Influence of delays to nonemergent colon cancer surgery on operative mortality, disease-specific survival and overall survival

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Background: There has been minimal research on the influence of delays for cancer treatments on patient outcomes. We measured the influence of delays to nonemergent colon cancer surgery on operative mortality, disease-specific survival and overall survival.

Methods: We used the linked Surveillance, Epidemiology and End Results (SEER)-Medicare databases (1993–1996) to identify patients who underwent nonemergent colon cancer surgery. We assessed 2 time intervals: surgeon consult to hospital admission for surgery and first diagnostic test for colon cancer to hospital admission. Follow-up data were available to the end of 2003. We selected the time intervals to create patient groups with clinical relevance and they did not extend past 120 days.

Results: We identified 7989 patients who underwent nonemergent colon cancer surgery. Median delays from surgeon consult to admission and from first diagnostic test to admission were 7 and 17 days, respectively. The odds of operative mortality were similar if the consult-to-admission interval was 22 days or more versus 1–7 days (odds ratio [OR] 1.0, 95% confidence interval [CI] 0.6–1.8, $p = 0.91$) or if the test-to-admission interval was 43 days or more versus 1–14 days (OR 0.8, 95% CI 0.4–1.5, $p = 0.51$), respectively. For these same respective interval comparisons, disease-specific survival was not influenced by the consult-to-admission wait (hazard ratio [HR] 1.0, 95% CI 0.9–1.2, $p = 0.91$) or the test-to-admission wait (HR 1.0, 95% CI 0.8–1.1, $p = 0.63$). The risk of death was slightly greater if the consult-to-admission interval was 22 or more days versus 1–7 days (HR 1.1, 95% CI 1.0–1.2, $p = 0.013$) and if the test-to-admission interval was 43 days or more versus 1–14 days (HR 1.2, 95% CI 1.1–1.3, $p = 0.003$).

Conclusion: It is unlikely that delays to nonemergent colon cancer surgery longer than 3 weeks from initial surgical consult or longer than 6 weeks from first diagnostic test negatively impact operative mortality, disease-specific survival or overall survival.

Contexte : Quelle influence le retard de traitement du cancer a-t-il sur le pronostic des patients? Peu de recherches ont porté sur cette question. Nous avons voulu mesurer l'influence du retard à opérer les cas de cancer du côlon jugés non urgents sur la mortalité opératoire, la survie spécifique à la maladie et la survie globale.

Méthodes : Nous avons utilisé les bases de données reliées Medicare-SEER (*Surveillance*, *Epidemiology and End Results*) de 1993 à 1996 afin de recenser les patients ayant subi une chirurgie non urgente pour cancer du côlon. Nous avons évalué 2 intervalles : soit le temps écoulé entre la consultation du chirurgien et l'hospitalisation pour chirurgie et le temps écoulé entre le premier test diagnostique pour cancer du côlon et l'hospitalisation. Nous disposions de données de suivi s'échelonnant jusqu'à la fin de 2003. Nous avons sélectionné les intervalles de façon à créer des groupes de patients cliniquement pertinents et ces intervalles ne dépassaient pas 120 jours.

Résultats : Nous avons recensé 7989 patients qui ont subi une chirurgie non urgente pour cancer du côlon. Les délais médians entre la consultation du chirurgien et l'hospitalisation et entre le premier test diagnostique et l'hospitalisation ont été respectivement de 7 et 17 jours. Le risque de mortalité opératoire était semblable si l'intervalle entre la consultation et l'hospitalisation était de 22 jours ou plus c. 1 à 7 jours (rapport des cotes [RC] 1,0; intervalle de confiance [IC] à 95 %, 0,6–1,8, $p = 0,91$) ou si l'intervalle entre le premier test diagnostique et l'hospitalisation était de 43 jours ou plus c. 1 à 14 jours (RC 0,8; IC à 95 %, 0,4–1,5, $p = 0,51$), respectivement. Pour ces mêmes comparaisons d'intervalles respectifs, la survie spécifique à la maladie n'a pas été affectée par le délai entre la consultation et l'hospitalisation (risque relatif [RR] 1,0; IC à 95 %, 0,9–1,2, $p = 0,91$) ni par le délai entre le premier test diagnostique et

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l'hospitalisation (RR 1,0; IC à 95 %, 0,8–1,1, p = 0,63). Un intervalle entre la consultation et l'hospitalisation de 22 jours ou plus plutôt que de 1 à 7 jours (RR 1,1; IC à 95 % 1,0–1,2, p = 0,013) et un intervalle entre le premier test diagnostique et l'hospitalisation de 43 jours ou plus plutôt que de 1 à 14 jours (RR 1,2; IC à 95 %, 1,1–1,3, p = 0,003) étaient associés à un risque global de décès légèrement supérieur.

Conclusion : Il semble peu probable que les retards de plus de 3 semaines avant une chirurgie non urgente pour un cancer du côlon à compter de la consultation avec le chirurgien, ou de plus de 6 semaines à compter du premier test diagnostique, aient un impact négatif sur le risque de mortalité opératoire, sur la survie spécifique à la maladie ou sur la survie globale.

Lengthy waits for cancer services may harm patients by causing psychological distress[1–3] or lessening the effectiveness of treatments.[4–7] Waiting times for surgery are of particular relevance since surgical removal of an offending lesion is a prerequisite for cure in most circumstances.[8] Surprisingly, there is little population-based data on the influence of cancer surgery delays on traditional patient outcomes such as operative mortality or overall survival. This is understandable since, although tumour stage is a key determining factor for such outcomes, cancer registries in most jurisdictions lack complete tumour staging data. For example, in most Canadian provinces, despite great interest in waiting times for cancer treatments, cancer registries lack staging data precluding assessment of the influence of delays on patient outcomes.

The linked Surveillance, Epidemiology and End Results (SEER)-Medicare database may efficiently allow for such assessments. This database contains comprehensive information, including tumour stage, on patients aged 65 and older who are treated within prespecified geographic regions of the United States.[9] Available data also include physician billing records, which contain dates of service provision.[10] We hypothesized that such dates could be used to ascertain the extent of delays to key treatment events among patients undergoing nonemergent colon cancer surgery. We examined waiting times for colon cancer surgery for 4 reasons. First, colon cancer is a leading cause of cancer death in western countries and, thus, is important from a disease burden and resource utilization perspective.[11] Second, if a patient with colon cancer and with no evidence of metastatic disease is medically fit, there is little controversy about the need for surgical resection to achieve cure. Third, preoperative therapies (e.g., chemo- or radiotherapy), which may complicate an assessment of surgical waiting times, are generally not used. And finally, the median age of patients with colon cancer in North America is 70 years or older, which is well above the lower-age limit of SEER-Medicare data.[12,13]

We measured waiting times for colon cancer surgery performed in 1993–1996 using the linked SEER-Medicare databases and assessed the influence of delays to surgery on patient outcomes, including in-hospital operative mortality, disease-specific survival and overall survival.

Methods

Intervals of interest

We defined 2 intervals of interest experienced by patients who underwent nonemergent colon cancer resection. The first was the "consult-to-admission interval," or the period from consult with a surgeon to hospital admission for surgery. During this interval a surgeon would first see a patient, order tests, consult with other specialists in preparation for surgery and finally admit the patient to hospital for definitive treatment. The second was the "test-to-admission interval," or the period from the first diagnostic test likely related to a diagnosis of colon cancer to the date of hospital admission for surgery. We limited diagnostic procedures for patients with colon cancer to rigid sigmoidoscopy, flexible sigmoidoscopy, colonoscopy and barium enema, since other tests such as a chest radiograph, ultrasound or computed tomography scan can be used to investigate patient signs or symptoms not related to a diagnosis of colon cancer.

Database

We used data from the linked SEER-Medicare database. The SEER database contains information on all cancer patients in 11 states or metropolitan areas covering 14% of the US population.[9] Areas selected for data capture are felt to represent an adequate cross-section of the national population. For each individual, data include demographic information (e.g., socioeconomic status), cancer diagnosis, stage and follow-up vital status. Nearly all citizens of the United States aged 65 and older are enrolled in Medicare Parts A (inpatient hospital coverage) and B (outpatient hospital and physician office services coverage). During our study period, the Medicare Provider Analysis and Review (MEDPAR) database used the International classification of diseases, ninth revision, clinical modification (ICD-9-CM) classification to code up to 10 diagnoses and 6 procedures for each patient admitted to hospital, along with other patient data such as date of admission, length of stay in hospital and discharge status (i.e., dead or alive). Outpatient files code hospital outpatient services, whereas National Claims History (NCH) physician billing records

track all inpatient, outpatient and physician office bills sent to Medicare. Patient records can be linked among these databases using a unique anonymous patient identifier, and NCH physician bills such as consult or procedure bills can be linked using a unique anonymous physician identifier. Investigators have demonstrated that 94% of patients in SEER aged 65 and older can be linked to their Medicare records.[14]

Cohort development

The Hamilton Health Sciences Research Ethics Board approved our study. We used the SEER database to select patients aged 65 and older with diagnoses of colon or rectosigmoid cancer in calendar years 1993–96. Follow-up data were available to the end of 2003. We used the MEDPAR database to identify patients who underwent a major colon resection (ICD-9-CM codes 48.5, 48.6, 48.4, 45.8 and 45.7). We merged the resulting SEER and Medicare cohorts using the unique patient identifier. Exclusions were histology not adenocarcinoma, patients enrolled in health maintenance organizations (since such organizations are not obligated to forward to Medicare detailed claims information), the identification of colon cancer diagnosis through "death certificate" or "autopsy report" and a history of previous or concomitant cancer. To prevent the inclusion of hospital admissions for recurrent disease or palliative procedures forced after a period of deliberate conservative management, we excluded patients admitted to hospital for surgery more than 120 days after the SEER diagnosis date. To lessen the chances of including rectal cancer patients in the cohort, we excluded patients with a rectosigmoid diagnosis linked to a rectal procedure (ICD-9-CM codes 48.5, 48.6 and 48.4) and patients with any records indicating the delivery or consideration of radiation therapy during the 120 days before or after surgery.[15]

We found NCH billing records for major colon resection during the appropriate hospital admission for most of the patients in our SEER-Medicare cohort. Unique physician identifiers attached to surgical billing records allowed linkage to consult billing records dated before or during the relevant hospital admission. We examined outpatient, MEDPAR and NCH databases to identify the first diagnostic procedure for colon cancer provided to patients in our cohort before hospital admission for surgery. We excluded surgeon consults and diagnostic tests provided more than 120 days before hospital admission to avoid identifying records not related to the surgical resection of interest. Dates for consult bill, diagnostic procedure and hospital admission allowed us to calculate the consult-to-admission interval and the test-to-admission interval for individual patients.

Studies using data from non-US jurisdictions have shown that 20% or more of colon cancer surgeries are delivered as emergency procedures and that patients requiring emergent versus nonemergent surgery have worse outcomes.[16] Furthermore, in many US practice settings, surgeon bills for a procedure (e.g., preoperative, in-hospital and immediate postoperative care for colon cancer) are bundled into 1 bill and are not distinguishable in the NCH database. Of the patients in our SEER-Medicare cohort linked to a major surgery billing record, some had no consult billing records, some had consult billing records dated during the hospital admission and some had consult billing records dated before the hospital admission. We surmised that the absence of a consult billing record was largely due to bundling, that consults provided during hospital admission indicated that colon cancer procedures had been provided emergently and billing records dated before the hospital admission represented nonemergent colon cancer surgery. We included the patients in the nonemergent group in our analysis.

Patient groups, hospital groups and outcomes of interest

Prior to measuring the influence of treatment delays on patient outcomes, we selected cut points with clinical relevance to create patient and hospital groups. For example, for the consult-to-admission interval, cut points created patient groups where the consult occurred 1–7 days, 8–14 days, 15–21 days or 22 or more days before admission. For the test-to-admission interval, cut points created patient groups where the diagnostic test occurred 1–14 days, 15–28 days, 29–42 days or 43 or more days before admission. We placed individual hospitals into low-, medium- or high-volume groups based on the number of major resections performed during the study period.[17] The choice of volume cutoffs created volume groups with clinical relevance. Our outcomes of interest were patient rates of in-hospital operative mortality, disease-specific survival and overall survival. We used in-hospital mortality since deaths directly related to surgery can occur after an arbitrary set point such as 30 days.

Statistical analysis

We described the patient groups by age, sex, race (white, black, other), presence of comorbid conditions, socioeconomic status (4 equally-sized groups based on median household income), place of residence (rural, urban), admission status (emergent, urgent, elective), disease stage and hospital procedure volume. We used Deyo's modified version of the Charleson index to define comorbidity scores.[18] We included only comorbid conditions coded during the surgical admission for colon cancer surgery. We measured for differences among the groups in patient and hospital descriptors. We used logistic regression models to assess the influence of delay in consult-to-admission

and test-to-admission intervals on operative mortality. We used Cox proportional hazards models to assess the influence of delay in consult-to-admission and test-to-admission intervals on disease-specific (i.e., colon cancer) survival and overall survival. We excluded patients who died in hospital from the survival models. Models controlled for available patient and hospital descriptors and also considered nested variation at the provider level.

We tested the robustness of our results. Since adjuvant chemotherapy may influence patient survival following colon cancer surgery, we reran survival models after adding a chemotherapy variable, which indicated if patients received or did not receive chemotherapy within 12 months of hospital discharge.[19] We also reran survival models with the inclusion of patients who died in hospital, with the extension of the maximum waiting time from 120 to 180 days and with the exclusion of patients with metastatic (distant) disease. We performed this latter check to ensure that patients with the poorest prognoses did not unduly influence model results.

We performed all analyses using Stata (version 6.0, Stata Corporation), SAS (version 8.2, SAS Institute Inc.) and MLWin (version 1.1, Centre for Multilevel Modelling, Institute of Education) software.

Results

We found NCH billing records for major colon resection during the appropriate hospital admission for 15 384 of 16 578 patients (93%) in our SEER-Medicare cohort. Of the 15 384 patients in our SEER-Medicare cohort linked to a major surgery billing record, there was no consult billing record for 2 983 patients (19%), there was a consult billing record dated during the hospital admission for 4 412 patients (29%) and there was a consult billing record dated before the hospital admission for 7 989 patients (52%). We surmised that the absence of a consult billing record among patients in the first group was largely due to bundling, that consults provided during hospital admission indicated that colon cancer procedures had been provided emergently and that the last group represented a cohort of patients who underwent nonemergent colon cancer surgery. Table 1 outlines a number of measures that support our reasoning. For example, for patients labelled as emergent versus nonemergent, the admission type was less likely to be urgent or elective (61% v. 94%), tumour stage was more likely to be distant (22% v. 15%), fewer patients underwent a preadmission diagnostic test (23% v. 92%), the length of stay in hospital was greater (13 d v. 8 d) and the rate of operative mortality was higher (6.9% v. 1.8%). Measures for the bundled group were in the range between those of the emergent and nonemergent groups, suggesting that this bundled group contained both nonemergent and emergent patients. We therefore were confident that the 7 989 patients in the nonemergent group represented patients aged 65 and older in the United States who underwent elective colon cancer surgery, and this is the group that we included in our analysis.

The median delays from surgeon consult to admission for surgery and first diagnostic test to admission for surgery were 7 and 17 days, respectively. Few of the 7 989 patients in our cohort had lengthy waits for treatment. For example, there were only 882 patients (11.0%) with a consult-to-admission wait of 22 days or more and only 1 017 patients (13.9%) with a test-to-admission wait of 43 days or more (Table 2 and Table 3). For both intervals, univariate analyses demonstrated that patient sex and

Table 1. Characteristics of bundled versus emergent versus nonemergent patient groups who underwent surgery for colon cancer in the United Sates from Jan. 1, 1993, to Dec. 31, 1996

	Group; no. (%)*			
Characteristic	Bundled†	Emergent‡	Nonemergent§	*p* value
Patients	2983 (19.4)	4412 (28.7)	7989 (51.9)	< 0.001
Admission type				
Elective and urgent	2103 (70.5)	2670 (60.5)	7539 (94.4)	< 0.001
Emergent	870 (29.2)	1732 (39.3)	442 (5.5)	
Tumour stage¶				
Localized	969 (33.0)	1289 (29.6)	3198 (40.5)	< 0.001
Regional	1443 (49.0)	2129 (48.9)	3515 (44.6)	
Distant	528 (18.0)	936 (21.5)	1174 (14.9)	
Preadmission test**	1438 (48.2)	1030 (23.4)	7332 (91.8)	< 0.001
Length of stay, median d	10.0	13.0	8.0	< 0.001
In-hospital mortality, %	6.1	6.9	1.8	< 0.001

*Unless otherwise indicated.
†No consult billing record identified.
‡Consult billing record dated during the hospital admission.
§Consult billing record dated before the hospital admission.
¶We defined tumour stages as follows: localized = confined to bowel wall, regional = local lymph nodes involved, distant = spread to other organs.
**Diagnostic procedures include rigid sigmoidoscopy, flexible sigmoidoscopy, colonoscopy and barium enema.

age did not influence treatment delays ($p > 0.05$ for both). Conversely, black race, presence of comorbidities, tumour stage localized and treatment in a high-volume hospital were predictive of a longer waiting time ($p < 0.001$ for all; Table 2 and Table 3). Rates of operative mortality among the consult-to-admission and test-to-admission groups ranged from 1.5%–2.4% ($p = 0.42$) and 1.3%–1.7% ($p = 0.75$), respectively (Table 2 and Table 3).

Results from the regression models show that treatment delays did not influence the risk of operative mortality or disease-specific survival. The odds of operative mortality were similar if the consult-to-admission interval was 22 or more days versus 1–7 days (odds ratio [OR] 1.0, 95% confidence interval [CI] 0.6–1.8, $p = 0.91$) or if the test-to-admission interval was 43 days or more versus 1–14 days (OR 0.8, 95% CI 0.4–1.5, $p = 0.51$; Table 4). For these same respective interval comparisons, disease-specific survival was not influenced by consult-to-admission wait (hazard ratio [HR] 1.0, 95% CI 0.9–1.2, $p = 0.91$) or test-to-admission wait (HR 1.0, 95% CI 0.8–1.1, $p = 0.63$; Table 5). The risk of death was slightly greater if the consult-to-admission interval was 22 days or more versus 1–7 days (HR 1.1, 95% CI 1.0–1.2, $p = 0.013$) and if the test-to-admission interval was 43 days or more versus 1–14 days (HR 1.2, 95% CI 1.1–1.3, $p = 0.003$; Table 6). Hazards of disease-specific and overall survival were similar for the remaining consult-to-admission and test-to-admission groups compared with the respective shortest interval group. As expected and for the various models, the odds of operative mortality were worse for the oldest versus youngest age groups, for patients with versus without comorbidities and for patients with distant versus localized tumours. Hazard ratios for these variables and for the consult-to-admission overall survival model were HR 2.3, 95% CI 2.1–2.5, $p < 0.001$; HR 1.6, 95% CI 1.5–1.7,

Table 2. Characteristics of patients who underwent surgery for colon cancer in the United Sates from Jan. 1, 1993, to Dec. 31, 1996, by consult-to-admission waiting time intervals

	Wait time; no. (%)*				
Characteristic	1–7 d	8–14 d	15–21 d	≥ 22 d	*p* value
Patients	4292 (53.7)	2056 (25.8)	759 (9.5)	882 (11.0)	0.002
Age, yr					0.11
65–73	1634 (55.0)	766 (25.8)	269 (9.0)	304 (10.2)	
74–80	1468 (53.2)	732 (26.5)	263 (9.5)	297 (10.8)	
≥ 81	1190 (52.7)	558 (24.7)	227 (10.1)	281 (12.5)	
Sex					0.19
Female	2459 (54.8)	1125 (25.1)	415 (9.2)	491 (10.9)	
Male	1833 (52.4)	931 (26.6)	344 (9.8)	391 (11.2)	
Race					< 0.001
White	3778 (53.7)	1808 (25.7)	665 (9.4)	785 (11.2)	
Black	178 (42.2)	125 (29.6)	64 (15.2)	55 (13.0)	
Other	287 (65.4)	100 (22.8)	26 (5.9)	26 (5.9)	
Median household income†					0.006
Low	903 (56.5)	364 (22.8)	135 (8.4)	197 (12.3)	
Low–medium	1084 (54.3)	498 (25.0)	197 (9.9)	215 (10.8)	
Medium–high	1035 (51.1)	558 (27.6)	197 (9.7)	234 (11.6)	
High	1128 (52.6)	585 (27.3)	214 (10.0)	217 (10.1)	
Comorbidity score					< 0.001
Score ≥ 1	1461 (50.7)	714 (24.8)	318 (11.0)	387 (13.5)	
Score = 0	2831 (55.4)	1342 (26.3)	441 (8.6)	495 (9.7)	
Tumour stage‡					< 0.001
Localized	1603 (50.1)	865 (27.0)	341 (10.7)	389 (12.2)	
Regional	1953 (55.6)	890 (25.3)	311 (8.8)	361 (10.3)	
Distant	691 (58.9)	269 (22.9)	100 (8.5)	114 (9.7)	
Hospital volume§					< 0.001
Low	1131 (56.9)	469 (23.6)	174 (8.8)	212 (10.7)	
Low–medium	1080 (56.4)	457 (23.9)	175 (9.1)	203 (10.6)	
Medium–high	1075 (53.9)	525 (26.3)	175 (8.8)	221 (11.0)	
High	1006 (48.1)	605 (28.9)	235 (11.2)	246 (11.8)	
In-hospital mortality, %	1.7	2.0	1.5	2.4	0.42

*Unless otherwise indicated.
†We defined median household income as low (≤ $29 726), low–medium ($29 727–$38 478), medium–high ($38 479–$48 015) or high (≥ $48 016).
‡We defined tumour stages as follows: localized = confined to bowel wall, regional = local lymph nodes involved, distant = spread to other organs.
§Hospital procedure volume was based on major colon resections for the period of Jan. 1, 1993, to Dec. 31, 1996: low (≤ 34), low–medium (35–62), medium–high (63–97) and high (≥ 98).

$p < 0.001$; and HR 4.6, 95% CI 4.2–5.0, $p < 0.001$, respectively. The value and significance of odds or hazards ratios were consistent in models testing the robustness of results.

Discussion

We assessed waiting times from surgical consult and first diagnostic test to hospital admission for colon cancer surgery using the linked SEER-Medicare database for the years 1993–96. We limited maximum waits to 120 days to avoid assessing procedures provided with palliative intent. Median waits were 7 and 17 days for the consult-to-admission and test-to-admission intervals, respectively. Only 11% of patients waited more than 3 weeks for surgery after a surgical consult, and only 14% of patients waited more than 6 weeks for surgery after a first diagnostic test. It is accepted that colon cancer tumours typically grow over many months and years before clinical presentation, thus one would expect that the delays to surgery that we observed should not have negatively impacted patient outcomes.[8] In fact, lengthy delays (i.e., more than 3 weeks from surgeon consult to surgical admission and more than 6 weeks from first diagnostic test to surgical admission) appeared to have no influence on the risk of operative mortality or disease-specific survival and a clinically insignificant influence on overall survival.

Despite the inclusion in our regression models of numerous variables that are known to impact patient outcomes, it is possible that we did not consider some variables that are associated with both treatment delay and

Table 3. Characteristics of patients who underwent surgery for colon cancer in the United Sates from Jan. 1, 1993, to Dec. 31, 1996, by first diagnostic test-to-admission waiting time intervals

Characteristic	Wait time; no. (%)*				*p* value
	1–14 d	15–28 d	29–42 d	≥ 43 d	
Patients	3162 (43.1)	2237 (30.5)	916 (12.5)	1017 (13.9)	0.67
Age, yr					0.12
65–73	1248 (45.1)	832 (30.1)	317 (11.5)	369 (13.3)	
74–80	1085 (42.5)	772 (30.2)	335 (13.1)	364 (14.2)	
≥ 81	829 (41.2)	633 (31.5)	264 (13.1)	284 (14.2)	
Sex					0.90
Female	1760 (43.2)	1252 (30.7)	499 (12.3)	564 (13.8)	
Male	1402 (43.1)	985 (30.1)	417 (12.8)	453 (13.9)	
Race					< 0.001
White	2817 (43.8)	1966 (30.6)	790 (12.3)	858 (13.3)	
Black	113 (28.7)	117 (29.7)	63 (16.0)	101 (25.6)	
Other	191 (45.3)	131 (31.0)	52 (12.3)	48 (11.4)	
Median household income†					< 0.001
Low	692 (48.8)	388 (27.4)	155 (10.9)	183 (12.9)	
Low–medium	774 (43.0)	590 (32.8)	199 (11.1)	236 (13.1)	
Medium–high	771 (41.2)	587 (31.3)	253 (13.5)	262 (14.0)	
High	827 (40.8)	615 (30.4)	274 (13.5)	309 (15.3)	
Comorbidity score					< 0.001
Score ≥ 1	1051 (39.9)	820 (31.2)	339 (12.9)	422 (16.0)	
Score = 0	2111 (44.9)	1417 (30.2)	577 (12.3)	595 (12.7)	
Tumour stage‡					< 0.001
Localized	1091 (36.0)	967 (31.9)	431 (14.2)	544 (17.9)	
Regional	1515 (47.4)	981 (30.7)	352 (11.0)	350 (10.9)	
Distant	529 (52.7)	266 (26.4)	120 (12.0)	89 (8.9)	
Hospital volume§					< 0.001
Low	877 (49.7)	510 (28.9)	185 (10.5)	192 (10.9)	
Low–medium	749 (42.5)	533 (30.3)	223 (12.7)	256 (14.5)	
Medium–high	774 (42.1)	568 (30.9)	246 (13.4)	249 (13.6)	
High	762 (38.7)	626 (31.8)	262 (13.3)	320 (16.2)	
In-hospital mortality, %	1.7	1.6	1.3	1.4	0.75

*Unless otherwise indicated.
†We defined median household income as low (≤ $29 726), low–medium ($29 727–$38 478), medium–high ($38 479–$48 015) or high (≥ $48 016).
‡We defined tumour stages as follows: localized = confined to bowel wall, regional = local lymph nodes involved, distant = spread to other organs.
§Hospital procedure volume was based on major colon resections for the period of Jan. 1, 1993, to Dec. 31, 1996: low (≤ 34), low–medium (35–62), medium–high (63–97) and high (≥ 98).

patient outcomes. This point is relevant for any nonrandomized study. Moreover, the need to appreciate potential confounding is heightened in our current study given the small number of patients in the groups with the longest delays to surgery. We suggest that our findings should be interpreted with caution given the potential for confounding in observational studies, the small absolute size of the overall survival hazard ratios comparing longest versus shortest delays and the lack of correlation between delay to surgery and disease-specific survival. Where possible, we also encourage investigators to repeat analyses similar to ours using data from other jurisdictions.

The increased waiting times experienced by patients with comorbidities are understandable. Such patients often require a relatively intense workup to ensure they are physiologically optimized to survive major surgery or to ensure that they are fully apprised of attendant surgical risks. The increased waiting times experienced by black patients are both concerning and consistent with some studies that demonstrate variation in patient access to care based on race.[20–22] The shorter intervals to treatment for patients with more advanced colon cancer parallels findings related to breast cancer surgery and may represent a rapid response among treating physicians owing to fears of impending problems (e.g., bowel obstruction) or to treatment of a presenting sign or symptom more likely to occur in a patient with an advanced versus a localized tumour (e.g., rectal bleeding).[23] For operative mortality, disease-specific survival and overall survival, the greater risk among older patients, patients with comorbidities and patients with high-stage tumours buttress the internal validity of our multivariable models.

We are unaware of other administrative database research that has measured the influence of cancer treatment delays on hard patient outcomes such as operative mortality or overall survival. Our group assessed cancer surgery waiting times in the province of Ontario, Canada, though inadequate population-based staging precluded assessing the impact of delay on patient outcomes.[16] Of interest, median waits from consult to admission for colon cancer surgery in Ontario for 1993–96 were 14 days, which is double the wait in the present study. In addition, we observed significant increases in surgical waiting times by year 2000, raising concerns of worsening patient access to care. As we have demonstrated with Ontario data and now with our present findings, jurisdictions with similar data sources can efficiently measure waiting times for cancer treatments, a useful exercise to gauge the impact of policy changes in a given geographic region on patient access to care.[16,24]

There are limitations with our study. The SEER-Medicare database includes mainly patients over the age of 65, thus, our results cannot be extrapolated to younger patients who undergo colon cancer surgery. However, our study does cover most patients in the United States with colon cancer, given that the median age for patients at diagnosis is 70 years or older.[12,13] In addition, our results

Table 4. In-hospital mortality among patients who underwent surgery for colon cancer in the United Sates from Jan. 1, 1993, to Dec. 31, 1996, by consult-to-admission and first diagnostic test-to-admission intervals*

	Consult-to-admission		First diagnostic test-to-admission	
Waiting time†	OR (95% CI)	*p* value	OR (95% CI)	*p* value
Short	1.0		1.0	
Short–medium	1.3 (0.9–1.9)	0.23	1.0 (0.6–1.5)	0.95
Medium–long	0.8 (0.4–1.5)	0.39	0.7 (0.4–1.5)	0.38
Long	1.0 (0.6–1.8)	0.91	0.8 (0.4–1.5)	0.51

CI = confidence interval; OR = odds ratio.
*Adjusted for age (65–73 yr, 74–80 yr, ≥ 81 yr), sex, race (white, black, other), median household income group (low, low–medium, medium–high, high), tumour stage (localized, regional, distant), admission type (emergency, elective, urgent), comorbidity score (0, ≥ 1) and hospital procedure volume (low, low–medium, medium–high, high).
†Consult-to-admission waiting time intervals: short wait (1–7 d), short–medium wait (8–14 d), medium–long wait (15–21 d) and long wait (≥ 22 d). First diagnostic test-to-admission waiting time intervals: short wait (1–14 d), short–medium wait (15–28 d), medium–long wait (29–42 d) and long wait (≥ 43 d).

Table 5. Disease-specific survival among patients who underwent surgery for colon cancer in the United Sates from Jan. 1, 1993, to Dec. 31, 1996, by consult-to-admission and first diagnostic test-to-admission intervals*

	Consult-to-admission		First diagnostic test-to-admission	
Waiting time†	HR (95% CI)	*p* value	HR (95% CI)	*p* value
Short	1.0		1.0	
Short–medium	0.9 (0.8–1.0)	0.21	0.9 (0.8–1.0)	0.21
Medium–long	1.0 (0.8–1.2)	0.89	0.9 (0.7–1.0)	0.08
Long	1.0 (0.9–1.2)	0.91	1.0 (0.8–1.1)	0.63

CI = confidence interval; HR = hazard ratio.
*Adjusted for age (65–73 yr, 74–80 yr, ≥ 81 yr), sex, race (white, black, other), median household income group (low, low-medium, medium-high, high), tumour stage (localized, regional, distant), admission type (emergency, elective, urgent), comorbidity score (0, ≥ 1) and hospital procedure volume (low, low-medium, medium-high, high).
†Consult-to-admission waiting time intervals: short wait (1–7 d), short–medium wait (8–14 d), medium–long wait (15–21 d) and long wait (≥ 22 d). First diagnostic test-to-admission waiting time intervals: short wait (1–14 d), short–medium wait (15–28 d), medium–long wait (29–42 d) and long wait (≥ 43 d).

Table 6. Overall survival among patients who underwent surgery for colon cancer in the United Sates from Jan. 1, 1993, to Dec. 31, 1996, by consult-to-admission and first diagnostic test-to-admission intervals*

	Consult-to-admission		First diagnostic test-to-admission	
Waiting time†	HR (95% CI)	*p* value	HR (95% CI)	*p* value
Short	1.0		1.0	
Short–medium	1.0 (0.9–1.1)	0.54	1.0 (0.9–1.1)	0.74
Medium–long	1.0 (0.9–1.1)	0.72	1.0 (0.9–1.1)	0.76
Long	1.1 (1.0–1.2)	0.013	1.2 (1.1–1.3)	0.003

CI = confidence interval; HR = hazard ratio.
*Adjusted for age (65–73 yr, 74–80 yr, ≥ 81 yr), sex, race (white, black, other), median household income group (low, low-medium, medium-high, high), tumour stage (localized, regional, distant), admission type (emergency, elective, urgent), comorbidity score (0, ≥ 1) and hospital procedure volume (low, low-medium, medium-high, high).
†Consult-to-admission waiting time intervals: short wait (1–7 d), short–medium wait (8–14 d), medium–long wait (15–21 d) and long wait (≥ 22 d). First diagnostic test-to-admission waiting time intervals: short wait (1–14 d), short–medium wait (15–28 d), medium–long wait (29–42 d) and long wait (≥ 43 d).

may not extrapolate to countries outside the United States, though patterns of prevalence for cancer diagnoses are similar in most western countries, including Canada.[25] We also only examined delays to surgery once a patient entered a sequence of tests or physician assessments that ended in colon cancer surgery. We did not assess delays due to a patient ignoring a symptom or to a physician not appreciating a concerning sign or symptom. Finally, owing to the observational design of the study there was a risk for confounding.

What then is an appropriate delay to elective colon cancer surgery? Whereas our results demonstrate that delays of weeks likely do not impact hard patient outcomes such as operative mortality or survival, our study did not address the anxiety and stress experienced by patients and their families during such treatment delays. We suggest that the recommendations produced by the Canadian Society of Surgical Oncology are reasonable: patients with a suspected cancer should be seen in consultation by a surgeon within 2 weeks, and once the decision for surgery is made, resection should occur within 2 weeks.[26]

In conclusion, it is unlikely that delays to nonemergent colon cancer surgery of longer than 3 weeks from initial surgical consult or longer than 6 weeks from first diagnostic test negatively impact operative mortality, disease-specific survival or overall survival.

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