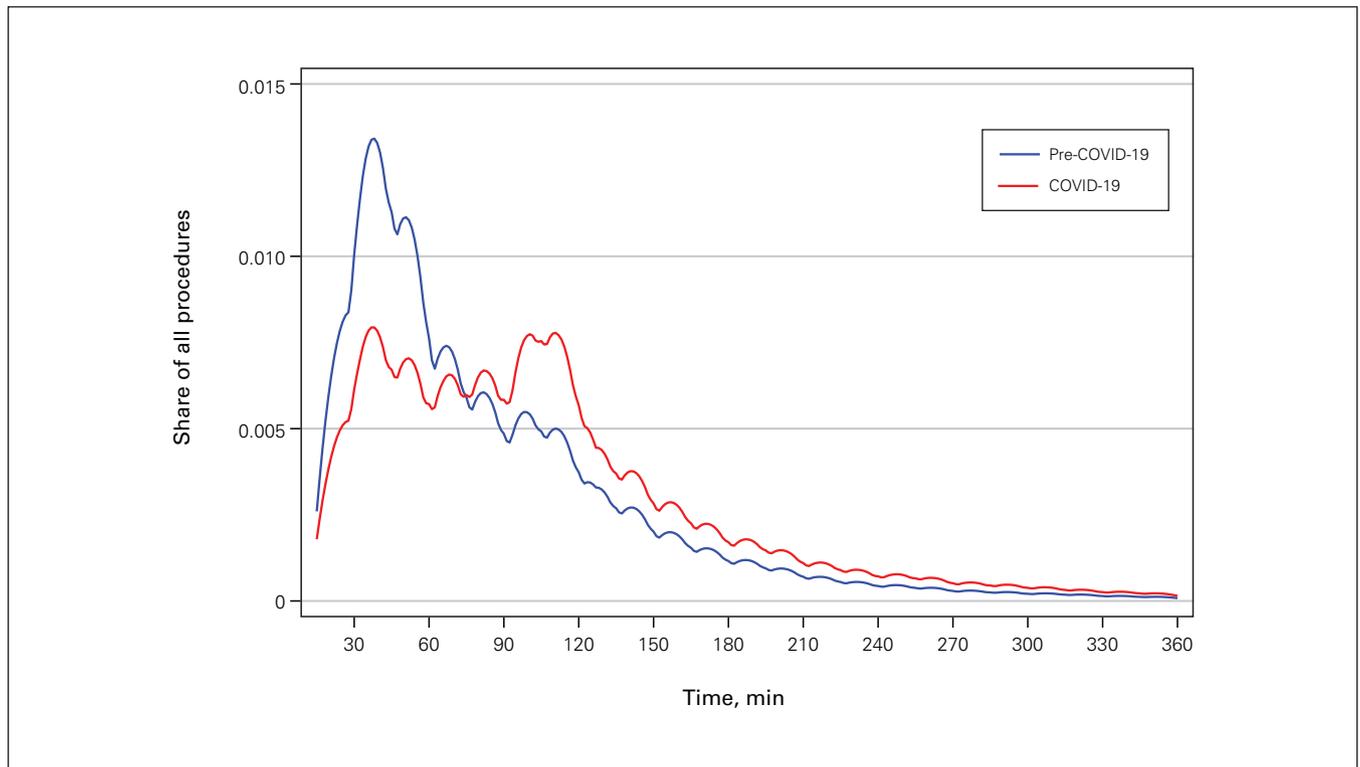


Fig. 1. Unadjusted share distribution of procedure duration by COVID-19 period.

Results of the main analysis in Table 2 showed that procedure duration increased by 34 minutes in the nonelective COVID-19 period and by 19 minutes when scheduled services were resumed. Analysis at the fee code level showed that the impact was around 12 and 5 minutes for procedures performed in the nonelective and elective COVID-19 periods, respectively. This impact was robust to the inclusion of physician, patient and hospital characteristics. These models contained fewer observations than the unadjusted model because they excluded observations with missing data on physician, patient or hospital characteristics.

Sensitivity analyses

Results of the sensitivity analyses are presented in Appendix 1. In an analysis measuring procedure duration across the entire COVID-19 period (no index term for the nonelective period), results showed a 23-minute unadjusted increase in procedure duration compared with the duration in the pre-COVID-19 period, which was reduced to 7 minutes for fee code level analysis (Appendix 1, Table A3). Findings also showed that the COVID-19 impact was robust to the restriction of fee codes billed in the COVID-19 nonelective period (Appendix 1, Table A4) and to physician and hospital restrictions (Appendix 1, Table A5). In the analysis adjusting for patient condition at time of procedure, and for emergency, after-hours, and weekend and holiday

procedures, estimates ranged between 2 and 5 minutes in the elective period and between 9 and 14 minutes in the nonelective period (Appendix 1, Table A5).

When we assessed 3 alternative start dates to the scaling down of scheduled procedures, the procedure durations were slightly shorter than those observed with the true start date of Mar. 15, 2020 (Appendix 1, Table A6). Results of the falsification test with 3 randomly assigned dates in the pre-COVID-19 period indicate that our analysis is robust because the coefficients on these random dates are close to zero (Appendix 1, Table A6). Multivariate regression results with month indicators support the finding that the increase in procedure durations in the COVID-19 period was highest in April 2020 and gradually decreased in the following months (Appendix 1, Table A7). Analysis by surgical time quartiles showed that procedures with longer durations in the pre-COVID-19 period had larger increases during the COVID-19 period (15 min compared with 12 min for the shortest durations), especially during the nonelective period (Appendix 1, Table A8). Using anesthesia time units instead of procedure duration in minutes as the outcome variable in the analysis showed an increase of 2.15 and 0.79 units during the COVID-19 nonelective and elective periods, respectively (Appendix 1, Table A9). Lastly, increases in procedure duration by procedure type ranged from 2 minutes for obstetrics to 23 minutes for hematic and lymphatic surgical procedures (Appendix 1, Table A10).

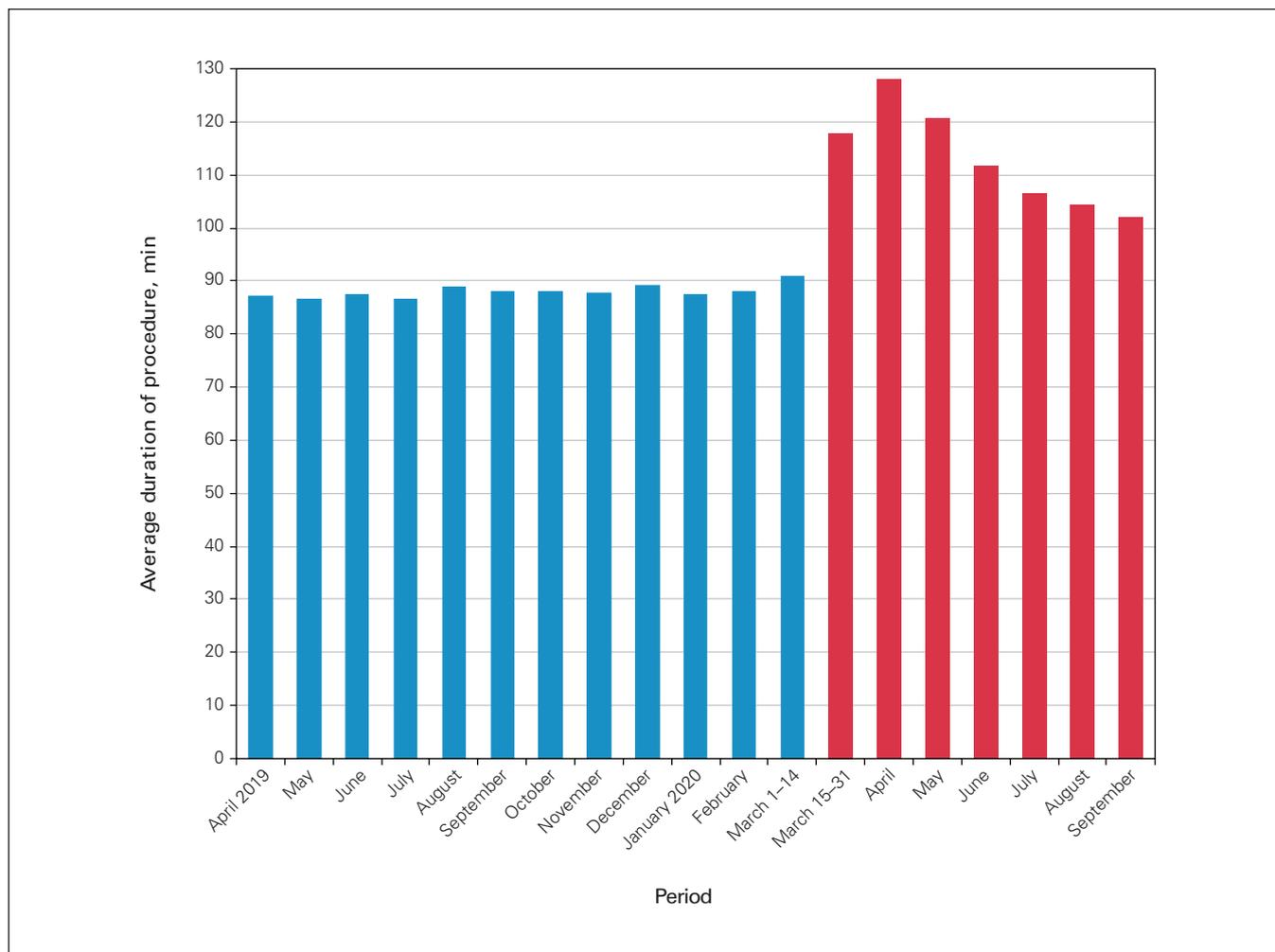


Fig. 2. Unadjusted average procedure duration by month, April 2019 to September 2020.

DISCUSSION

This study documented an overall increase in average procedure duration of around 34 minutes for procedures performed in the nonelective COVID-19 period and 19 minutes for those performed after the resumption of scheduled procedures in Ontario. Analysis at the fee code level controlling for physician, patient and hospital characteristics showed that the average procedure duration increased by around 12 minutes in the nonelective COVID-19 period compared with the pre-COVID-19 period and by 5 minutes when scheduled procedures resumed. Results were robust to sample restrictions including emergency procedures and proxies for severity of patient condition.

Two potential explanations for the increase in procedure duration are that the mix of procedures shifted to those that have longer durations and the average times for the same procedures were longer in the COVID-19 period. The latter may be due to hospital protocols recommended and mandated during the pandemic, including enhanced infection

prevention and control and appropriate use of (and additional donning and doffing of) personal protective equipment, as well as additional time for health care workers to become accustomed to the new protocols.^{6,11-13}

The increase in average procedure duration may in part be attributed to the change in the urgency and complexity of the procedures performed. Although the complexity of patients' health needs was controlled for in the analysis, patients who had a procedure done during the COVID-19 period may have had additional health complications that made it necessary for them to receive medical care. This reflects the focus on nonelective and prioritized scheduled procedures during the COVID-19 period. These patients may also have experienced prolonged waits before receiving care because of either surgical triage or fear and anxiety about seeking medical care during a pandemic, especially among elderly and immunocompromised individuals; such delays may have worsened health conditions and led to more complications.¹⁴ However, this was mitigated in a sensitivity analysis adjusting for severity of patient condition at the time of procedure captured by anesthesia billing codes

Table 1: Sample sizes by COVID-19 period

Category	Total	No. (%); period			
		Pre-COVID-19	COVID-19*	COVID-19 (nonelective period)	COVID-19 (elective period)
Physicians	8968	8219 (92)	6978 (78)	4923 (55)	6430 (72)
Patients	1 104 299	931 918 (84)	211 686 (19)	50 286 (5)	165 713 (15)
Hospitals	478	452 (95)	366 (77)	294 (62)	338 (71)
Distinct OR procedures	1877	1877 (100)	1877 (100)	1381 (74)	1796 (96)

OR = operating room.
*Combination of both the elective and nonelective periods.

Table 2: Multivariate regression results

Variable	Model 1	Model 2	Model 3	Model 4	Model 5
COVID-19	19.1* (0.7)	4.9* (0.3)	4.7* (0.3)	4.7* (0.3)	4.7* (0.3)
COVID-19 nonelective period	14.6* (0.9)	6.9* (0.4)	7.7* (0.4)	7.7* (0.4)	7.7* (0.4)
Physician age quartile					
1 (youngest)					
2			-3.3* (1.0)	-3.4* (1.0)	-3.3* (1.0)
3			-4.3* (0.9)	-4.3* (0.9)	-4.2* (0.9)
4 (oldest)			-4.8* (0.9)	-4.8* (0.9)	-4.7* (0.9)
Physician sex					
Female (ref.)					
Male			-5.5* (0.7)	-5.6* (0.7)	-5.6* (0.7)
Physician location					
Central Ontario (ref.)					
Eastern Ontario			3.8* (0.8)	3.8* (0.8)	3.7* (0.8)
Northern Ontario			-1.6 (1.2)	-1.8 (1.2)	-2.1 (1.2)
Western Ontario			1.3 (0.8)	1.2 (0.8)	1.1 (0.8)
Patient age quartile					
1 (ref.)					
2				-1.2* (0.3)	-1.2* (0.3)
3				-0.9† (0.3)	-0.9† (0.3)
4 (oldest)				-1.1† (0.4)	-1.1† (0.4)
Patient sex					
Female (ref.)					
Male				2.3* (0.1)	2.3* (0.1)
Complexity of patients' health needs quartile					
1 (ref.)					
2				0.3† (0.1)	0.3† (0.1)
3				1.0* (0.1)	1.0* (0.1)
4 (most complex)				3.9* (0.2)	3.9* (0.2)
Hospital size					
1 (ref.)					
2					-7.6† (3.7)
3					-4.5 (3.4)
4 (largest)					-6.2‡ (3.3)
Fee code fixed effects	No	Yes	Yes	Yes	Yes
OHIP specialty fixed effects	No	No	Yes	Yes	Yes
Month of year fixed effects	No	No	Yes	Yes	Yes
Sample size	1 295 509	1 295 509	1 196 418	1 149 378	1 149 170
Adjusted R ²	0.016	0.695	0.701	0.701	0.701

OHIP = Ontario Health Insurance Plan, ref. = reference category.
*Coefficient estimate is significant at the 5% level ($p < 0.05$).
†Coefficient estimate is significant at the 1% level ($p < 0.01$).
‡Coefficient estimate is significant at the 0.1% level ($p < 0.001$).

and emergency and trauma procedures, which are urgent and presumably nonelective. Results of this analysis also showed an increase in average procedure duration in the nonelective COVID-19 period and after elective procedures were resumed, indicating that factors beyond the complexity of patients' health needs at the time of the procedure were contributing to increased average procedure duration.

To our knowledge, no published studies have looked at the impact of COVID-19 on procedure duration; however, several studies conducted before the pandemic have identified important factors that predict duration. One study estimated that almost 32% of total variability in OR time could be accounted for by procedure type.¹⁵ Other studies concluded that team composition and surgeon experience are important factors for improving surgical time prediction.^{16–19} These studies suggest that mix of procedure type and possible changes in surgical team composition may be important factors affecting procedure duration during the COVID-19 period.

Studies estimated the pandemic deficit generated by the emergency measure in Ontario to be 138 000–148 000 procedures by mid-June 2020, with further accumulation of 11 500–12 200 procedures weekly thereafter.^{5,6} Using data that reflected the increased surgical time during the COVID-19 period, 1 study found that the time required to clear the estimated surgical backlog in Ontario caused by the COVID-19 pandemic as of September 2020 was 84 weeks, or approximately 19 months.⁶ Similarly, other studies done in the United States and United Kingdom found that it may take 1–8 months for cardiac surgeries,²⁰ 7–16 months for elective orthopedic surgeries,²¹ 3–8 months for vascular surgery procedures²² and 1–12 months for nuclear medicine services²³ to recover from the pandemic, depending on the capacity to reschedule procedures and the timing. The findings of this study have substantial implications for procedure wait time and backlog planning, especially because the results remained significant even after elective procedures were resumed, which probably reflects a new normal of enhanced infection prevention and control in the OR compared with the period before the pandemic. Understanding how factors associated with the COVID-19 pandemic have influenced surgical care is imperative for preparing and managing the large backlog of procedures and providing patients with timely care.

Limitations

A limitation of this study is that procedure duration was calculated on the basis of 15-minute increments of anesthesia units, which may have resulted in lack of precision in estimates. An increase of 15 minutes has a large impact on the duration of shorter procedures and minimal impact on that of longer procedures. Additionally, anesthesia time units reflected what the anesthesiologist billed for the procedure and may not necessarily have been consistent with the service

the physician submitted for payment to OHIP. Lack of data on surgical teams, such as the number of nurses who assisted on the procedure, may also have affected duration estimates. The procedure time estimate did not account for changes in the behaviours of physicians and patients that may have occurred as a result of the COVID-19 pandemic, which could not be measured in our data, nor for patient selection effects not captured by observable patient characteristics that may have affected the duration of the same procedures performed on different patients. We also could not capture duration of turnover between OR procedures, which probably increased because of enhanced infection prevention precautions between procedures, especially at the beginning of the pandemic, and which may have additional implications for future resource allocation planning to clear surgical backlogs.

CONCLUSION

This study demonstrated the impact of the COVID-19 pandemic on the duration of OR procedures in Ontario. The main implication of this study is that procedures may take longer during the COVID-19 pandemic. This will have an impact on wait times, which were already longer because procedures were deferred at the beginning of the pandemic, and on the ability of the health care system to provide patients with timely care.

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Competing interests: C. Vinden is chair of the Section of General Surgery, Ontario Medical Association. S. Hill is a past president and board member of the Ontario Medical Association. No other competing interests were declared.

Contributors: J. Kantarevic, C. Vinden and S. Hill designed the study. J. Nadolski and M. Adamson acquired the data, which N. Chami, Y. Li, S. Weir, J. Wright and A. McClure analyzed. J. Kantarevic and N. Chami wrote the article, which C. Vinden, J. Nadolski, M. Adamson, Y. Li, S. Weir, J. Wright, A. McClure and S. Hill reviewed for important intellectual content. All authors approved the final version for publication.

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