Cancer surgery cancellation: incidence, outcomes and recovery in a universal health care system

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Background: Cancer surgery cancellation can have negative consequences for the patient, the surgeon and the health care system. There is a paucity of literature on cancer surgery cancellation and its association with wait times, perioperative outcomes, survival and costs of care. Therefore, the objective of this study was to determine the incidence of same-day cancer surgery cancellation in a universal health care context and its association with short and long-term outcomes.

Methods: This was a population-based retrospective cancer cohort study in Ontario, Canada (2010–2016). There were 199 599 patients in the control cohort and 3539 patients in the cohort that experienced a cancellation. We assessed the cohorts for differences in survival, perioperative complications and costs of care.

Results: The overall cancellation rate was 1.74% and was predicted by cancer type (genitourinary), lower income quintile, and more central region of residence. Wait times in the cancelled cohort were longer than in the control cohort; however, this difference was not associated with worse survival outcomes. Patients in the cancelled cohort had higher complication rates while in hospital (7.3 %) than those in the control cohort (4.9%; $p < 0.01$). After adjusting for important confounders, the cancelled cohort was more costly ($1100).

Conclusion: Same-day cancer surgery cancellation rates were low. They were associated with longer wait times, higher complication rates and increased costs of care. Survival was not worse in the cancelled cohort, suggesting that appropriate cancer urgency prioritization occurs. Preventable causes of cancellation should be targeted to improve outcomes in patients with cancer.

Contexte : L'annulation des chirurgies pour le cancer peut avoir de lourdes conséquences pour les patients, les chirurgiens, et pour le système de santé. On a peu écrit sur l'annulation des chirurgies pour le cancer et son lien avec les temps d'attente, l'issue des interventions, la survie et les coûts de santé. Cette étude avait donc pour but de mesurer l'incidence des annulations des chirurgies d'un jour dans le contexte d'un système de santé universel et son lien avec les résultats à court et à long terme.

Méthodes : Il s'agit d'une étude de cohorte rétrospective basée dans la population menée en Ontario, au Canada (2010–16). La cohorte témoin comptait 199 599 patients et la cohorte soumise à des annulations en comptait 3539. Nous avons examiné les différences entre les 2 cohortes aux plans de la survie, des complications périopératoires et des coûts de santé.

Résultats : Le taux d'annulation global a été de 1,74 % et était en lien avec le type de cancer (génito-urinaire), le quintile de revenu inférieur et un lieu de résidence plus central. Les temps d'attente ont été plus longs dans la cohorte soumise à des annulations que dans la cohorte témoin; toutefois, la différence n'a pas été associée à une issue plus négative au plan de la survie. Les patients dont l'intervention a été annulée ont présenté un taux de complications perhospitalières plus élevé (7,3 %) que ceux de la cohorte témoin (4,9 %; $p < 0,01$). Après ajustement pour tenir compte de variables de confusion, la cohorte soumise à des annulations a généré des coûts plus élevés (1100 $).

Conclusion : Les taux d'annulation des chirurgies d'un jour ont été bas. Ils ont été associés à des temps d'attente plus longs, à des hausses des taux de complications et des coûts de santé. La survie n'a pas été abrégée dans la cohorte soumise à des annulations, on en déduit qu'il s'effectue une priorisation adéquate des cas urgents. Il faudra cibler les causes d'annulation évitables pour améliorer les résultats chez les patients atteints de cancer.

Cancer surgery cancellation can have negative consequences for the patient, the surgeon and the health care system. Delays in cancer surgery, even by a few weeks, can have a negative impact on curability and overall survival, particularly for aggressive malignancies.[1,2] During the first wave of the COVID-19 pandemic in Canada, many surgeries were cancelled, of which cancer surgeries were relatively protected, likely owing to prioritization over nononcologic procedures.[3]

Although many studies have looked at surgery cancellation with a broad overview of incidence and causes (40% unavoidable; medical/patient causes and health system capacity reasons), to our knowledge none have focused on cancer surgery specifically.[4–6] Furthermore, there are no studies comparing outcomes between those who experienced a cancellation followed by eventual completion of the intended procedure and those who did not experience a cancellation. There is therefore a paucity of literature on cancer surgery cancellation and its association with wait times, perioperative outcomes, survival and costs of care.

The objective of our study was to determine the incidence of same-day cancer surgery cancellation in a universal health care context. The secondary objective was to determine the association of cancellations with outcomes, including wait times, survival, perioperative complications, 30-day readmission and emergency department (ED) use, and costs of care.

Methods

Study design and setting

This was a population-based retrospective cohort study in Ontario, Canada, using linked health administrative databases available at Ontario Health — Cancer Care Ontario (OH-CCO). Cohort development was based on prespecified inclusion and exclusion criteria to develop a comprehensive cohort of patients who had cancer surgery in Ontario during the study period.

Cohort development (inclusion/exclusion criteria)

The study used an initial list of patients who had a diagnosis of cancer in the Ontario Cancer Registry (OCR) from January 1, 2010, to December 31, 2016. This period was selected to allow for mature survival data given it was one of our secondary outcomes. Furthermore, at the time of study inception, cancer data around the pandemic period in our jurisdiction were not mature. The OCR is a well-validated cancer registry with a cancer capture rate greater than 98% for all noncutaneous malignancies.[7,8] The OCR has a much higher cancer capture rate than the 2 most commonly used US databases (Surveillance, Epidemiology, and End Results [26%] and the National Cancer Database [70%]), providing a less biased initial cohort.

We identified 2 cohorts: a control cohort who had a cancer surgery without prior history of cancellation, and a cancelled cohort who ultimately received a cancer surgery, but had a prior history of cancellation.

To identify patients who underwent cancer surgery, we used the Canadian Institute for Health Information (CIHI) databases. Cancer surgery could have occurred up to 3 months before cancer diagnosis date, as procedures can be both diagnostic and therapeutic in the prediagnosis period. All hospitals in Ontario, Canada, are required to submit demographic and clinical information about all hospital admissions and discharges, including cancelled surgery, transfers and deaths, to CIHI. The CIHI data have a specific *International Classification of Diseases* (ICD) code for cancelled surgeries: Z53.

Similarly, the Wait Time Information System (WTIS) was also used to identify patients whose oncology procedures occurred during the same time period. The WTIS is an Ontario database that collects prospective wait time data for a variety of scheduled clinical services in the province. It captures wait times for all publicly funded surgical procedures performed in an operating room; the exception is cataract procedures, which are captured regardless of location. In addition to demographic data allowing linkage with other databases, the WTIS also includes information on priority categorization, referral source, system delay reasons, Wait 2 (time from the decision to treat to the procedure date), Dates Affecting Readiness to Treat (DART), and reasons for delay.[9] The WTIS also codes cancelled surgeries and when they are rebooked. This allows a restrictive approach to identify patients with cancer surgery cancellations; to be included in the cancelled cohort, a patient had to have a Z53 ICD code in CIHI databases and a cancelled surgery intervention code in the WTIS. The coding regarding reason for cancellation is not reliable and was not used. As such, whether the cancellation was related to administrative limitations (e.g., lack of operating room time, nursing, beds) or to medical concerns could not be assessed. To be included in the cancelled cohort, the same cancer surgery that was initially booked must have eventually been completed; those who ultimately never had cancer surgery were not included. Finally, a linkage with the OCR was then used to validate that the cancer diagnosis site and date matched that of the cancer surgical procedure received.

We excluded patients if they were not adults (age < 18) at the index date, had a Priority 1 or emergency nonelective cancer surgery, had an out-of-province postal code at the time of surgery, had a missing or invalid health care number, or were not eligible for the Ontario Health Insurance Plan (OHIP) at the time of their index surgery. The study protocol was approved by the Privacy Office at OH-CCO and is otherwise exempt from the requirement for research ethics board approval.

Covariates

Age was defined at the time of cancer diagnosis. Charlson Comorbidity score (categorical; 0, 1, 2 or more) was defined by the sum of comorbidities from administrative data. Data from the 2016 Census Profile available at the dissemination area geographic level were used to calculate neighbourhood income quintiles and deciles. This analysis relied on single-person equivalent (SPE) to take into consideration household size; SPE is the person-weights implicit in the Statistics Canada low-income cut-offs needed to specify an appropriate multiplier for different household sizes. This adjustment is necessary because it generally costs less per person for 2 or more persons living together than for 1 person living alone.[10] Regions were defined according to the new Ontario Health categorization: Toronto, North, West, East, and Central. Cancer sites were categorized into breast, lung, genitourinary (not including prostate), prostate, gastrointestinal, gynecologic and other. It should be noted that lymphomas and cutaneous malignancies (including melanoma, squamous cell carcinoma and basal cell carcinoma) were not included. Race and ethnicity data are not readily available in the OH-CCO data set holdings that were used for this study and as such could not be included as covariates.

Wait times and survival

Patients in the different cohorts were compared for median and 90th percentile wait time using the Student *t* test. Cohorts were then compared based on the aforementioned covariates using the χ^2 test for categorical variables and a *t* test for continuous variables.

Vital status was captured from the Registered Persons Database (RPDB), which contains information on all persons who are registered for the purposes of OHIP and the Ontario Drug Benefits. For the survival output, we generated a Kaplan–Meier curve using the unadjusted association between cohort status and overall survival. A multivariable Cox regression analysis was to be performed if the cancelled cohort had worse survival than the control cohort on univariable analysis necessitating adjustment for confounders. However, if no difference was noted or if the opposite effect was identified, the a priori statistical plan would not involve a multivariable model.

Complications, 30-day ED visit and unplanned hospitalization

Patients who died while still in hospital (any time from admission to discharge) or who died during surgery were excluded for this portion of the analysis. Similarly, patients who had a return visit or admission on the same day of discharge or surgery were excluded in the numerator, as these are often considered coding errors with patient transfers from one admission type to another or between institutions. Readmission or visit to the ED within 30 days for our surgical cohorts was captured using the CIHI Discharge Abstract Database (DAD) and the National Ambulatory Care Reporting System (NACRS).

Costs of care

Similarly, costs from Sept. 1, 2015, to Mar. 31, 2016, were calculated using a well-described algorithm that uses both hospital and physician claims data. Cost is defined as the amount of hospital expenditures for resources used to deliver care, including physician fees. Operating room costs depend on start time, turnover times, cancellation rates, supplies, equipment and staffing.[11,12] The costing window start date was 180 days before the surgical date and ended 180 days after the surgery date. To ensure full cost capture, and given the limitations of the costing database, which starts on Apr. 1, 2012, and ends on Mar. 31, 2019, cases with a start date before these 2 dates were removed. Costs were adjusted for inflation; base year was set at 2017. Costs are based on a methodology similar to that outlined and used by ICES. The most notable difference is that the CIHI data sets use the Health Based Allocation Model Inpatient Group/Ontario Specific Comprehensive Ambulatory Classification System (CAC) weights rather than Case Mix Groups/National CAC weights and use facility-specific costs, whereas Community Care Access Centre methodology uses costs from the Healthcare Indicator Tool. Physician costs included are those billed through OHIP. Any non-fee-for-service physician compensation is not included, and any shadow billing has no associated cost.

Modelling statistical analysis

For the outcome of ED visits and unplanned readmission within 30 days, we used a logistic regression model. To compare costs, we used a generalized linear model. Covariates with a p value < 0.25 on univariable analysis were considered for inclusion in the final multivariable models. Other variables were included based on a priori hypotheses and for face validity. All potential covariates were assessed for collinearity, defined as a variance inflation factor > 2.5. None of the variables in our analysis were found to be collinear. Statistical significance was defined by a 2-sided p value of 0.05 or a standardized difference > 0.10. All analyses were performed using SAS version 9.4 (SAS Institute).

Results

Cohort description – cancellation rate

The overall cancellation rate in our cohort was 1.74%, with the cancelled cohort comprising 3539 patients compared with 199 599 patients in the control cohort. Patients in the cancelled cohort were more likely to be younger and male; however, this difference was not clinically meaningful in the standard difference analysis (Table 1). The cancelled cohort had a clinically and significantly higher comorbidity index than the control cohort. The cohorts did not differ by income quintile. Genitourinary cancers were more likely to be cancelled, while gastrointestinal and "other" cancers were less likely to be cancelled. There was a higher proportion of patients cancelled in the Central region than in other regions.

Wait times comparison

Figure 1 and Figure 2 represent the median and 90th percentile wait times, respectively, for the cancelled and control cohorts by year of surgery. The median overall wait time was very stable throughout the study years (Figure 1): 19–20 days for the control cohort and 41–49 days for the cancelled cohort. The median wait time of patients without prior cancellations was 57% shorter than that of patients whose surgery was cancelled. Patients with cancelled cancer procedures who ultimately went on to receive surgery did so within a median of 21–29 days. Similarly, the 90th percentile wait time was very stable throughout the study years (Figure 2): 49–55 days for the control cohort and 98–143 days for the cancelled cohort. The wait times in the cancelled cohort (mean 66.9 d ± standard deviation [SD] 67 d) were significantly longer ($p < 0.01$) than in the control cohort (mean 25.4 d ± SD 25 d).

Table 1. Sociodemographic and clinic differences between the control cohort and the cancelled cohort

Variable	Control cohort, no. (%) *n* = 199599	Cancelled cohort, no. (%) *n* = 3539	Standardized difference
Age, yr			
< 56	60430 (30.3)	1186 (33.5)	0.07
56–65	55585 (27.8)	946 (26.7)	0.02
66–75	50765 (25.4)	833 (23.5)	0.04
≥ 76	32819 (16.4)	574 (16.2)	0.01
Gender			
Female	116912 (58.6)	2012 (56.9)	0.03
Male	82687 (41.4)	1527 (43.1)	0.03
Charlson Comorbidity Index score			
0	57503 (28.8)	604 (17.1)	0.28
1	10440 (5.2)	111 (3.1)	0.11
≥ 2	81767 (41.0)	2382 (67.3)	0.55
No score	49889 (25.0)	442 (12.5)	0.32
Cancer site			
Breast	49050 (24.6)	898 (25.4)	0.02
Lung	11717 (5.9)	170 (4.8)	0.05
Prostate	19782 (9.9)	440 (12.4)	0.08
Genitourinary	21808 (10.9)	580 (16.4)	0.16
Gastrointestinal	33959 (17.0)	456 (12.9)	0.12
Gynaecologic	18791 (9.4)	398 (11.2)	0.06
Other	44492 (22.3)	597 (16.9)	0.14
Income quintile			
Quintile 1 (lowest)	39450 (19.8)	709 (20.0)	0.01
2	39506 (19.8)	685 (19.4)	0.01
3	40584 (20.3)	719 (20.3)	0.00
4	38122 (19.1)	666 (18.8)	0.01
Quintile 5 (highest)	40995 (20.5)	733 (20.7)	0.00
LHIN region			
Toronto	43397 (21.7)	745 (21.1)	0.01
West	58256 (29.2)	961 (27.2)	0.04
Central	42908 (21.5)	898 (25.4)	0.09
East	43737 (21.9)	810 (22.9)	0.02
North	11301 (5.7)	125 (3.5)	0.11

LHIN = Local Health Integration Network.

The much longer 90th percentile wait times for the cancelled cohort suggest a distribution with longer tail in a minority of patients.

Survival analysis

Notable survival differences were found when comparing the cancelled and control cohorts (Figure 3). Patients who had a prior cancer surgery cancellation had a higher overall survival (hazard ratio 0.921, 95% confidence interval [CI] 0.882–0.960, $p < 0.01$). The control cohort had a 3-year survival of 83.5% (95% CI 82.2%–84.6%) and the cancelled cohort, 84.8% (95% CI 84.7%–85%).

Complications

Patients in the cancelled cohort had higher complication rates while in hospital than the control cohort (7.3% v. 4.9%, $p < 0.01$). When each complication was assessed individually, there was a higher rate of only myocardial infarctions in the cancelled cohort than the control cohort (1.5% v. 0.7%, $p = 0.01$). Rates of inpatient infection, reoperation/readmission to the intensive care unit (ICU), pneumonia, stroke and pulmonary embolism did not differ between the cohorts.

Readmission or ED return within 30 days

Hospital readmission and/or ED visits within 30 days for any reason were higher in the cancelled cohort than the control cohort (35.8% v. 31.7%, $p < 0.01$). When the cause for readmission and/or ED visit was narrowed to surgical complications, the rates were much lower and were no longer significantly different between the cohorts (4.2% event rate in the cancelled cohort v. 3.6% in the control cohort, $p = 0.08$).

Univariable and multivariable predictors for all cause hospital readmission and/or ED visit within 30 days are shown in Table 2. On univariable analysis, rates of readmission or ED visits were higher in the cancelled cohort (odds ratio [OR] 1.12, $p < 0.01$); however, after controlling for confounders, this was no longer significant (OR 1.01, $p = 0.76$).

Costs of care

Costs of care in the 2 years following surgery were also assessed (Table 3). On univariable analysis, the cancelled cohort cost significantly more than the control group ($35 568 v. $30 573). After adjusting for important clinical and sociodemographic confounders that may be associated with costs using a generalized linear model,

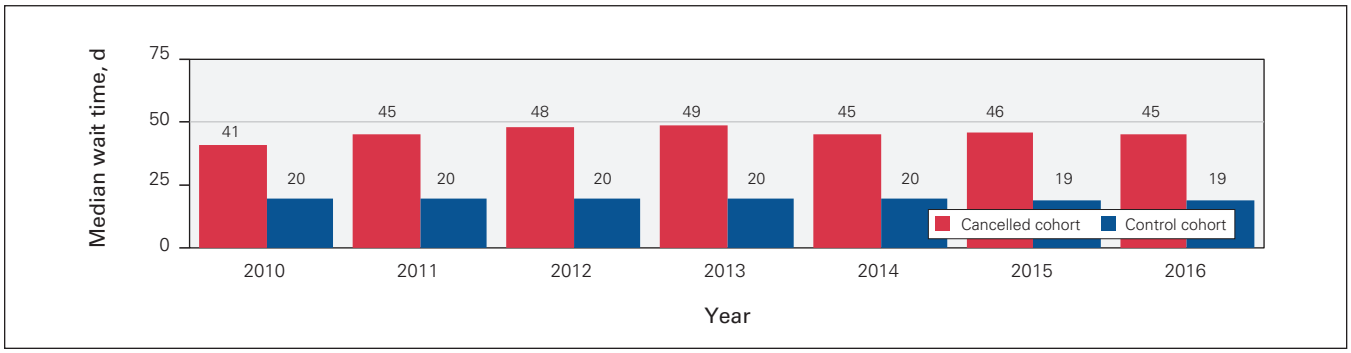

Fig. 1. Comparison of the overall median wait times for cancer surgery between patients who experienced a same-day cancellation but ultimately went on to receive cancer surgery (cancelled cohort) and those whose cancer surgeries were not cancelled (control cohort).

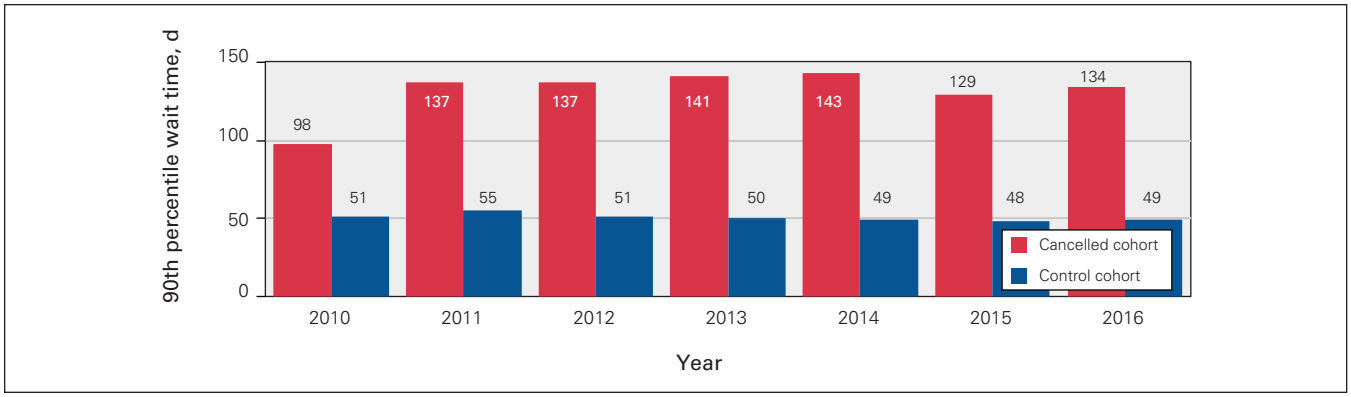

Fig. 2. Comparison of the 90th percentile median wait times for cancer surgery between patients who experienced a same-day cancellation but ultimately went on to receive cancer surgery (cancelled cohort) and those whose cancer surgeries were not cancelled (control cohort).

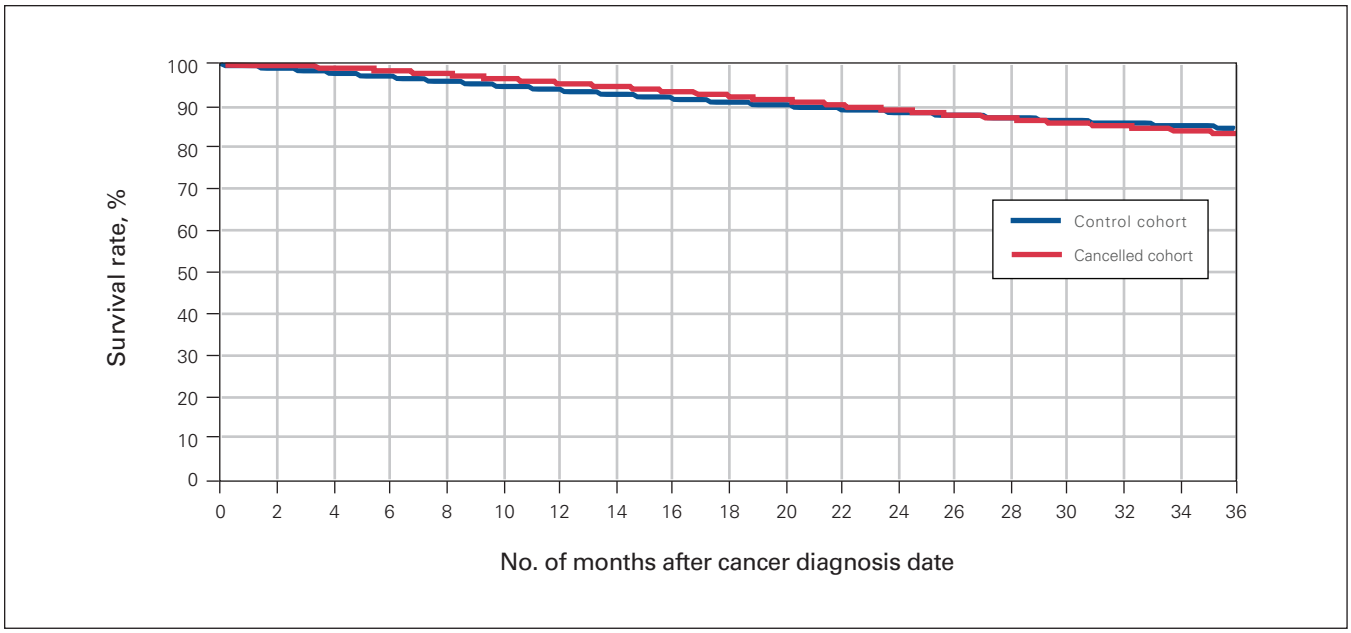

Fig. 3. Comparison of overall survival between patients who experienced a same-day cancellation but ultimately went on to receive cancer surgery (cancelled cohort) and those whose cancer surgeries were not cancelled (control cohort). Patients who had a prior cancer surgery cancellation had a higher overall survival (hazard ratio 0.921, 95% confidence interval [CI] 0.882–0.960, $p < 0.01$).

these differences were sustained and the cancelled cohort cost $1100 more (95% CI $3–$2196, $p = 0.049$).

Discussion

In Ontario, between 2010 and 2016, 1.74% of cancer surgeries experienced a same-day cancellation and were eventually completed. Cancellations were more common in patients with comorbidities and in those with genitourinary cancers, but less common in patients with other cancers (gastrointestinal and "other," which includes head and neck). Not surprisingly, the wait times in the cancelled cohort were longer than in the control cohort (mean 66.9 d ± SD 67d v. mean 25.4 d ± SD 25 d), showing the significant association this has on overall wait time. Paradoxically, patients who experienced a cancellation had improved overall survival on univariable analysis. Further work is required to corroborate this finding; however, it may be related to appropriate cancer prioritization, with the most urgent cancer procedures being performed sooner than those that were less acute. Overall surgical complication rates were higher in the cancelled cohort than the control cohort. Emergency department and readmission rates within 30 days did not differ between the cohorts; however, the cancelled cohort was more costly to treat ($1100/patient) after multivariable model adjustment.

The rates of cancellation in this study are much lower than those reported in the literature in many other countries and health systems, largely because those studies examined elective procedures and did not focus on cancer surgery specifically. In the United Kingdom, a study of 245 hospitals in a 7-day period reported a 13.9% same-day cancellation rate owing to lack of bed capacity, with cancer surgery being cancelled less often (OR 0.32).[13] In Australia, a cross-sectional single-institution assessment in 2002 reported an 11.9% cancellation rate, which was highest for ear, nose and throat surgery (19.6%) and cardiothoracic surgery (15.8%).[5] In Korea, a 10-year retrospective study in a single general hospital reported an 8.0% cancellation rate that was predominantly related to patient (93.2%) rather than hospital (6.8%) factors.[6] Another study identified that larger academic hospitals had higher cancellation rates (12.4%) than mid- to small-size community hospitals (5.0%).[14] Although this was not specifically examined in our study, we suspect this to also be true in our health care environment as many academic hospitals are responsible for trauma and transplant surgery, which are resource intensive and unscheduled. Overall, these rates are much higher than reported in our study because they include all surgical procedures rather than cancer surgery specifically.

Despite a lack of oncology-specific data, there are some reports on other high-risk time-sensitive elective procedures, such as vascular and cardiac surgery, which show far lower cancellation rates (2%).[15,16] In the vascular and cardiac cohorts, there was a 7% and 5% 30-day mortality, respectively, in those who experienced cancellations, with an additional wait time of 46 and 12 days, respectively.[15,16] In the present study, we did not identify a lower overall survival in the cancelled cohort; however, the additional wait time (25 d) is in keeping with those reported for these vascular and cardiac cohorts. We hypothesize that appropriate prioritization of more urgent cancers on days where cancellations were required

Table 2. Predictors of all-cause readmission or ED return visits within 30 days

Variable	Univariable model OR (95% CI)	*p* value	Multivariable model OR (95% CI)	*p* value
Age, yr	1.00 (ref.)		1.00 (ref.)	
< 56				
56–65	0.999 (0.975–1.024)	0.97	0.938 (0.915–0.962)	< 0.01
66–75	0.991 (0.966–1.016)	0.46	0.902 (0.879–0.926)	< 0.01
≥ 76	0.929 (0.903–0.956)	< 0.01	0.838 (0.814–0.864)	< 0.01
Gender				
Female	1.00 (ref.)		1.00 (ref.)	
Male	1.093 (1.073–1.114)	< 0.01	1.245 (1.212–1.278)	< 0.01
Charlson Comorbidity Index score				
0	1.00 (ref.)		1.00 (ref.)	
1	1.106 (1.058–1.157)	< 0.01	1.145 (1.094–1.198)	< 0.01
≥ 2	1.418 (1.387–1.451)	< 0.01	1.564 (1.527–1.602)	< 0.01
No score	0.789 (0.768–0.811)	< 0.01	0.733 (0.713–0.753)	< 0.01
Cancer site				
Breast	1.00 (ref.)		1.00 (ref.)	
Lung	0.991 (0.950–1.033)	0.67	0.695 (0.665–0.728)	< 0.01
Prostate	0.991 (0.957–1.025)	0.59	0.752 (0.72–0.786)	< 0.01
Genitourinary	0.772 (0.746–0.799)	< 0.01	0.543 (0.521–0.565)	< 0.01
Gastrointestinal	0.831 (0.807 0.855)	< 0.01	0.530 (0.511–0.549)	< 0.01
Gynaecological	0.790 (0.762–0.819)	< 0.01	0.683 (0.658–0.709)	< 0.01
Other	0.697 (0.678–0.717)	< 0.01	0.561 (0.544–0.579)	< 0.01
Income quintile				
Quintile 1 (lowest)	1.00 (ref.)		1.00 (ref.)	
2	0.951 (0.923–0.979)	< 0.01	0.959 (0.93–0.988)	< 0.01
3	0.950 (0.922–0.978)	< 0.01	0.954 (0.926–0.983)	< 0.01
4	0.928 (0.901–0.956)	< 0.01	0.931 (0.903–0.960)	< 0.01
Quintile 5 (highest)	0.931 (0.904–0.959)	< 0.01	0.940 (0.913–0.969)	< 0.01
LHIN region				
Toronto	1.00 (ref.)		1.00 (ref.)	
West	1.004 (0.977–1.031)	0.79	0.964 (0.937–0.99)	< 0.01
Central	1.147 (1.115–1.179)	< 0.01	1.103 (1.071–1.136)	< 0.01
East	0.909 (0.883–0.935)	< 0.01	0.880 (0.854–0.906)	< 0.01
North	1.161 (1.111–1.212)	< 0.01	1.068 (1.021–1.117)	< 0.01
Cohort				
Control	1.00 (ref.)		1.00 (ref.)	
Cancelled	1.2 (1.120–1.286)	< 0.01	1.011 (0.942–1.085)	0.76

CI = confidence interval; LHIN = Local Health Integration Network; OR = odds ratio; ref. = reference.

may explain the paradoxically higher survival in the cancelled cohort (which may have included patients with cancers for which a longer wait time may have had less of an association with survival). Our broad capture of all cancers would not allow us to determine whether delays led to more extensive adjuvant therapies.

From an equity lens, we did not identify any sociodemographic factors that predicted a higher rate of same-day cancellation. There is a paucity of literature comparing sociodemographic factors between patients who have had a cancelled cancer procedure and those who did not experience a cancellation. There was little geographic variation, and the most rural health region (North) had a lower rate of cancellation than the other regions. Age, gender, and socioeconomic status did not predict cancellation, which speaks to the fact that cancellations are multifactorial and occur equally for all patients in a publicly funded cancer care system. Patients with greater comorbidities had higher rates of cancellations potentially related to medical reasons for cancellation, which has been previously reported in a noncancer cohort.[4] It is therefore not surprising that we observed an overall higher complication rate in our cancelled cohort (largely related to myocardial infarction postoperatively) that did not translate into differences in surgical complications between the cohorts. The variations we observed between cancer sites is worth noting: higher rate of cancellation for genitourinary cancer procedures and lower rates of cancellation for gastrointestinal and "other" cancers, which include sarcoma, and head and neck cancers. We hypothesize that

Table 3. Univariable and multivariable costs of care

Variable	Total cost , mean, $	*p* value	Multivariable adjusted regression coefficient, $ (95% CI)	*p* value
Age, yr				
< 56	29132	< 0.01	0 (ref.)	
56–65	30475		1385 (996 to 1775)	< 0.01
66–75	31849		1057 (659 to 1455)	< 0.01
≥ 76	31837		–1024 (–1482 to –565)	< 0.01
Gender				
Female	29514	< 0.01	0 (ref.)	
Male	32323		5195 (4799 to 5591)	< 0.01
Charlson Comorbidity Index score				
0	23611	< 0.01	0 (ref.)	
1	28163		4186 (3507 to 4865)	< 0.01
≥ 2	41404		16961 (16595 to 17326)	< 0.01
No Score	20874		–3464 (–3867 to –3060)	< 0.01
Cancer site				
Breast	29897	< 0.01	0 (ref.)	
Lung	40748		–142 (–835 to 551)	0.69
Prostate	18812		–19066 (–19748 to –18385)	< 0.01
Genitourinary	27572		–11787 (–12390 to –11184)	< 0.01
Gastrointestinal	38649		–3946 (–4483 to –3410)	< 0.01
Gynaecological	25592		–9293 (–9850 to –8736)	< 0.01
Other	31477		–142 (–5481 to –4546)	< 0.01
Income quintile				
Quintile 1 (lowest)	32632	< 0.01	0 (ref.)	
2	31000		–857 (–1318 to –396)	< 0.01
3	30515		–1081 (–1538 to –624)	< 0.01
4	29800		–1610 (–2074 to –1146)	< 0.01
Quintile 5 (highest)	29396		–1737 (–2196 to –1279)	< 0.01
LHIN region				
Toronto	35849	< 0.01	0 (ref.)	
West	30667		–5572 (–5989 to –5155)	< 0.01
Central	27565		–8182 (–8630 to –7734)	< 0.01
East	28138		–7593 (–8038 to –7148)	< 0.01
North	32421		–5725 (–6418 to –5031)	< 0.01
Cohort				
Control	30573	< 0.01	0 (ref.)	
Cancelled	35568		1100 (3 to 2196)	0.049

CI = confidence interval; LHIN = Local Health Integration Network; ref. = reference.

this is related to within-hospital prioritization of urgent cancers. Further work will be required to confirm this using more granular data, which are not available in the current data set. Despite similar surgical complications and comparable readmission/ED visit rates, surgery in the cancelled cohort was more costly ($1100/patient), highlighting the detrimental cost implications of cancellations on the health care system.

Limitations

These data must be interpreted in the context of the study design. Our cohort included only patients who ultimately went on to receive their planned procedure. While some patients whose surgeries are cancelled never go on to receive cancer surgery, this is quite rare and is unlikely to influence our overall findings or conclusions.

Also, our study was able to ascertain only those who had cancellation on the same day as their planned surgery, and therefore underestimates the true cancer surgery cancellation rate. Nonetheless, same-day cancer surgery cancellation is a negative outcome for the patient, their family, the surgeon and the health care system overall. Although our data show the incidence and clinical predictors of cancellations from an advanced wait times information capture system, our study did not include more granular data on the reason for the same-day cancellation. Such data would likely require a single-institution type of study. Fortunately, this has been well studied in the past with fairly consistent findings showing that cancellations are partly patient driven (17%–90%) and partly system driven (e.g., lack of ward/ICU beds, staff; 7%–50%).[5,13,15–17] Nonetheless, to our knowledge, our study is the largest examining cancer surgery cancellation and the first to assess predictors of these events and their downstream health care implications (wait time, survival, complications, ED use, and costs).

Cancellations are unavoidable in 40% of surgical cases (not exclusively oncology).[5] However, given the negative impact of cancellations on patients and the health care system, a focus on avoidable cancellations is required. Although operating room time is often listed as a limiting factor, adding additional operating room capacity has been previously well studied and does not decrease cancellation rates, as often ward and ICU bed flow issues become the next limiting factor.[18,19] In our publicly funded and administered health care environment it is unlikely that adding private operating room facilities will improve cancellation rates for cancer surgery, as cancellation rates are already quite low. In the United Kingdom, it was noted that private facilities have the lowest cancellation rates, with large variation compared with publicly funded institutions, which raises concerns around case mix and equity.[4] Finally, although we hypothesized that appropriate prioritization is taking place, more formal guidelines are required that should consider the differential impact of additional wait time on different cases to assist those making such decisions at the institutional level.[1]

Conclusion

We identified a low rate (1.74%) of cancellation of cancer surgery in a publicly funded health care context. This leads to increased wait times and costs of care, but does not have an apparent association with survival, increased complication rates or ED use postoperatively.

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