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The impact of diagnostic assessment programs on the diagnosis and treatment of colon and rectal cancers in a single-payer system

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ABSTRACT

Introduction: To streamline the diagnostic and pretreatment assessments for patients with colorectal cancer, specialized diagnostic assessment programs (DAPs) were developed across the province of Ontario, Canada. We compared the performance of DAPs with usual care (non-DAPs).

Methods: Patients with colorectal cancer diagnosed between 2014 and 2016 were identified from the Ontario Cancer Registry. Using administrative databases, we compared the wait times, healthcare utilization, and overall survival between DAP and non-DAP patients.

Results: A total of 2,606/18,046 (14%) colorectal cancer patients attended a DAP for part of their diagnostic assessment. DAP patients were younger, lived closer to a DAP, had higher income, were more likely to have stage 2 or 3 disease (versus stage 1), had tumors in the rectum or rectosigmoid junction, and were less likely to have been an inpatient at the time of diagnosis [odds ratio 0.30 (0.24–0.37)]. DAP patients were more likely to receive diagnostic imaging before treatment, consultation with a medical oncologist or radiation oncologist, and chemotherapy or radiation compared with non-DAP patients. After adjusting for case mix, DAP patients had a time until treatment that was longer by 9.5 (7.4, 11.5) days, but better overall survival than non-DAP patients [hazard ratio 0.84 (0.75–0.94)]. A longer time from diagnosis until treatment was not associated with worse overall survival [hazard ratio 0.96 (0.93–1.00)].

Conclusion: Colorectal DAPs provide more comprehensive healthcare and are associated with better overall survival. Wait times as efficiency metrics should be interpreted carefully, as this is affected by triaging or enhanced treatment planning that may promote improved outcomes.

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Colon cancer; rectal cancer; colorectal cancer; diagnostic assessment program; cancer care Ontario; efficiency; wait times; guideline concordance

Introduction

Colorectal cancer is one of the most common cancers and a leading cause of death worldwide [1]. Most patients are diagnosed by endoscopic biopsy after investigation of clinical symptoms or a positive screening test suggestive of colorectal cancer, but other patients may present with symptoms requiring urgent surgery and are diagnosed at the time of operation [2]. Surgery is generally the first therapeutic intervention in patients with colon cancer, while chemotherapy and radiotherapy may be employed before surgery in patients with rectal cancer.

Health systems aiming to optimize patient outcomes and system efficiency have directed considerable attention to reducing the time until treatment in patients with colorectal cancer [3–6]. However, timeliness is only one component of an efficient healthcare system and may not translate into improved patient outcomes [7,8]. Time is needed to ensure appropriate diagnosis, staging, and treatment planning, and there is limited evidence that a

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shorter duration of the symptomatic phase before initiation of treatment is associated with improved clinical outcomes [9–12]. Other indices of efficiency in the diagnostic evaluation of colorectal cancer include adherence to evidence-based guidelines regarding the utilization of various diagnostic tests, access to multidisciplinary consultation to develop treatment plans, and the burden on patients associated with repeated testing or multiple encounters with the healthcare system [13,14].

In order to facilitate the diagnostic and pretreatment assessments for patients with suspected colorectal cancer, specialized Diagnostic Assessment Programs (DAPs) were developed across the province of Ontario, Canada [15]. DAPs were designed to provide coordinated access to all necessary healthcare professionals (e.g., surgeon, medical oncologist, radiation oncologist, and allied healthcare providers) and diagnostic testing [e.g., colonoscopy, computed tomography (CT), and magnetic resonance imaging (MRI)] to ensure standardized, efficient care concordant with evidence-based guidelines. Patient navigation to facilitate and coordinate testing and support patients to improve compliance is central to the model and reduces the number of visits required to render a diagnosis and plan treatment [16]. The purpose of this study is to evaluate whether DAPs outperform usual care (non-DAPs) on wait times, healthcare utilization, and patient survival.

Methods

Cohort

We identified patients with incident colorectal cancer using the Ontario Cancer Registry (OCR), restricted to patients who were assigned an ICD-O-3 code of C180, C182-C189, C199, or C260 between 2014 and 2016. We restricted our cohort to adult patients (aged 18 years or older) who were Ontario residents at the time of diagnosis. To ensure completeness of their diagnostic and treatment procedures, we excluded patients with missing health card numbers (required for access to healthcare services in the province), missing age or sex from the Registered Person's database, missing Ontario postal code, or without evidence of healthcare utilization activity in the Ontario Health Insurance Program (OHIP) database ± 1 year of diagnosis. The date of diagnosis was obtained from the OCR and is preferentially assigned using the retrieval date of the pathology specimen associated with the cancer diagnosis. Only patients with adenocarcinoma histology types were included (ICD-O-3 histology codes 8140, 8263, 8210, 8480, 8261, 8481, 8255, 8213, 8574, 8244, 8144, 8211, 8560, 8310, 8260, 8245, 8323, 8460, and 8441). Patients were excluded if they were diagnosed at the time of death or at autopsy, or if they had multiple cancer diagnoses over their lifetime, as this may influence their diagnostic, treatment, and referral patterns compared with single-cancer-only patients.

Healthcare utilization

To identify diagnostic tests (e.g., colonoscopy and sigmoidoscopy, imaging) and surgical treatments (e.g., excision), we used the OHIP database (an administrative database used for physician billing across the province), the positron emission tomography (PET) registry, the Discharge Abstract Database (used to capture inpatient procedures), and the National Ambulatory Care Reporting System (used to capture outpatient procedures). The latter two are national databases maintained by the Canadian Institute for Health Information (CIHI), a nonprofit organization that collects Canadian health system data. We used physician billing codes and procedure codes to capture healthcare utilization (Appendix 1). We used activity-level reporting (ALR) to identify the date of radiation applied to the abdomen and/or pelvis. The ALR contains all the data elements from the provinces' cancer programs required to produce the quality, cost, and performance indicators for the cancer system. To identify systemic therapy, we used the CIHI databases, ALR, Ontario Drug Benefits, and the New Drug Funding Program databases, restricting chemotherapy, targeted therapy, immunotherapy, and hormones with antineoplastic activity. Details of the surgery date are provided in Appendices 2 and 3.

Time intervals

We defined the "diagnostic interval" as the time from the earliest relevant healthcare encounter within 6 months before diagnosis, or "first visit," until the diagnosis date from the OCR. First visits could, therefore, be a consultation or visit with various healthcare providers (general practitioner, general surgeon, general thoracic surgeon, gastroenterologist, internist, cardiologist, radiation oncologist, or medical oncologist), or a diagnostic imaging test (chest X-ray, chest CT, abdominal CT, colonoscopy/endoscopy, brain CT or MRI). To avoid negative diagnostic intervals, the diagnosis date was the first visit in instances where there was no healthcare

utilization before this date. We defined the "pre-treatment interval" as the time from the diagnosis date reported in the OCR until first treatment (surgery, systemic therapy, or radiation).

Diagnostic assessment programs

To assign patients as having been assessed in a DAP, we obtained data from the Diagnostic Data Upload Tool (DDUT)—an individual-level data set that tracks patient referral and diagnosis activity in Ontario's colorectal DAPs. Facilities provide these data to Cancer Care Ontario on a quarterly basis. Patients were assigned as having been assessed in a DAP if they had a diagnosis date from DDUT within 30 days before or after the diagnosis date from the OCR. This window was permitted because the diagnosis date entered in the DDUT may differ from the OCR diagnosis date (e.g., may be the date the pathology results were received by the most responsible physician). However, the OCR diagnosis date was considered the gold standard and is comparable between DAP and non-DAP patients. The diagnosis date from the DDUT was a median 4 (2, 7) days after the OCR diagnosis date. Ontario's colorectal DAPs vary in the services they provide: while some focus on facilitating access to colonoscopy for patients with symptoms or a positive screen, most also provide diagnostics for staging and multidisciplinary consultation for treatment planning for patients with suspicious lesions or biopsy-proven cancers. Some DAPs are limited to rectal cancers only, but since some cancers coded as occurring in the "rectosigmoid junction" in the administrative data may be variably managed according to guidelines for colon or rectal cancer, colon cancer patients may be diagnosed at a rectal DAP and vice versa. For this reason, we distinguished between cancer in the colon, rectosigmoid junction, and rectum for some analyses.

Statistical methods

We used logistic regression for dichotomous outcomes (e.g., DAP *vs.* non-DAP), reporting odds ratios (OR) with 95% confidence intervals (CI). We used Cox proportional hazards regression for overall survival analyses, reporting hazard ratios (HR) with 95% CI. We used linear regression for estimates of effects of study variables on wait times, reporting the beta coefficient, with 95% CI, on the scale of days. All models were adjusted for clinical and demographic factors, including age, sex, urban residence, neighborhood income quintile, neighborhood immigrant density, stage, disease subsite, comorbidity score according to Charlson's Comorbidity Index, diagnosis on or during a hospital admission, and an emergency department visit within 7 days before diagnosis. SAS version 9.4 was used for all analyses. We report proportions, means with the standard deviation (SD), and medians with the interquartile range (IQR; 25th, 75th percentile), where appropriate.

Privacy and ethics

When analyses identified fewer than 6 patients in a category, the results were suppressed due to privacy requirements. Research Ethics approval was waived, as the purpose of this study is to ascertain the relative effectiveness of DAPs for the purpose of system monitoring by Cancer Care Ontario.

Results

Cohort description

After applying the exclusion criteria to the initial cohort, 18,046 incident colorectal cancer cases remained (Figure 1) and consisted of 12,261 (68%) colon, 4,281 (24%) rectum, and 1,499 (8%) rectosigmoid junction cancers. Patients were a mean 70 (SD 13.0) years of age at diagnosis and most patients were male (52% for colon, 59% for rectosigmoid, and 63% for rectal cancers). Colon cancer patients were more likely to be admitted to a hospital at the time of diagnosis (39%) compared to patients with a cancer of the rectosigmoid junction (28%) or rectum (14%). A similar trend was observed for having an emergency visit within 7 days before diagnosis (27% for colon, 18% for rectosigmoid junction, and 12% for rectum). Unless otherwise indicated, the rectosigmoid junction was included with the colon.

Characteristics of DAP and non-DAP patients

A total of 1628/13,761 (12%) colon cancer and 978/4,258 (23%) rectal cancer patients were diagnosed in a DAP (Table 1). After adjustment for sociodemographic and clinical characteristics, patients were more likely to be diagnosed in a DAP if they were younger [OR 0.88 (0.83–0.93) per 10 years], lived closer to a DAP [OR 0.84 (0.82–0.87) per 10 km], lived in a rural neighborhood [OR 1.27 (1.02–1.59)], lived in a higher-income neighborhood ($p = 0.04$), and lived in a less immigrant-dense neighborhood ($p = 0.02$) (Table 1). DAP patients also differed from non-DAP patients on various clinical factors: DAP patients were more likely to have stage 2 or 3 disease [OR 1.43

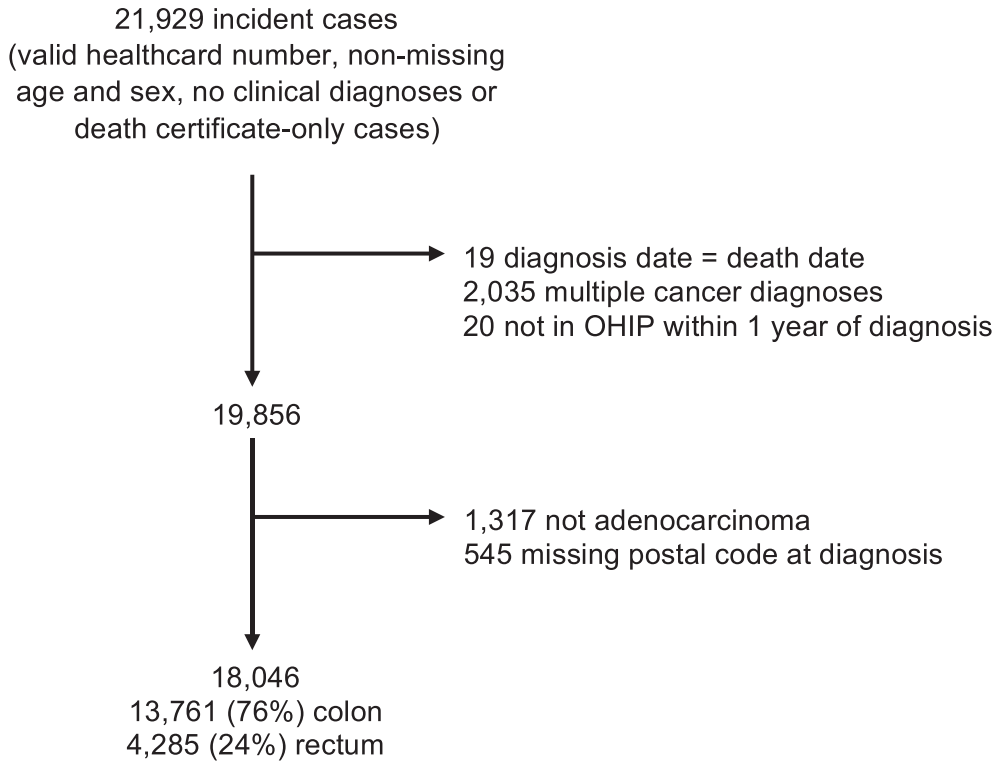

Figure 1. Cohort identification and selection.

Table 1. Demographic and clinical characteristics of DAP and non-DAP patients.

Characteristic	Non-DAP *n* = 15,440 *N* (%)	DAP *n* = 2,606 N (%)	Odds of attending a DAP			
			Unadjusted		Adjusted[f]	
			OR (95% CI)	*p*-value	OR (95% CI)	*p*-value
Socio-demographic factors						
Age, years[a]	70 (12.9)	67 (13.2)	0.84 (0.81–0.86)	<0.0001	0.88 (0.83–0.93)	<0.0001
Sex						
Female	6,953 (45%)	1,097 (42%)	1.0 (ref)	0.005	1.0 (ref)	0.94
Male	8,487 (55%)	1,509 (58%)	1.13 (1.04–1.23)		1.01 (0.88–1.15)	
Geographic region[b,c,d]						
Central	1,840 (89%)	224 (11%)	1.0 (ref)	<0.0001	1.0 (ref)	<0.0001
Central East	1,802 (85%)	309 (15%)	1.41 (1.17–1.69)		1.62 (1.20–2.19)	
Central West	767 (95%)	38 (5%)	0.41 (0.29–0.58)		0.56 (0.33–0.94)	
Champlain	1,318 (69%)	582 (31%)	3.63 (3.06–4.30)		4.25 (3.16–5.72)	
Erie St. Clair	983 (94%)	62 (6%)	0.52 (0.39–0.67)		0.52 (0.32–0.83)	
Hamilton Niagara	2,114 (95%)	116 (5%)	0.45 (0.36–0.57)		0.41 (0.28–0.60)	
Mississauga Halton	1,125 (94%)	76 (6%)	0.56 (0.42–0.73)		0.48 (0.30–0.77)	
North East	872 (97%)	23 (3%)	0.22 (0.14–0.34)		0.58 (0.31–1.07)	
North Simcoe Muskoka	648 (87%)	95 (13%)	1.20 (0.93–1.56)		1.68 (1.10–2.57)	
North West	342 (92%)	30 (8%)	0.72 (0.48–1.07)		0.85 (0.43–1.66)	
South East	576 (68%)	277 (32%)	3.95 (3.24–4.82)		7.06 (4.99–10.0)	
South West	1,434 (93%)	110 (7%)	0.63 (0.50–0.80)		0.68 (0.46–0.99)	
Toronto Central	1,029 (79%)	275 (21%)	2.20 (1.81–2.66)		2.12 (1.57–2.88)	
Waterloo Wellington	590 (60%)	389 (40%)	5.52 (4.48–6.41)		6.48 (4.69–8.94)	

Continued

Characteristic	Non-DAP *n* = 15,440 *N* (%)	DAP *n* = 2,606 N (%)	Odds of attending a DAP			
			Unadjusted		Adjusted[f]	
			OR (95% CI)	*p*-value	OR (95% CI)	*p*-value
Distance to closest DAP, km[a]						
Mean (SD) Median (IQR)	39.0 (54.5) 19 (8, 52)	21.3 (30.8) 9 (4, 23)	0.87 (0.86–0.89)	<0.0001	0.84 (0.82–0.87)	<0.0001
Urban[c]						
Urban	13,158 (85%)	2,257 (87%)	1.0 (ref)	0.06	1.0 (ref)	0.04
Rural	2,282 (15%)	349 (13%)	0.89 (0.79–1.01)		1.27 (1.02–1.59)	
Immigrant density[c]						
Least dense	9,425 (62%)	1,699 (66%)	1.0 (ref)	<0.0001	1.0 (ref)	0.02
Mid-dense	3,419 (22%)	596 (23%)	0.97 (0.87–1.07)		0.78 (0.64–0.94)	
Most dense	2,395 (16%)	293 (11%)	0.68 (0.60–0.78)		0.77 (0.59–1.01)	
Income quintile[c]						
Highest	2,940 (19%)	616 (24%)	1.0 (ref)	<0.0001	1.0 (ref)	0.04
Mid-high	3,183 (21%)	528 (20%)	0.79 (0.70–0.90)		0.85 (0.69–1.04)	
Middle	3,162 (21%)	481 (19%)	0.73 (0.64–0.83)		0.77 (0.63–0.95)	
Mid-low	3,090 (20%)	534 (21%)	0.83 (0.73–0.94)		0.85 (0.69–1.04)	
Lowest	3,005 (20%)	440 (17%)	0.70 (0.61–0.80)		0.72 (0.58–0.90)	
Clinical factors						
Charlson comorbidity score						
0	7,657 (66%)	1,291 (71%)	1.0 (ref)	0.0004	1.0 (ref)	0.17
1	2,182(19%)	292 (16%)	0.79 (0.69–0.91)		0.87 (0.72–1.05)	
2	9,388 (8%)	131 (7%)	0.83 (0.68–1.00)		1.01 (0.78–1.31)	
3+	894 (8%)	113 (6%)	0.75 (0.61–0.92)		1.21 (0.93–1.57)	
Cancer stage						
I	2,949 (26%)	435 (24%)	1.0 (ref)	<0.0001	1.0 (ref)	<0.0001
II	3,051 (27%)	511 (28%)	1.14 (0.99–1.30)		1.43 (1.19–1.71)	
III	3,019 (27%)	612 (34%)	1.37 (1.20–1.57)		1.47 (1.23–1.76)	
IV	1,918 (17%)	222 (12%)	0.79 (0.66–0.93)		0.91 (0.73–1.15)	
Unknown	237 (2%)	25 (11%)	0.72 (0.47–1.09)		0.96 (0.58–1.60)	
Disease site[e]						
Colon	10,861 (70%)	1,401 (54%)	1.0 (ref)	<0.0001	1.0 (ref)	<0.0001
Rectosigmoid junction	1,272 (8%)	227 (9%)	1.38 (1.19–1.61)		1.62 (1.19–2.21)	
Rectum	3,307 (21%)	978 (38%)	2.29 (2.09–2.51)		2.15 (1.64–2.82)	
Year of diagnosis[b]						
2014	5,239 (87%)	811 (13%)	1.0 (ref)	0.02	1.0 (ref)	0.11
2015	5,067 (85%)	890 (15%)	1.14 (1.02–1.26)		1.14 (0.98–1.33)	
2016	5,134 (85%)	905 (15%)	1.14 (1.03–1.26)		1.17 (0.99–1.39)	
Admitted at the time of diagnosis						
No	9,920 (64%)	2,242 (86%)	1.0 (ref)	<0.0001	1.0 (ref)	<0.0001
Yes	5,520 (36%)	364 (14%)	0.29 (0.26–0.33)		0.30 (0.24–0.37)	

Continued

Characteristic	Non-DAP *n* = 15,440 *N* (%)	DAP *n* = 2,606 N (%)	Odds of attending a DAP			
			Unadjusted		Adjusted[f]	
			OR (95% CI)	*p*-value	OR (95% CI)	*p*-value
Emergency department visit within 7 days of diagnosis						
No	11,554 (75%)	2,309 (89%)	1.0 (ref)	<0.0001	1.0 (ref)	0.78
Yes	3,886 (25%)	297 (11%)	0.38 (0.34–0.43)		0.94 (0.75 -1.20)	

[a]OR represents a 10-years change in age or 10-km change in distance.
[b]Row percentages provided.
[c]Source: (or adapted from) Statistics Canada Postal Code Conversion File and Postal Code Conversion File Plus (June 2017) which is based on data licensed from Canada Post Corporation. The patients' postal code at diagnosis was used.
[d]Ontario was broken down into 14 geographic regions called Local Health Integration Networks, where healthcare was administered and funded independently.
[e]Identified from the OCR using the ICD-O-3 codes for cecum [C180, *n* = 2,965 (16%)], ascending colon [C182, *n* = 2,552 (14%)], hepatic flexure [C183, *n* = 545 (3%)], transverse colon [C184, 1,153 (6%)], splenic flexure [C185, *n* = 390 (2%)], descending colon [C186, *n* = 757 (4%)], sigmoid colon [C187, *n* = 3,637 (20%)], large intestine not otherwise specified [C188–189, C260, *n* = 263 (1%)], rectosigmoid junction [C199, *n* = 1,499 (8%)], and rectum [C209, *n* = 4,285 (24%)].
[f]Adjusted for all variables in the table.
DAP = Diagnostic Assessment Program; OR = odds ratio; CI = confidence interval; SD = standard deviation; IQR = (25th, 75th percentile).

(1.19–1.71) for stage 2 and OR 1.47 (1.23–1.76) for stage 3 versus stage 1], less likely to be admitted to a hospital at the time of diagnosis [OR 0.30 (0.24–0.37)], and more likely to have cancers of the rectum [OR 2.15 (1.64–2.82)] or the rectosigmoid junction [OR 1.62 (1.19–2.21)] compared to the colon (Table 1). Significant regional variation was observed, with the proportion of colorectal cancer patients diagnosed in a DAP ranging from 5% to 40% between regions.

Frequency of healthcare utilization

Between 3 months before diagnosis and the initiation of treatment, most patients had a colonoscopy (>92%), an abdominal CT scan (>91%), and a chest CT scan (>88%), with little difference observed between DAP and non-DAP patients by disease site (Appendix 4). DAP patients were more likely to receive a pelvic/abdominal MRI [23% *vs.* 9% for colon (69% *vs.* 35% for rectosigmoid junction; 16% *vs.* 6% for other colon); 89% *vs.* 67% for rectum], and among stage 4 patients, were less likely to receive a brain scan (14% *vs.* 22% for colon and 8% *vs.* 16% for rectal cancer patients). DAP patients were also more likely to have multiple colonoscopies and multiple pelvic or abdominal MRIs than non-DAP patients (Appendix 4). DAP patients with rectal cancer were more likely to have had a consultation with a medical oncologist (53% *vs.* 36%), radiation oncologist (63% *vs.* 48%), or gastroenterologist (36% *vs.* 27%); DAP patients with colon cancer were more likely than non-DAP patients to see a gastroenterologist (55% *vs.* 31%) and a cardiologist (Appendix 4). Among stage 2 and 3 rectal cancer patients (and to a lesser extent colon cancer patients), the receipt of chemotherapy or radiation was more likely if they were diagnosed in a DAP.

Wait times

Milestones along the patient's journey

The first treatment received by disease site and stage is reported in Appendix 5. To explore the timeliness of the diagnostic work-up for patients with colorectal cancer, we captured healthcare utilization from 6 months before diagnosis until the first treatment date (Appendix 6). Most patients received a colonoscopy on the date of diagnosis [median 0 (0, 0) days], and this was the most common procedure on the date of diagnosis (Appendix 7). One-third of the patients received a second colonoscopy 1–2 weeks later (Appendix 6, Figure 2). Other tests carried out within one week of the diagnosis date included abdominal CT scan, chest X-ray, and chest CT scan. Pelvic or abdominal MRI was most frequently carried out 2–3 weeks after diagnosis. The wait time for a medical oncology or radiation oncology consultation was longer, with consultations occurring up to 1 month after diagnosis.

The first visit

Generally, similar proportions of DAP and non-DAP patients had each type of first visit (Appendix 8). However, DAP patients were more likely to have a colonoscopy or a gastroenterology consult as a first visit than non-DAP patients, while non-DAP patients were more likely to have a chest X-ray or chest or abdominal CT scan.

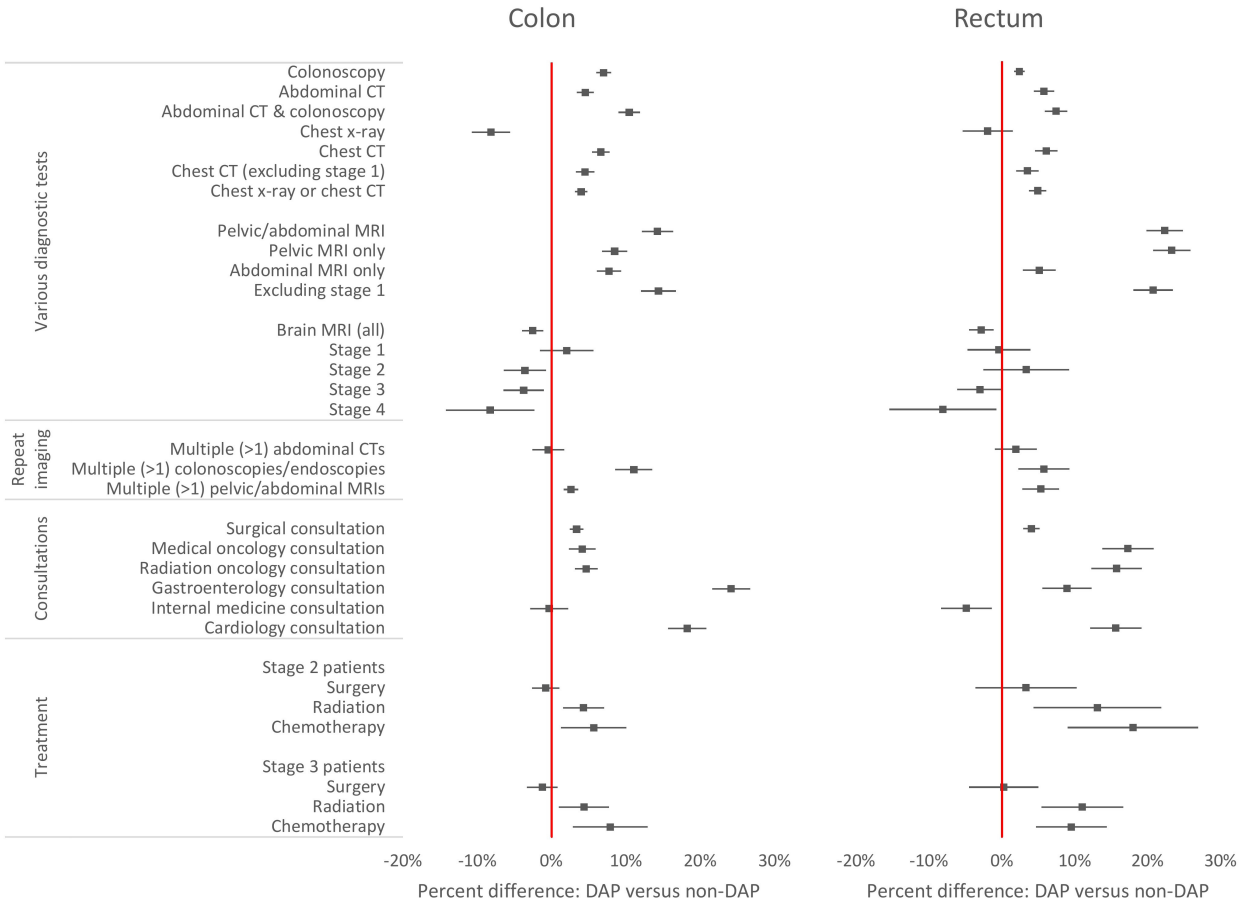

Figure 2. Difference in proportion between DAP and non-DAP on the frequency of healthcare utilization 3 months before diagnosis until the date of first treatment (or 2 months after diagnosis if no treatment was observed). The percentage difference is shown as the colored rectangle and 95% confidence intervals as horizontal lines. Positive (negative) percentage differences indicate a higher (lower) proportion of DAP patients had that healthcare encounter than non-DAP patients. CT = computed tomography; MRI = magnetic resonance imaging; DAP = Diagnostic Assessment Program.

The diagnostic and pretreatment intervals

Among all colon cancer patients, the time from the first visit until initiation of treatment was a median 85 (42, 151) days, the time from first visit until diagnosis was 57 (11, 125) days, and the time from diagnosis until initiation of treatment was 27 (4, 45) days (Appendix 6). Among all rectal cancer patients, time from first visit until first treatment was a median 94 (57, 163) days, from first visit until diagnosis was a median 45 (8, 114) days, and from diagnosis until first treatment was a median 48 (31, 67) days. Regional variation in wait times is reported in Appendix 9.

After accounting for case mix (e.g., demographic and clinical factors), the diagnostic interval was a mean of 3.7 (95% CI 0.0, 7.4) days shorter for DAP patients, while the pretreatment interval was a mean of 9.5 (7.4, 11.5) days longer (Table 2). The effect of DAPs on wait times did not differ between the colorectal subsites (rectum *vs.* rectosigmoid junction *vs.* colon) for the time from first visit to diagnosis (p-interaction = 0.71) or from diagnosis to start of treatment (p-interaction = 0.09). Significant regional variation in wait times was observed (Table 2).

Overall survival

The median follow-up time of the cohort was 23 (IQR 14, 34) months. DAP patients had a significantly better overall survival than non-DAP patients [HR 0.68 (0.62–0.74), $p < 0.0001$; Table 3]. After adjusting for case mix, this association was attenuated but still statistically significant [HR 0.84

Table 2. Effect of patient clinical and demographic variables on the duration of the diagnostic and pre-treatment intervals (in days).

Clinical or demographic variable	Time from first visit until diagnosis (diagnostic interval)		Time from diagnosis until first treatment (pre-treatment interval)	
	Beta (95% CI)[a]	*p*-value	Beta (95% CI)[a]	*p*-value
Diagnostic assessment program				
No	0 (ref)	0.05	0 (ref)	<0.0001
Yes	−3.7 (−7.4, 0.0)		9.5 (7.4, 11.5)	
Age (per 10 years of age)	1.8 (0.9, 2.8)	0.0001	1.4 (0.8, 1.9)	<0.0001
Sex				
Male	0 (ref)	0.004	0 (ref)	0.17
Female	3.5 (1.2, 5.8)		−0.9 (−2.3, 0.4)	
Urban residence[c]				
Urban	0 (ref)	0.009	0 (ref)	0.10
Rural	−4.7 (−8.2, −1.2)		1.7 (−0.3, 3.6)	
Income[c]				
Highest	0 (ref)	0.39	0 (ref)	0.24
Mid-to-high	−0.8 (−4.5, 2.9)		0.1 (−2, 2.1)	
Middle	2.1 (−1.7, 5.9)		0.3 (−1.8, 2.4)	
Mid-to-low	2.4 (−1.3, 6.2)		−0.2 (−2.3, 1.9)	
Lowest	0.5 (2.0, −3.4)		2.1 (−0.1, 4.2)	
Immigrant density[c]				
Least dense	0 (ref)	0.66	0 (ref)	0.03
Mid-dense	0.1 (−3.4, 3.5)		2.3 (0.4, 4.2)	
Most dense	2.0 (−2.7, 6.6)		2.8 (0.2, 5.4)	
Local health integration network[c,d]				
Central	0 (ref)	0.02	0 (ref)	<0.0001
Central East	4.1 (−1.3, 9.5)		−2.4 (−5.4, 0.6)	
Central West	4.6 (−2.4, 11.5)		0.5 (−3.4, 4.3)	
Champlain	9.6 (3.9, 15.3)		8.6 (5.4, 11.8)	
Erie St. Clair	5.8 (−0.7, 12.3)		0.7 (−2.9, 4.4)	
Hamilton Niagara	3.4 (−2.0, 8.9)		2.7 (−0.4, 5.7)	
Mississauga Halton	6.0 (−0.2, 12.2)		1.5 (−2, 5)	
North East	−2.7 (−9.7, 4.2)		−0.3 (−4.2, 3.6)	
North Simcoe Muskoka	1.6 (−5.7, 8.8)		−0.4 (−4.4, 3.7)	
North West	1.2 (−8.4, 10.8)		−0.8 (−6.2, 4.5)	
South East	2.2 (−4.9, 9.2)		3.6 (−0.4, 7.7)	
South West	6.2 (0.2, 12.2)		5 (1.6, 8.3)	
Toronto Central	6.8 (0.9, 12.6)		2 (−1.3, 5.3)	
Waterloo Wellington	3.6 (−3.2, 10.4)		−1.3 (−5.1, 2.5)	
Charlson comorbidity index				
0	0 (ref)	<0.0001	0 (ref)	<0.0001
1	14.8 (11.7, 17.9)		3.5 (1.7, 5.3)	
2	19.1 (14.7, 23.5)		4.2 (1.6, 6.7)	
3+	35.3 (30.8, 39.7)		8.8 (6.2, 11.4)	
Cancer stage				
1	0 (ref)	<0.0001	0 (ref)	<0.0001

Continued

Clinical or demographic variable	Time from first visit until diagnosis (diagnostic interval)		Time from diagnosis until first treatment (pre-treatment interval)	
	Beta (95% CI)[a]	*p*-value	Beta (95% CI)[a]	*p*-value
2	−9.1 (−12.4, −5.9)		−10.4 (−12.2, −8.6)	
3	−10.2 (−13.5, −7.0)		−10.2 (−12.1, −8.4)	
4	−17.8 (−21.6, −14.0)		−9 (−11.4, −6.7)	
Unknown	−18.1 (−26.3, −9.9)		13 (4.6, 21.5)	
Disease site				
Colon	0 (ref)	0.02	0 (ref)	<0.0001
Rectosigmoid junction	−3.0 (−7.5, 1.5)		6.8 (4.3, 9.3)	
Rectum	−4.0 (−7.0, −1.0)		16.2 (14.4, 17.9)	
Admission on diagnosis date				
No	0 (ref)	<0.0001	0 (ref)	<0.0001
Yes	15.6 (12.4, 18.8)		−36.4 (−38.2, −34.6)	
Emergency visit within 7 days of diagnosis				
No	0 (ref)	<0.0001	0 (ref)	<0.0001
Yes	−31.5 (−35.0, −27.9)		9.7 (11.7, 7.7)	

[a]After adjustment for age, sex, urban residence, neighbourhood income quintile, neighbourhood immigrant density, disease site, Local Health Integration Network at the time of diagnosis, Charlson comorbidity index, cancer stage, hospital admission on diagnosis date, and emergency visit within 7 days of diagnosis.
[b]Beta is the average number of days increase per 1-unit change in the predictor variable using linear regression.
[c]Source: (or adapted from) Statistics Canada Postal Code Conversion File and Postal Code Conversion File Plus (June 2017) which is based on data licensed from Canada Post Corporation. The patients' postal code at diagnosis was used.
[d]Ontario was broken down into 14 geographic regions called Local Health Integration Networks, where healthcare was administered and funded independently.
CI = confidence interval.

(0.75–0.94), $p = 0.001$; Table 3]. Other factors associated with worse overall survival included older age [HR 1.38 (1.34–1.44) per 10 years], male sex [HR 1.11 (1.04–1.19)], residence in a lower-income neighborhood [HR 1.19 (1.07–1.32) for the lowest versus the highest income quintile], residence in the most immigrant-dense neighborhood [HR 0.78 (0.70–0.87) for neighborhoods with the highest density], more comorbidities [HR 1.79 (1.61–1.99) for 3+ versus none], more advanced cancer stage ($p < 0.0001$), rectal cancer [HR 1.12 (1.02–1.22) versus colon cancer], hospital admission at the time of diagnosis [HR 1.20 (1.09–1.32)], and a visit to the emergency department within 7 days before diagnosis [HR 1.77 (1.60–1.95)].

We explored the effect of wait times on overall survival. Patients who were diagnosed more quickly (e.g., within 3 weeks of first visit) had worse survival ($p < 0.0001$), although this effect was lost after adjustment. A longer pretreatment interval was associated with better survival in an unadjusted model in a dose-dependent manner (Table 3). After minimal adjustment (age, sex, and stage), the association was unchanged [HR 0.89 (0.86–0.92). After full adjustment, this effect was completely abrogated ($p = 0.43$).

Discussion

DAP patients had better overall survival than non-DAP patients, but waited 10 days longer to receive treatment. Although DAP and non-DAP patients had similar numbers of healthcare encounters during the diagnostic and pretreatment intervals, DAP patients had more healthcare utilization overall, despite no increase in the number of visit dates.

A longer pretreatment interval for DAP patients was unexpected, but unlikely to have affected survival, since the additional 10 days are unlikely to result in disease progression in patients who experience the delay. Moreover, there is limited evidence that longer wait times are associated with worse survival. A systematic review on this topic concluded that there is either a null or an inverse association, but adjustment for confounders is needed for appropriate interpretation [9]. Many recent studies have corroborated our findings, while others observed a nonlinear association with worse survival for cancer patients diagnosed

Table 3. Factors associated with all-cause mortality.

	Unadjusted		Adjusted[a]	
	HR (95% CI)	***p*-value**	**HR (95% CI)**	***p*-value**
Diagnostic assessment program				
No	1.0 (ref)	<0.0001	1.0 (ref)	0.002
Yes	0.68 (0.62–0.74)		0.84 (0.75–0.94)	
Age (per 10 years of age)	1.43 (1.39–1.46)		1.38 (1.34–1.44)	<0.0001
Sex				
Male	1.0 (ref)	0.18	1.0 (ref)	0.002
Female	0.96 (0.91–1.02)		0.90 (0.84–0.96)	
Urban residence[b]				
Urban	1.0 (ref)	0.24	1.0 (ref)	0.95
Rural	1.05 (0.97–1.13)		1.00 (0.91–1.10)	
Neighbourhood income[b]				
Highest	1.0 (ref)	<0.0001	1.0 (ref)	0.0009
Mid-to-high	1.04 (0.95–1.14)		0.97 (0.87–1.08)	
Middle	1.09 (0.99–1.19)		1.02 (0.91–1.13)	
Mid-to-low	1.16 (1.06–1.26)		1.12 (1.00–1.24)	
Lowest	1.26 (1.16–1.34)		1.19 (1.07–1.32)	
Neighbourhood immigrant density[b]				
Least dense	1.0 (ref)	0.0003	1.0 (ref)	<0.0001
Mid-dense	0.93 (0.87–1.00)		0.95 (0.87–1.04)	
Most dense	0.86 (0.79–0.93)		0.78 (0.70–0.87)	
Local health integration network[b,c]				
Central	1.0 (ref)	<0.0001	1.0 (ref)	0.03
Central East	1.18 (1.05–1.33)		1.22 (1.05–1.43)	
Central West	0.92 (0.77–1.08)		0.87 (0.7–1.08)	
Champlain	1.12 (0.99–1.26)		1.2 (1.02–1.42)	
Erie St. Clair	1.33 (1.16–1.53)		1.19 (1–1.43)	
Hamilton Niagara	1.29 (1.15–1.44)		1.21 (1.03–1.41)	
Mississauga Halton	1.01 (0.87–1.16)		1.05 (0.88–1.26)	
North East	1.35 (1.16–1.56)		1.19 (0.98–1.45)	
North Simcoe Muskoka	1.26 (1.07–1.47)		1.11 (0.9–1.37)	
North West	1.22 (0.99–1.50)		1.22 (0.92–1.62)	
South East	1.30 (1.12–1.51)		1.26 (1.03–1.54)	
South West	1.38 (1.22–1.56)		1.25 (1.06–1.49)	
Toronto Central	1.14 (0.99–1.30)		1.05 (0.89–1.25)	
Waterloo Wellington	1.28 (1.11–1.47)		1.39 (1.15–1.68)	
Charlson Comorbidity Index				
0	1.0 (ref)	<0.0001	1.0 (ref)	<0.0001
1	1.32 (1.22–1.43)		1.18 (1.08–1.29)	
2	1.70 (1.53–1.88)		1.27 (1.13–1.42)	
3+	2.31 (2.10–2.54)		1.79 (1.61–1.99)	
Cancer Stage				
1	1.0 (ref)	<0.0001	1.0 (ref)	<0.0001
2	1.70 (0.51–1.92)		1.35 (1.18–1.54)	
3	2.59 (2.31–2.90)		2.31 (2.04–2.62)	

Continued

	Unadjusted		Adjusted[a]	
	HR (95% CI)	*p*-value	HR (95% CI)	*p*-value
4	15.2 (13.6–16.9)		13.0 (11.5–14.7)	
Unknown	13.0 (11.0–15.4)		6.85 (5.70–8.24)	
Disease site				
Colon	1.0 (ref)	<0.0001	1 (ref)	0.02
Rectosigmoid junction	0.91 (0.82–1.01)		0.93 (0.82–1.06)	
Rectum	0.84 (0.79–0.90)		1.12 (1.02–1.22)	
Hospital admission on diagnosis date				
No	1.0 (ref)	<0.0001	1 (ref)	0.0003
Yes	2.43 (2.30–2.57)		1.20 (1.09–1.32)	
Emergency visit within 7 days of diagnosis				
No	1.0 (ref)	<0.0001	1.0 (ref)	<0.0001
Yes	3.30 (3.12–3.48)		1.77 (1.60–1.95)	
Diagnostic interval duration				
Continuous (days)	0.92 (0.91–0.94)	<0.0001	0.99 (0.94–1.02)	0.57
Categorical				
0 days	1.09 (0.99–1.21)		0.89 (0.79–1.01)	
1–7 days	1.93 (1.71–2.18)		0.99 (0.85–1.15)	
8–14 days	1.79 (1.55–2.06)		1.27 (1.07–1.50)	
15–21 days	1.47 (1.25–1.73)		0.96 (0.79–1.17)	
22–28 days	1.09 (0.91–1.30)		0.92 (0.74–1.14)	
29–35 days	1.07 (0.89–1.30)		0.93 (0.74–1.17)	
36–66 days	1.0 (ref)	<0.0001	1.0 (ref)	0.0005
>63 days	1.01 (0.90–1.13)		0.97 (0.85–1.11)	
Pre-treatment interval duration				
Continuous (days)	0.68 (0.62–0.74)	<0.0001	0.97 (0.93–1.00)	0.07
Categorical				
0 days	1.36 (1.22–1.50)		1.14 (0.98–1.33)	
1–7 days	2.24 (2.02–2.49)		1.13 (0.97–1.33)	
8–14 days	1.83 (1.60–2.10)		1.18 (0.99–1.40)	
15–21 days	1.47 (1.30–1.68)		1.15 (0.98–1.36)	
22–28 days	1.20 (1.06–1.36)		1.05 (0.90–1.24)	
29–35 days	1.05 (0.93–1.19)		0.99 (0.85–1.16)	
36–66 days	1.0 (ref)	<0.0001	1.0 (ref)	0.43
>63 days	1.14 (1.03–1.27)		1.02 (0.89–1.16)	

[a]After adjustment for age, sex, urban residence, neighbourhood income quintile, neighbourhood immigrant density, disease site, Local Health Integration Network at the time of diagnosis, Charlson comorbidity index, cancer stage, hospital admission on diagnosis date, and emergency visit within 7 days of diagnosis.
[b]Source: (or adapted from) Statistics Canada Postal Code Conversion File and Postal Code Conversion File Plus (June 2017) which is based on data licensed from Canada Post Corporation. The patients' postal code at diagnosis was used.
[c]Ontario was broken down into 14 geographic regions called Local Health Integration Networks, where healthcare was administered and funded independently.
HR = hazard ratio; CI = confidence interval.

within the shortest and longest wait times (<23 days or >77 days after diagnosis) [17,18]. Without data on factors that predict patient triage, such as symptoms and functional status, most associations of wait times with survival will remain confounded [12,18–20]. For example, patients treated on the date of diagnosis are likely different than those treated after some delay, and include both incidental cases and cases with advanced

disease and emergency presentation [2,21]. Taking this into account, we categorized the time from first visit until treatment using shorter time increments that reveal more meaningful trends than as a single continuous variable [18,22]. Using this approach, we observed a nonlinear association between wait times and survival, but the association was no longer significant after adjustment for important prognostic factors in addition to age, sex, and cancer stage.

Our findings that DAPs lead to longer wait times but better overall survival may be attributable to increased utilization of diverse healthcare services. DAP patients were more likely to receive imaging (CT or MRI), treatment (e.g., chemotherapy and radiation among stage 2 and 3 colorectal cancer patients), and consultations with various specialists (e.g., medical oncologist, radiation oncologist, and cardiologist). Relatively fewer resources in non-DAP systems may have acted as a barrier to surgeons referring patients for adjuvant therapy with consequent effect on survival [23]. DAPs are more likely to provide multidisciplinary consultation, which has been shown to improve survival for patients with colorectal cancer [24,25]. Such consultation may have occurred through multidisciplinary cancer conferences, which were emphasized by the province during the study period and have been shown to modify 29% of treatment plans for rectal cancer patients in Ontario [23,26]. Multidisciplinary cancer care has also been associated with a prolonged time from diagnosis until appointment scheduling for patients involved with multidisciplinary case conferences (mean difference of 8 days), but a similar time from diagnosis until treatment (43 days) [27]. That study population was matched on the number of treating specialities; therefore, it is likely that the time until treatment is longer for patients receiving multidisciplinary consultation in an unmatched population (i.e., at the population level). Additionally, DAPs are more likely to be served by specialized surgeons, so a volume–outcome relationship may contribute to improved survival [28]. It is noteworthy that although DAPs were intended to improve efficiency in diagnostic assessment, our finding suggests that they may also lead to improved access to and initiation of pathway concordant therapies. Thus, while the delay until treatment may not negatively impact survival, the effect that this delay may have on patient anxiety and quality of life remains to be established and should be the focus of future work.

Despite the observations that wait times are not the most critical drivers of patient outcomes, efforts to reduce wait times have been at the forefront of most quality improvement interventions in colorectal cancer care. Other groups have focused on enabling access to colonoscopy (e.g., straight-to-test colonoscopy in the United Kingdom; direct access colonoscopy in Australia), but these interventions were not linked to survival [6,29,30]. The lack of association between facilitated access to diagnosis (colonoscopy) and survival in these studies is consistent with our findings, suggesting that the additional time required to complete necessary investigations and secure consultation with multiple specialists may be worth the time invested [31–33]. From a patient's perspective, timeliness is only one component of the colorectal cancer journey, and does not consider the benefits of navigation and information sharing on the patient experience [13] We have shown that a positive experience with the navigator in DAPs mitigates the effect of longer wait times on patient experience [34].

A limitation of this study is the definition of a DAP patient. We considered a patient belonging to a DAP if their DAP-associated diagnosis date was ± 30 days of the OCR diagnosis date. Some patients may have been referred to a DAP after their diagnostic assessment was in progress or their colorectal cancer diagnosis was already established. As a result, some patients assigned to the DAP group may have only received a portion of their diagnostic assessment in a DAP, which would result in some misclassification and underestimation of the effect of DAPs. Thus, a prolonged time from first visit until treatment may be due to a longer time until referral to a DAP, which may be occurring too late in the diagnostic interval to impact diagnostic wait times (Figure 2). We also included patients in DAPs that primarily facilitate diagnostic colonoscopy rather than the entire diagnostic work-up and treatment planning. Including these patients in the DAP definition is conservative, and may have made it more difficult to identify significant differences in outcomes between DAP and non-DAP patients. Finally, although the lack of data regarding the indications for diagnostic assessment (positive screen or symptoms) limits the application of our findings to individual patients, the comparable proportion of DAP and non-DAP patients diagnosed with Stage I or II disease suggests that any differences in screening rates are unlikely to affect the validity of our results.

In conclusion, DAPs provide more diverse healthcare services for colorectal cancer patients during the diagnostic and treatment planning phases of their cancer journey. Despite the longer time from diagnosis until treatment associated with attendance at a DAP, wait times is only one surro-

gate measure of the efficiency of a healthcare system and may not be the most critical aspect of a patients' cancer journey. The improved overall survival among DAP patients is encouraging and warrants further research on the reasons behind this survival benefit. Wait times should be considered as a measure of healthcare system efficiency alongside other metrics, such as survival and patient experience measures. Further exploration of the effect of DAPs in these areas would better characterize their impact on healthcare system efficiency.

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Conflicts of interest

The authors have no conflicts of interest to disclose.

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Appendix 1. Codes for healthcare utilization.

Surgery—colon cancer	
OHIP	
S162	Intestine-exc.-loc.lesion of intestine.
S166	Intestine-exc.-sml&lge intestine-term.ileum-caecum asc.colon
S167	Intestine-exc.-anasto.-large intestine -any portion.
S168	Intestine-exc.-ileostomy.subtotal colectomy
S169	Intestine-exc-total colectomy w/ileo-rectal anastomosis.
S170	Intestine-exc.-ileostomy&ttlcolectomy&abdom-perin. resection
S171	Intestine-exc-lt.hemicolectomy with ant.resect/anast. Etc.
S172	Intestine-exc.-total colectomy with loop ileostomy.
S177	Intestinal-obstruction-one stage-with resection
S188	Intestine-exc.-bowel resection-without anastomosis.
S195	Mesentery local exc. Of lesion
Z765	Intestines-exc.obst.tumour/strict-colonoscopy 2cm/more
CIHI DAD and NACRS (5-digit code only)	
1NM59	Destruction, large intestine
1NM87	Excision partial, large intestine
1NM89	Excision total, large intestine
1NM91	Excision radical, large intestine
1NP73	Reduction, small and large intestine
CIHI DAD and NACRS (based on quality-based procedures)—colon (includes day surgery)[a]	
1NK87DN	Excision partial, small intestine endoscopic [laparoscopic] approach Enterocolostomy anastomosis technique
1NK87RE	Excision partial, small intestine open approach Enterocolostomy anastomosis technique
1NM87DA	Excision partial, large intestine endoscopic [laparoscopic] approach Simple excisional technique
1NM87DE	Excision partial, large intestine endoscopic [laparoscopic] approach Colorectal anastomosis technique
1NM87DF	Excision partial, large intestine endoscopic [laparoscopic] approach Colocolostomy anastomosis technique
1NM87DN	Excision partial, large intestine endoscopic [laparoscopic] approach Enterocolostomy anastomosis technique
1NM87LA	Excision partial, large intestine open approach Simple excisional technique
1NM87PN	Excision partial, large intestine endoscopic [laparoscopic, laparoscopic-assisted, hand-assisted] approach robotic assisted telemanipulation of tools [telesurgery]
1NM87RD	Excision partial, large intestine open approach Colorectal anastomosis technique
1NM87RE	Excision partial, large intestine open approach Enterocolostomy anastomosis technique
1NM87RN	Excision partial, large intestine open approach Colocolostomy anastomosis technique
1NM89DF	Excision total, large intestine endoscopic [laparoscopic] approach Ileorectal [endorectal, ileoproctostomy] anastomosis technique
1NM89RN	Excision total, large intestine open approach using Ileorectal [endorectal, ileoproctostomy] anastomosis technique
1NM91DF	Excision radical, large intestine endoscopic [laparoscopic] approach Colocolostomy anastomosis technique
1NM91DN	Excision radical, large intestine endoscopic [laparoscopic] approach Enterocolostomy anastomosis technique
1NM91RD	Excision radical, large intestine open approach Colorectal anastomosis technique
1NM91RE	Excision radical, large intestine open approach Enterocolostomy anastomosis technique
1NM91RN	Excision radical, large intestine open approach Colocolostomy anastomosis technique
1NM91DE	Excision radical, large intestine endoscopic [laparoscopic] approach Colorectal anastomosis technique
1NM87DX	Excision partial, large intestine endoscopic [laparoscopic] approach Stoma formation and distal closure
1NM87TF	Excision partial, large intestine open approach Stoma formation with distal closure
1NM89DX	Excision total, large intestine endoscopic [laparoscopic] approach Stoma formation with distal closure
1NM91DX	Excision radical, large intestine endoscopic [laparoscopic] approach Stoma formation with distal closure

Continued

Surgery—colon cancer	
1NM91TF	Excision radical, large intestine open approach Stoma formation with distal closure
1NM87DY	Excision partial, large intestine endoscopic [laparoscopic] approach Stoma formation with creation of mucous fistula
1NM89TF	Excision total, large intestine open approach Stoma formation with distal closure
1NM91TG	Excision radical, large intestine open approach Stoma formation with creation of mucous fistula
1NM87TG	Excision partial, large intestine open approach Stoma formation with creation of mucous fistula
1NM91DY	Excision radical, large intestine endoscopic [laparoscopic, laparoscopic-assisted, hand-assisted] approach stoma formation with creation of mucous fistula
1NM87GB	Excision partial, large intestine endoscopic [laparoscopic, laparoscopic-assisted, hand-assisted] approach special excisional technique (without anastomosis)
1NM87WJ	Excision partial, large intestine open approach special excisional technique (without anastomosis)
1NM89GB	Excision total, large intestine endoscopic [laparoscopic, laparoscopic-assisted, hand-assisted] approach special excisional technique without anastomosis
1NM89WJ	Excision total, large intestine open approach special excisional technique without anastomosis
Surgery—rectum cancer	
OHIP	
S213	Rectum-exc.-proctectomy-anterior resect./proctosigmoidectomy
S214	Rectum-exc.-proctectomy-abdomino-perineal resec/pull thru
S215	Rectum-exc.proctectomy-2 surg. Team abdominal surgeon
S217	Rectum-exc.-proctectomy-hartmann proc.
S216	Rectum-exc.-proctectomy-2 surg. Team perineal surgeon
CIHI (5-digit codes only)	
1NQ87	Excision partial, rectum
1NQ89	Excision total, rectum
1NQ90	Excision total, with reconstruction, rectum
1NQ59	Destruction, rectum
CIHI DAD (based on quality-based procedure)—rectum (excludes day surgery)[a]	
1NQ89SFXXG	Excision total, rectum abdominal [anterior] approach pouch formation
1NQ90LAXXG	Excision total with reconstruction, rectum using open approach with ileum [for construction of pouch]
1NQ89KZXXG	Excision total, rectum abdominoperineal approach pouch formation
1NQ87CA	Excision partial, rectum perineal [e.g., pull through, transanal, sacral or sphincteric] approach closure by apposition technique [e.g.,
1NQ87DA	Excision partial, rectum endoscopic [laparoscopic] approach closure by apposition technique [e.g., suturing, stapling] or no closure re
1NQ87DE	Excision partial, rectum endoscopic [laparoscopic, laparoscopic-assisted, hand-assisted] approach colorectal anastomosis technique
1NQ87DF	Excision partial, rectum endoscopic [laparoscopic] approach colorectal anastomosis technique
1NQ87LA	Excision partial, rectum open abdominal [e.g., anterior] approach closure by apposition technique [e.g., suturing, stapling] or no closure
1NQ87PB	Excision partial, rectum perineal (e.g., pull through, transanal, sacral or sphincteric) approach colorectal anastomosis technique
1NQ87PF	Excision partial, rectum posterior [e.g., entering through incision between coccyx and anal verge with proctotomy] approach closure by
1NQ87RD	Excision partial, rectum open abdominal [e.g., anterior] approach colorectal anastomosis technique
1NQ89GV	Excision total, rectum combined endoscopic [abdominal] with perineal approach Coloanal [or ileoanal] anastomosis technique
1NQ89KZ	Excision total, rectum abdominoperineal approach Coloanal [or ileoanal] anastomosis technique
1NQ89SF	Excision total, rectum abdominal [anterior] approach Coloanal [or ileoanal] anastomosis technique

Continued

Surgery—colon cancer	
1NQ89AB	Excision total, rectum, stoma formation with distal closure, combined endoscopic [laparoscopic] abdominoperineal
1NQ89LH	Excision total, rectum abdominoperineal approach Stoma formation with distal closure
1NQ89LHXXG	Excision total, rectum abdominoperineal approach Continent ileostomy formation
1NQ89RSXXG	Excision total, rectum abdominal [anterior] approach Continent ileostomy formation
1NQ87TF	Excision partial, rectum open abdominal approach [e.g., anterior] stoma formation with distal closure
1NQ89RS	Excision total, rectum abdominal [anterior] approach Stoma formation with distal closure
1NQ87DX	Excision partial, rectum endoscopic [laparoscopic, laparoscopic-assisted, hand-assisted] approach stoma formation with distal closure
1NQ87PN	Excision partial, rectum endoscopic [laparoscopic, laparoscopic-assisted, hand-assisted] approach robotic assisted telemanipulation of tools [telesurgery]
1NQ87CAFA	Excision partial, rectum per orifice approach [e.g., perineal, pull through, transanal, sacral or sphincteric] encirclage device (banding)
1NQ87BA	Excision partial, rectum using closure by apposition technique [e.g., suturing, stapling] or no closure required (for tissue regeneration) using endoscopic per orifice approach
Abdominal CT (OHIP, DAD, NACRS)	
X410	Diag. Radiology-CT-abdomen-with i.v. contrast.
X409	Diag. Radiology-CT-abdomen-wout i.v. contrast.
X126	Diagnostic radiology-abdomen-with /out i.v. contrast c.t.t.
3OT20	Computerized tomography [CT], abdominal cavity
Chest CT (OHIP, DAD, NACRS)	
3GY20	Computerized tomography [CT], thoracic cavity NEC
3OT20	Computerized tomography [CT], abdominal cavity
X125	Diagnostic radiology-thorax-with and without i.v. cont-c.t.t
X406	Diag. Radiology-CT-thorax-without i.v.contr
X407	Diag. Radiology-CT-thorax-with i.v.contr.
X409	Diag. Radiology-CT-abdomen-wout i.v.contr.
X410	Diag. Radiology-CT-abdomen-with i.v.contr.
Treatment—radiation (ALR)	
Any treatment visit	First evidence of radiation in ALR, restricted to the pelvis or abdomen
Treatment—chemotherapy	
ALR	First evidence of chemotherapy in with antineoplastic activity flag
DAD, NACRS	1ZZ35CAM0—1ZZ35CAM9, 1ZZ35HAM0—1ZZ35HAM9, 1ZZ35YAM0—1ZZ35YAM9
Various diagnostic tests	
Chest x-ray (OHIP)	
X090	Diagnostic radiology chest single view
X091	Diagnostic radiology chest 2 views
X092	Diagnostic radiology chest 3 or more views
Colonoscopy or endoscopy (OHIP, DAD, NACRS)	
E717	Intestine -endosc-colonoscopy-biopsy/coagul
E747	Intestine-endoscopy-sigmoid.to caecum add to z512/z555
E720	Intestine-exc.-polyp thru colonoscope-each-max of 2
A120	Colonoscopy assessment same day as colonoscopy
Z491	Follow up of unsatisfactory colonoscopy
Z492	5 yr f/u of normal colonoscopy-absence of intrvn signs
Z493	Ten year follow up of normal colonoscopy (Z497, Z555), absence of intervening signs or symptoms—sigmoid to descending

Continued

Surgery—colon cancer	
Z494	Hereditary or other bowel disorders assoc w. Incr risk malig
Z495	Follow up of unsatisfactory colonoscopy
Z496	Presence of signs or symptoms—sigmoid to descending colon
Z497	Confirmatory colonoscopy—sigmoid to descending colon
Z498	Surveillance colonoscopy—sigmoid to descending colon
Z499	Colonoscopy—absence of signs or symptoms family history
Z555	Intestines-endoscopy-colonoscopy into descending colon
Z580	Intestine-endoscopy-using 60c.m. flexible endoscope.
Z535	Intestines-endoscopy-sigmoidoscopy w/without anoscopy
E740	Intestine endo sigmoid to splenic flexure add
E741	Intestine end sigmoid to hepatic flexure add
E705	Digest.syst.intest.endosc.into terminal ileumadd.
Z570	Intestines-excision-fulguration of polyps thro.colonoscope
Z571	Intestines-exc.-polyps thro. Colonoscope
E719	Intestine-exc.-fulg. Polyp-each-max of 4
Z764	Excision of obstructive tumour or stricture through colonoscopy—less than 2 cm
Z765	Intestines-exc.obst.tumour/strict-colonoscopy 2cm/more
E687	Excision of obstructive tumour or stricture through colonoscopy with laser debulking . . . Add
E685	Intestines endo total excis greater than 3cm sessile polyps
X234	Computed tomography colonography
2NM71	Biopsy, large intestine
2NM70	Inspection, large intestine
3NM20	Computerized tomography [CT], large intestine
Z296	Fiberoptic endoscopy of upper airway with flexible endoscope
Z514	Intestine-endoscopy-ileostomy/colostomy-with biopsy.
Z512	Intestine-endoscopy-ileostomy/colostomy.
E797	Endoscopy-uncomplicated upp or low gi bleeding-add
E746	Rectum-endoscopy-extra to z535z536z592-rend.in.priv.office
Z536	Rectum-endoscopy-extra to z535z536z592-rend.in.priv.office
Z592	Sigmoidoscopy with or without anoscopy
Z632	Cystoscopy-endoscopy with exc.single tumour 1 to 2cm diam.
Z634	Cystoscopy-endoscopy with exc.multiple tumours
2NQ71	Biopsy, large intestine
2NQ70	Inspection, rectum
PET scan (OHIP, PET Database)	
J703	Pet scan—colorectal cancer
Other	PET Database (e.g., PET registry, a database maintained at Cancer Care Ontario)
Other (OHIP)	
X112	Diagnostic radiology—colon—barium enema including survey films, if taken
X113	Diagnostic radiology—colon—air contrast, primary or secondary, including survey films, if taken
Q043	New patient fee FOBT positive/colorectal cancer increased risk
Q150	FOBT distribution and counselling fee
Q152	FOBT completion fee
Pelvic MRI (OHIP)	
X461	Diag.rad.magnet.resonan.imag.pelvis multislice s.e(1–2echos)
X465	Diag.rad.magnet.resonan.imag.pelvis repeat max.2

Continued

Surgery—colon cancer	
Abdominal MRI (OHIP, DAD, NACRS)	
X451	DIAG.RAD.MAGNET.RESONAN.IMAG.ABDOMEN MULTISLICE S.E(1–2ECHOS)
X455	DIAG.RAD.MAGNET.RESONAN.IMAG.ABDOMEN REPEAT MAX.2
3OT40[b]	MRI, abdominal cavity

[a]Procedural code must be the main procedure and must be associated with an ICD-10-CA diagnostic code as the main problem (C00-C97, D010, D011, D012, D014, D017, D019, D038, D039, D048, D049, D097, D099, D120, D121, D122, D123, D124, D125, D126, D127, D128, D139, D175, D197, D199, D367, D369, D373, D374, D375, D377, D379, D487, D489).
[b]Only included when pelvic/abdominal MRI are combined for reporting. No corresponding "MRI, pelvis" CIHI code was observed.

Appendix 2. Identification of the surgery date.

We explored OHIP billing codes and CIHI procedural codes to identify the date of surgery.

Colon cancer: Using OHIP colon surgery codes alone, 73% of patients had evidence of surgery a median 25 (3, 44) days after diagnosis. Supplementing this definition with rectal surgery codes, 82% of colon cancer patients had evidence of surgery a median 26 (3, 46) days after diagnosis (Table). This addition is likely attributable to surgeries performed on the rectosigmoid junction. Using 5-digit CIHI codes, a slightly higher proportion of patients had surgery, but the median time until surgery was substantially reduced [median 0 (0–28 days)]. Refining this definition to follow the CIHI Quality-Based Procedure (QBP) funding methodology yielded more similar estimates to OHIP with respect to the time until surgery (algorithm 6c *vs.* 2c), although fewer patients were identified as having had surgery. This effect may be because QBP methodology excludes day surgery, and requires CIHI codes to be identified as the main surgical intervention. Thus, the optimal method was a hierarchy: OHIP colorectal codes (algorithm 2c) followed by QBP methodology using both colon and rectum CIHI codes (algorithm 6c).

Rectal cancer: Using OHIP rectum surgery codes alone, 64% of patients had evidence of surgery a median 114 (51,155) days after diagnosis. Supplementing this definition with a predetermined subset of the colon surgery codes, 69% of rectal cancer patients had evidence of surgery a median 107 (48, 153) days after diagnosis (Table). Using CIHI codes, we observed a similar pattern as with colon cancers (shorter time until surgery, more surgeries captured). However, the CIHI QBP funding methodology (which excludes day surgery) again yielded similar estimates as OHIP alone on the time until surgery, yet identified fewer cases (algorithm 7r *vs.* 2r). Thus, the final algorithm was a hierarchy of OHIP (algorithm 2r) followed by QBP (algorithm 7r).

	Data source	Breadth of codes	*n* (%)	Days between diagnosis and surgery
Colon cancer			*n* = 13,761	Median (IQR)
1c.	OHIP	Colon codes only	10,010 (73%)	25 (3, 44)
2c.	OHIP	Colon and rectum codes	11,274 (82%)	26 (3, 46)
3c.	DAD/NACRS (5-digit codes only)	Colon codes only	10,571 (77%)	0 (0, 28)
4c.	DAD/NACRS (5-digit codes only)	Colon and rectum codes	11,868 (86%)	0 (0, 29)
5c.	DAD/NACRS (QBP)	Colon codes	8,721 (63%)	25 (0, 43)
6c.	DAD/NACRS (QBP)	Colon and rectum codes	10,602 (77%)	26 (0, 46)
7c.	DAD only (QBP)	Colon and rectum codes	10,530 (77%)	27 (0, 47)
Final	1. OHIP 2. DAD only (QBP)	1. Colon and rectum codes 2. Colon and rectum codes	11,305 (82%)	26 (3, 46)
Rectal cancer			*n* = 4,285	Median (IQR)
1r.	OHIP	Rectum codes only	2,734 (64%)	114 (51, 155)
2r.	OHIP	Rectum and select colon codes (S167, S171, S177, S249)	2,948 (69%)	107 (48, 153)
3r.	CIHI (5-digit codes only)	Rectum codes only	3,198 (75%)	70 (0, 145)

	Data source	Breadth of codes	*n* (%)	Days between diagnosis and surgery
4r.	CIHI (5-digit codes only)	Colon and rectum codes	3,513 (82%)	26 (0, 123)
5r.	DAD/NACRS (QBP)	Rectum codes	2,995 (70%)	83 (32, 148)
6r.	DAD/NACRS (QBP)	Colon and rectum codes	3,113 (73%)	81 (30, 147)
7r.	DAD only (QBP)	Colon and rectum codes	2,899 (68%)	106 (49, 153)
Final	1. OHIP 2. DAD only (QBP)	1. Rectum codes and select colon codes (S167, S171, S177, S249) 2. Colon and rectum codes	3,063 (71%)	105 (48, 153)

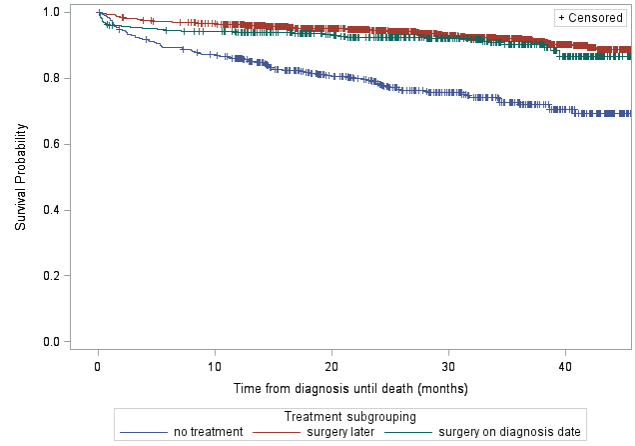
Details of codes are provided in Appendix 2.

QBP (quality-based procedures) methodology requires that the CIHI codes be identified as the main intervention and the ICD-10-CA diagnostic code is the main reason for the visit.

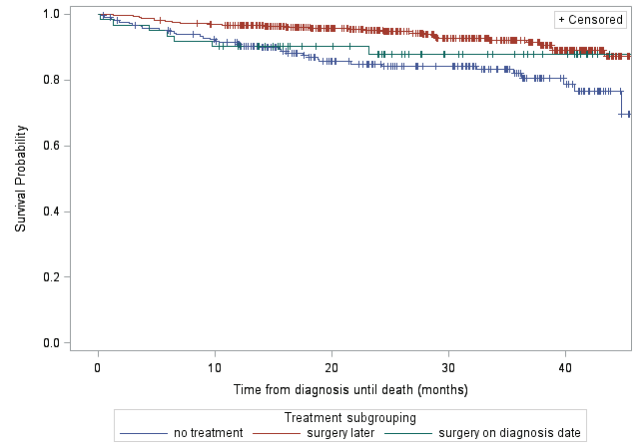
Appendix 3. Overall survival among stage 1 cancers receiving no treatment or surgery alone.

Nineteen percent of stage 1 colon and 24% of stage 1 rectal cancer patients had no evidence of treatment within the first year after diagnosis (Appendix 5). Since it is possible that these patients had their tumor completely resected during the diagnostic biopsy (i.e., had an excisional biopsy), we expected these patients to have similar (or better) overall survival than patients who were treated with surgery alone. However, stage 1 patients who received no treatment had significantly worse survival than those who received surgery alone during the first year post-diagnosis for both stage 1 colon (A) and stage 1 rectum (B). Thus, patients who had no evidence of treatment will not be combined with the surgery-only group.

A) Colon cancer



B) Rectal cancer



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Appendix 4. Healthcare utilization for DAP and non-DAP patients during the 3-month period before diagnosis.

Type of healthcare encounter	Colon cancer (*n* = 13,761)		Rectal cancer (*n* = 4,258)	
	Non-DAP (*n* = 12,133)	DAP (*n* = 1,628)	Non-DAP (*n* = 3,307)	DAP (*n* = 978)
Diagnostic test[a]		*n* (%)		
Colonoscopy	10,906 (90%)	1,577 (97%)	3,211 (97%)	973 (99%)
Abdominal CT	11,027 (91%)	1,553 (95%)	3,025 (91%)	951 (97%)
Abdominal CT and colonoscopy	9,952 (82%)	1,505 (92%)	2,953 (89%)	946 (97%)
Chest x-ray	6,797 (56%)	779 (48%)	1,299 (39%)	365 (37%)
Chest CT	10,735 (88%)	1,548 (95%)	2,987 (90%)	943 (96%)
Excluding stage 1	9,009 (91%)	1,293 (95%)	2,412 (93%)	790 (97%)
Chest x-ray or chest CT	11,391 (94%)	1,593 (98%)	3,084 (93%)	960 (98%)
Pelvic/abdominal MRI[b]	1,084 (9%)	377 (23%)	2,213 (67%)	873 (89%)
Pelvic MRI only	583 (5%)	216 (13%)	2,164 (65%)	868 (89%)
Abdominal MRI only	547 (5%)	199 (12%)	246 (7%)	123 (13%)
Excluding stage 1	940 (9%)	323 (24%)	1,789 (69%)	734 (90%)
Brain MRI	1,288 (11%)	131 (8%)	273 (8%)	53 (5%)
Stage 1	159 (7%)	25 (9%)	52 (7%)	11 (7%)
Stage 2	276 (10%)	25 (7%)	34 (8%)	17 (12%)
Stage 3	226 (10%)	22 (6%)	50 (7%)	10 (4%)
Stage 4	347 (22%)	21 (14%)	60 (16%)	6 (8%)
Repeat imaging[a]		*n* (%)		
Multiple (>1) abdominal CTs	2,679 (22%)	352 (22%)	637 (19%)	207 (21%)
Multiple (>1) colonoscopies/endoscopies	3,416 (28%)	638 (39%)	1,778 (54%)	582 (60%)
Multiple (>1) pelvic/abdominal MRIs	186 (2%)	67 (4%)	348 (11%)	155 (16%)
Consultation[a]		*n* (%)		
Surgical consultation	11,382 (94%)	1,577 (97%)	3,131 (95%)	962 (98%)
Medical oncology consultation	1,253 (10%)	235 (14%)	1,190 (36%)	521 (53%)
Radiation oncology consultation	681 (6%)	167 (10%)	1,573 (48%)	619 (63%)
Gastroenterology consultation	3,795 (31%)	902 (55%)	905 (27%)	355 (36%)
Internal medicine consultation	5,333 (44%)	710 (44%)	1,440 (44%)	378 (39%)
Cardiology consultation	3,870 (32%)	816 (50%)	1,235 (37%)	518 (53%)
Number of healthcare encounters[c]		mean (SD)/median (p25, p50)		
Six months before diagnosis until treatment				
Number of different health system encounters	19.3 (12.9) 16 (11, 23)	20 (12) 17 (13, 24)	21 (13) 18 (13, 24)	20 (12) 17 (13, 24)
Number of different hospital encounters	2.0 (0.74) 2 (2, 2)	2.1 (0.83) 2 (2, 2)	2.0 (0.87) 2 (1, 2)	2.0 (0.96) 2 (1, 2)
Six months before diagnosis until diagnosis				
Number of different health system encounters	12.2 (9.5) 10 (6, 15)	11.4 (8.1) 9 (6, 14)	10.6 (9.2) 8 (5, 13)	9.2 (7.3) 7 (5, 11)
Number of different hospital encounters	1.4 (0.84) 1 (1, 2)	1.1 (0.80) 1 (1, 2)	1.1 (0.77) 1 (1, 1)	0.9 (0.73) 1 (1, 1)
Receipt of any treatment		n (%)		
Stage 2 patients				
Surgery	2,587 (98%)	355 (97%)	331 (82%)	123 (85%)
Radiation	82 (3%)	27 (7%)	238 (59%)	104 (72%)
Chemotherapy	407 (15%)	77 (21%)	207 (51%)	100 (69%)

Continued

Type of healthcare encounter	Colon cancer (*n* = 13,761)		Rectal cancer (*n* = 4,258)	
	Non-DAP (*n* = 12,133)	DAP (*n* = 1,628)	Non-DAP (*n* = 3,307)	DAP (*n* = 978)
Stage 3 patients				
Surgery	2,255 (97%)	353 (96%)	617 (88%)	215 (88%)
Radiation	158 (7%)	41 (11%)	515 (73%)	206 (84%)
Chemotherapy	1,470 (64%)	262 (71%)	563 (80%)	219 (89%)

[a]Between 3 months before diagnosis until the date of first treatment (or 2 months after diagnosis if no treatment).
[b]Separating the rectosigmoid junction, this breaks down to 156 (69%) for DAP and 441 (35%) for non-DAP patients with rectosigmoid junction cancer and 221 (16%) for DAP and 643 (6%) for non-DAP patients with other colon cancers.
[c]Timeframe extended to 6 months to identify additional potentially relevant encounters. The number of different health system counters was calculated as the number of unique billing dates from OHIP (CIHI omitted to avoid potential double-counting). The number of different hospital encounters was calculated as the number of unique registration dates (NACRS) or admission dates (DAD).
DAP = Diagnostic Assessment Program; CT = computed tomography; MRI = magnetic resonance imaging; SD = standard deviation.

Appendix 5. Treatment by cancer stage.

Colon cancer	All patients *n* = 13,761	Stage				
		1 *n* = 2,500	2 *n* = 3,011	3 *n* = 2,681	4 *n* = 1,700	Unknown *n* = 180
Any treatment						
Surgery	11,305 (82%)	1,977 (79%)	2,942 (98%)	2,608 (97%)	733 (43%)	14 (8%)
Radiation	696 (5%)[a]	18 (1%)	109 (4%)	199 (7%)	121 (7%)	12 (7%)
Chemo	5,169 (38%)	138 (6%)	484 (16%)	1,732 (65%)	916 (54%)	11 (6%)
First treatment						
Surgery[b]	10,753 (78%)	1,946 (78%)	2,846 (94%)	2,463 (92%)	658 (39%)	13 (7%)
No treatment	1,516 (11%)	485 (19%)	39 (1%)	41 (2%)	474 (28%)	145 (81%)
Chemotherapy	1,220 (9%)	58 (2%)	79 (3%)	112 (4%)	512 (30%)	10 (6%)
Radiation	199 (1%)	9 (0%)	36 (1%)	35 (1%)	53 (3%)	12 (7%)
Chemoradiation	73 (1%)	2 (0%)	11 (0%)	30 (1%)	3 (0%)	0 (0%)
Pre-treatment interval[c] Median (IQR)	27 (4, 45) days	33 (1, 53) days	24 (4, 41) days	23 (3, 41) days	24 (5, 42) days	49 (24, 80) days
Rectal cancer	All patients *n* = 4,285	1 *n* = 884	2 *n* = 551	3 *n* = 950	4 *n* = 440	Unknown *n* = 82
Any treatment						
Surgery	3,063 (71%)	627 (71%)	454 (82%)	832 (88%)	115 (26%)	10 (12%)
Radiation	2,171 (51%)	117 (13%)	342 (62%)	721 (76%)	195 (44%)	21 (26%)
Chemo	2,407 (56%)	127 (14%)	307 (56%)	782 (82%)	265 (60%)	12 (15%)
First treatment						
Surgery	1,508 (35%)	543 (61%)	209 (38%)	269 (28%)	43 (10%)	6 (7%)
Chemotherapy	1,317 (31%)	75 (8%)	161 (29%)	363 (38%)	178 (40%)	8 (10%)
Radiation	525 (12%)	32 (4%)	87 (16%)	130 (14%)	99 (23%)	16 (20%)
Chemoradiation	408 (10%)	21 (2%)	73 (13%)	166 (17%)	20 (5%)	2 (2%)
No treatment	527 (12%)	213 (24%)	21 (4%)	22 (2%)	100 (23%)	50 (61%)
Pret-reatment interval[c] Median (IQR)	48 (31, 67) days	56 (35–83) days	47 (32–64) days	48 (32–63) days	40 (27–59) days	46 (27–77) days

[a]28% of rectosigmoid junction cancer patients received radiation. After removing these patients, only 2% of colon cancer patients received radiation within 1 year of diagnosis.
[b]Includes patients who also received chemo on this date.
[c]The earliest of surgery, chemotherapy, or radiation.

Appendix 6. Healthcare utilization and timing for DAP and non-DAP patients.

Type of healthcare encounter	Colon cancer (*n* = 13,761)		Rectal cancer (*n* = 4,258)	
	Non-DAP (*n* = 12,133)	DAP (*n* = 1,628)	Non-DAP (*n* = 3,307)	DAP (*n* = 978)
Diagnostic test[a]	*n* (%)/mean (SD)/median (p25, p50)			
Any colonoscopy/endoscopy				
Time until diagnosis (earliest scope)	11,023 (91%) 11 (34) 0 (0, 0)	1,583 (97%) 9 (29) 0 (0, 0)	3,230 (98%) 10 (33) 0 (0, 0)	973 (99%) 7 (25) 0 (0, 0)
Time since diagnosis (second scope)	3,664 (30%) 11 (34) 7 (0, 27)	665 (41%) 19 (33) 15 (0, 34)	1,837 (56%) 16 (35) 13 (0, 30)	587 (60%) 20 (26) 18 (1, 35)
Abdominal CT	11,154 (92%)	1,557 (96%)	3,051 (92%)	951 (97%)
Time until diagnosis	5 (38) 0 (−11, 7)	0 (35) −7 (−14, 0)	−2 (41) −7 (−18, 0)	−7 (29) −9 (−18, −3)
Chest x-ray	7,234 (50%)	837 (51%)	1,415 (43%)	396 (40%)
Time until diagnosis	29 (62) 4 (−3, 61)	22 (64) 1 (−19, 52)	17 (70) 0 (−26, 56)	11 (66) −7 (−28, 38)
Chest CT	10,875 (90%)	1,553 (95%)	3,018 (91%)	943 (96%)
Time until diagnosis	6 (41) −1 (−11, 9)	1 (37) −7 (−15, 0)	0 (42) −7 (−18, 0)	−6 (33) −9 (−19, −3)
Pelvic/abdominal MRI	1,118 (9%)	379 (23%)	2,228 (67%)	873 (89%)
Time since diagnosis	7 (44) 12 (0, 27)	19 (33) 21 (11, 31)	14 (34) 16 (7, 28)	18 (22) 18 (10, 27)
Consultation[a]	N (%) / mean (SD) / median (p25, p50)			
Surgical consultation	11,434 (94%)	1,580 (97%)	3,139 (95%)	963 (98%)
Time until diagnosis (first consultation)	19 (46) 0 (−2, 30)	5 (43) −2 (−17, 9)	20 (48) 3 (−1, 33)	8 (40) 0 (−14, 15)
Time since diagnosis (second visit)	8,035 (66%) 1 (37) 0 (−1, 14)	1,066 (65%) 13 (34) 13 (0, 28)	2,646 (80%) 2 (37) 0 (0, 17)	761 (78%) 10 (27) 5 (0, 25)
Time since diagnosis (third visit)	4,722 (39%) 9 (37) 11 (0, 24)	593 (36%) 22 (35) 20 (8, 35)	1,872 (57%) 15 (35) 16 (5, 30)	546 (56%) 26 (31) 22 (10, 41)
Medical oncology consultation	1,295 (11%)	237 (15%)	1,198 (36%)	523 (53%)
Time since diagnosis	7 (56) 17 (3, 31)	27 (34) 28 (17, 41)	29 (44) 31 (18, 47)	37 (32) 33 (23, 46)
Radiation oncology consultation	728 (6%)	178 (11%)	1,585 (48%)	620 (63%)
Time since diagnosis	7 (66) 21 (1, 40)	14 (60) 28 (14, 42)	30 (41) 32 (19, 46)	34 (29) 32 (22, 43)
Gastroenterology consultation	3,965 (33%)	932 (57%)	942 (28%)	365 (37%)
Time until diagnosis	23 (45) 0 (0, 35)	19 (41) 0 (0, 22)	19 (49) 0 (0, 31)	11 (42) 0 (0, 14)
Internal medicine consultation	5,629 (46%)	740 (45%)	1,522 (46%)	398 (41%)

Continued

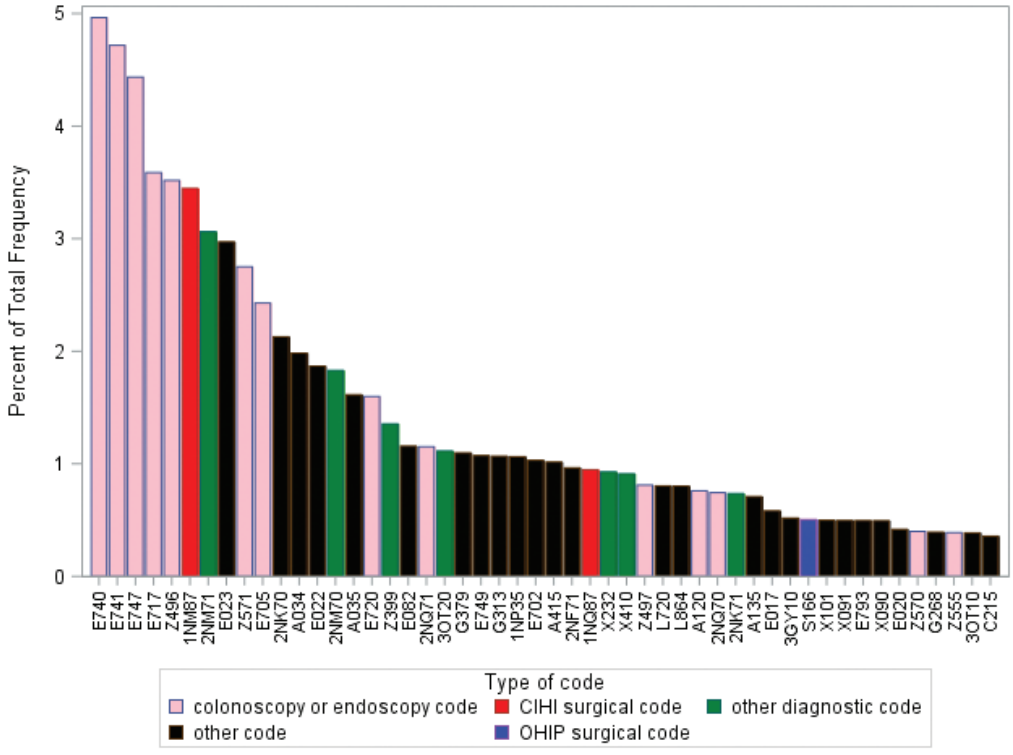
Type of healthcare encounter	Colon cancer (*n* = 13,761)		Rectal cancer (*n* = 4,258)	
	Non-DAP (*n* = 12,133)	DAP (*n* = 1,628)	Non-DAP (*n* = 3,307)	DAP (*n* = 978)
Time until diagnosis	30 (63) 4 (−3, 63)	19 (67) 0 (−25, 49)	16 (66) 0 (−25, 41)	6 (63) 0 (−35, 21)
Cardiology consultation	4,161 (34%)	849 (52%)	1,296 (39%)	527 (54%)
Time until diagnosis	22 (62) 0 (−13, 46)	6 (59) −14 (−27, 9)	3 (59) −8 (−27, 10)	−9 (51) −19 (−34, −3)
General practitioner visit				
Time until diagnosis (first visit)	8,038 (66%) 52 (64) 34 (1, 102)	920 (57%) 57 (64) 43 (5, 106)	1,809 (55%) 51 (67) 40 (1, 102)	499 (51%) 56 (70) 45 (5, 114)
Time until diagnosis (second visit)	4,341 (36%) 27 (56) 6 (0, 54)	443 (27%) 27 (58) 13 (−3, 61)	887 (27%) 23 (60) 6 (−11, 59)	231 (24%) 18 (67) 10 (−11, 51)
Time until diagnosis (third visit)	2,218 (18%) 16 (54) 1 (−7, 40)	225 (14%) 15 (54) 3 (−14, 41)	438 (13%) 11 (57) 0 (−24, 45)	120 (12%) −3 (66) −2 (−39, 17)
Wait times	N (%) / mean (SD) / median (p25, p50), p90			
First visit until first treatment	10,733 (88%) 97 (69) 85 (41, 150), 191	1,513 (93%) 109 (71) 92 (50, 161), 209	2,828 (86%) 114 (71) 94 (58, 163), 212	930 (95%) 115 (74) 93 (57, 164), 219
First visit until diagnosis (excluding GP visits)	12,133 (100%) 58 (59) 37 (3, 104), 155	1,628 (100%) 55 (58) 32 (1, 99), 154	3,307 (100%) 53 (57) 30 (3, 95), 152	978 (100%) 45 (54) 20 (0, 75), 140
First visit until diagnosis (including GP visits)	12,133 (100%) 70 (61) 57 (12, 125), 165	1,628 (100%) 68 (61) 54 (11, 120), 162	3,307 (100%) 65 (60) 47 (9, 116), 161	978 (100%) 60 (59) 41 (5, 107), 158
Diagnosis until first treatment	10,733 (88%) 30 (35) 24 (2, 42), 64	1,513 (93%) 47 (36) 42 (26, 59), 86	2,828 (86%) 52 (41) 47 (29, 66), 89	930 (95%) 59 (41) 50 (34, 71), 100
DAP referral until diagnosis				
DAP (Type 1)[b]	–	72 (4%) 28.6 (51.9) 30 (0, 49)	–	89 (9%) 10.8 (69.5) −1 (−18, 28)
DAP (Type 2)[b]	–	1,536 (94%) −8.3 (37.0) −3 (−14, 0)	–	794 (81%) −19.1 (50.2) −7 (−23, 0)
Rectal DAP (focus on rectal cancers)	–	20 (2%) −8.2 (15.7) −6 (14.5, −1)	–	95 (10%) −5.9 (10.9) −3 (−11, 0)

DAP = Diagnostic Assessment Program; CT = computed tomography; MRI = magnetic resonance imaging; SD = standard deviation; IQR = 25th, 75th percentile; p90 – 90th percentile.

[a]Between 6 months before diagnosis until the date of first treatment (or 2 months after diagnosis if no treatment)

[b]Type 1 DAP is only able to provide the diagnostic colonoscopy and does not take the patient through the entire diagnostic and treatment planning phases. A Type 2 DAP can, in contrast, complete all components of the diagnostic and treatment planning phases.

Appendix 7. *Distribution of OHIP and CIHI codes observed on the date of diagnosis (colon and rectum combined).*



Top 50 codes:

Rank	Code	Description
1	E740	Intestine endo sigmoid to splenic flexure add
2	E741	Intestine end sigmoid to hepatic flexure add
3	E747	Intestine-endoscopy-sigmoid.to caecum add to z512/z555
4	E717	Intestine -endosc-colonoscopy-biopsy/coagul
5	Z496	Presence of signs or symptoms—sigmoid to descending colon
6	1NM87	Excision partial, large intestine
7	2NM71	Biopsy, large intestine
8	E023	Anaesthesia unit services
9	Z571	Intestines-exc.-polyps thro. Colonoscope
10	E705	Digest.syst.intest.endosc.into terminal ileumadd.
11	2NK70	Inspection, small intestine
12	A034	Partial-assess. -gen. Surg.
13	E022	Patients asa 3
14	2NM70	Inspection, large intestine
15	A035	Consult.-gen. Surg.
16	E720	Intestine-exc.-polyp thru colonoscope-each-max of 2
17	Z399	Oesophagus-oesophago/gastro. With/out duodenoscopy
18	E082	Admission assessment by the mrp to admission assessment
19	2NQ71	Biopsy, rectum
20	3OT20	Computerized tomography [CT], abdominal cavity
21	G379	D./t. Proc.-inj./infusion-intravenous-child or adult
22	E749	Digest syst.-when z512555580 performed out hosp....add
23	G313	D./.t.proc cardiov ecg prof.comp-g.p.
24	1NP35	Pharmacotherapy (local), small and large intestine

Continued

Rank	Code	Description
25	E702	Oesoph/gastro/duodenoscopy mult.biopsy 3 or more add
26	A415	Consult.-gastroenterology
27	2NF71	Biopsy, stomach
28	1NQ87	Excision partial, rectum
29	X232	Diag.rad.-pelvis with i.v. contrast
30	X410	Diag. Radiology-CT-abdomen-with i.v.contr.
31	Z497	Confirmatory colonoscopy—sigmoid to descending colon
32	L720	Lab.med.-anat pathhistcyt-cytol-surgical pathology
33	L864	Surgical pathology level 4
34	A120	Colonoscopy assessment same day as colonoscopy
35	2NQ70	Inspection, rectum
36	2NK71	Biopsy, small intestine
37	A135	Consult.-internal med.
38	E017	Patients asa 4—patient with incapacitating
39	3GY10	Xray, thoracic cavity NEC
40	S166	Intestine-exc.-sml&lge intestine-term.ileum-caecum asc.colon
41	X101	Diag.radiology abdomen two/more views
42	X091	Diagnostic radiology chest 2 views
43	E793	Laprscopic/asstd proc(s166/7/9s171r905s798/9s800s091/2
44	X090	Diagnostic radiology chest single view
45	E020	Anaes asa emerg patient premium (applic asa iii iv & v pts
46	Z570	Intestines-excision-fulguration of polyps thro.colonoscope
47	G268	D./t. Proc.-cardiov.-cannul. Vein or artery
48	Z555	Intestines-endoscopy-colonoscopy into descending colon
49	3OT10	Xray, abdominal cavity
50	C215	Ltd.consult for acute pain management

Appendix 8. Type of healthcare encounter on the first visit within 6 months before diagnosis.

	Non-DAP	DAP
General practitioner consult	6,177 (21%)	880 (20%)
Colonoscopy/endoscopy	5,057 (17%)	1,020 (23%)
General surgery consult	4,001 (14%)	555 (13%)
Chest x-ray	3,470 (12%)	386 (9%)
Chest CT	2,601 (9%)	269 (6%)
Abdominal CT	2,152 (7%)	186 (4%)
Gastroenterology consult	1,610 (6%)	474 (11%)
Internal medicine consult	1,437 (5%)	179 (4%)
Other	1,071 (4%)	234 (5%)
Brain CT	490 (2%)	41 (1%)
Cardiology consult	392 (1%)	54 (1%)
MRI	208 (1%)	38 (1%)
Radiation oncology consult	102 (<1%)	28 (1%)
Medical oncology consult	96 (<1%)	<6
General thoracic surgery consult	48 (<1%)	7 (<1%)
Brain MRI	42 (<1%)	<6

CT = computed tomography; MRI = magnetic resonance imaging

Appendix 9. Regional variation in wait times

A) Time from first visit until treatment (the health care interval), days.

Colon cancer								
Local health integration Network[a]	**N Obs**	***n***	**Mean**	**Std Dev**	**Median**	**Lower quartile**	**Upper quartile**	**90th Pctl**
Central	1,608	1,437	93.1	66.9	76	38	143	189
Central East	1,610	1,427	97.5	68.0	85	42	149	190
Central West	602	536	95.9	67.1	83	39	148	191
Champlain	1,509	1,310	110.9	74.6	98	52	163	211.5
Erie St. Clair	767	685	100.2	69.6	87	42	155	198
Hamilton Niagara	1,652	1,471	101.2	68.3	91	46	153	190
Mississauga Halton	940	847	94.8	69.2	82	38	146	188
North East	687	625	90.4	66.6	78	32	145	183
North Simcoe Muskoka	577	521	91.6	67.1	76	38	142	183
North West	283	250	99.1	75.5	88.5	34	163	202.5
South East	665	583	98.6	67.3	85	43	149	188
South West	1,138	998	102.2	71.9	88.5	45	159	199
Toronto Central	976	866	101.3	71.7	86	42	157	202
Waterloo Wellington	747	690	94.5	68.2	79	41	143	191
Overall	13,761	12,246	98.7	69.6	85	42	151	194
Rectal cancer								
Local health integration network[a]	N Obs	*n*	Mean	Std Dev	Median	Lower quartile	Upper quartile	90th Pctl
Central	453	386	101.2	62.9	84	53	148	191
Central East	509	459	111.1	71.6	93	54	162	207
Central West	202	182	113.5	73.4	87.5	56	166	213
Champlain	394	347	128.3	79.4	112	63	185	223
Erie St. Clair	278	235	118.1	67.4	102	66	168	216
Hamilton Niagara	587	506	116.0	71.5	97	62	166	211
Mississauga Halton	260	230	112.4	77.2	87	55	164	218.5
North East	206	188	100.9	62.9	81	51	138.5	189
North Simcoe Muskoka	179	157	110.7	77.6	93	50	153	197
North West	89	77	96.5	70.3	70	50	136	198
South East	178	163	111.5	72.0	86	56	142	228
South West	378	322	126.5	68.6	114	70	176	220
Toronto Central	325	281	123.8	76.8	97	63	176	223
Waterloo Wellington	247	225	103.5	73.0	82	49	148	200
Overall	4,285	3,758	114.0	72.2	94	57	163	214

[a]Ontario was broken down into 14 geographic regions called Local Health Integration Networks, where healthcare was administered and funded independently.

B) Time from first visit until diagnosis (the diagnostic interval), days.

Colon cancer								
Local health integration network[a]	**N diagnosed**	**N treated**	**Mean**	**Std Dev**	**Median**	**Lower quartile**	**Upper quartile**	**90th Pctl**
Central	1,608	1,608	66.6	60.4	50	7	118.5	161
Central East	1,610	1,610	70.9	59.7	58	15	123	162
Central West	602	602	68.4	60.3	55.5	8	120	164
Champlain	1,509	1,509	74.8	62.1	64	15	133	168
Erie St. Clair	767	767	72.6	61.8	58	13	129	167
Hamilton Niagara	1,652	1,652	72.3	60.6	60	14	128	163
Mississauga Halton	940	940	69.4	61.0	55.5	11	121.5	165
North East	687	687	67.3	61.8	50	7	121	166
North Simcoe Muskoka	577	577	66.3	60.1	50	8	116	161
North West	283	283	72.0	64.3	58	4	135	168
South East	665	665	66.2	59.0	54	10	116	158
South West	1,138	1,138	72.4	61.0	62	14	127	167
Toronto Central	976	976	69.6	62.4	57	6	127	164
Waterloo Wellington	747	747	68.2	60.2	52	12	119	164
Overall	13,761	13,761	70.2	60.9	57	11	125	165
Rectal cancer								
Local health integration network[a]	N diagnosed	N treated	Mean	Std Dev	Median	Lower quartile	Upper quartile	90th Pctl
Central	453	453	59.0	58.0	41	6	103	155
Central East	509	509	65.9	60.2	43	11	118	162
Central West	202	202	63.4	60.0	45	10	110	159
Champlain	394	394	67.4	61.4	49	8	120	165
Erie St. Clair	278	278	65.0	59.9	47	10	115	160
Hamilton Niagara	587	587	64.6	58.0	47	12	112	159
Mississauga Halton	260	260	61.6	64.2	36	3	119	169
North East	206	206	58.5	56.5	36	9	99	154
North Simcoe Muskoka	179	179	62.5	56.2	52	9	105	151
North West	89	89	52.1	59.6	26	0	84	162
South East	178	178	56.9	57.1	39.5	2	98	153
South West	378	378	68.6	60.0	55	9	127	160
Toronto Central	325	325	70.2	64.4	52	8	129	171
Waterloo Wellington	247	247	57.8	57.0	38	7	100	155
Overall	4,285	4,285	63.6	59.7	45.0	8	114	160

[a]Ontario was broken down into 14 geographic regions called Local Health Integration Networks, where healthcare was administered and funded independently.

C) Time from diagnosis until treatment (the pre-treatment interval), days

Colon cancer								
Local health integration network[a]	**N diagnosed**	**N treated**	**Mean**	**Std Dev**	**Median**	**Lower quartile**	**Upper quartile**	**90th Pctl**
Central	1,608	1,437	30.2	34.4	24	4	42	66
Central East	1,610	1,427	29.1	32.6	25	4	42	60
Central West	602	536	30.8	32.0	27	3.5	45	66
Champlain	1,509	1,310	40.9	40.7	35	7	56	84
Erie St. Clair	767	685	31.0	32.0	27	5	45	65
Hamilton Niagara	1,652	1,471	31.6	36.4	27	2	45	69
Mississauga Halton	940	847	28.7	34.1	23	3	40	63
North East	687	625	24.8	30.7	20	1	35	55
North Simcoe Muskoka	577	521	28.2	31.2	24	3	41	59
North West	283	250	29.3	37.4	23	4	42	63
South East	665	583	34.6	35.5	32	5	48	69
South West	1,138	998	32.9	37.3	27	4	48	71
Toronto Central	976	866	33.6	37.7	27	6	47	69
Waterloo Wellington	747	690	30.3	30.9	27	3	45	64
Overall	13,761	12,246	31.6	35.2	27	4	45	68
Rectal cancer								
Local health integration network[a]	N Obs	N	Mean	Std Dev	Median	Lower quartile	Upper quartile	90th Pctl
Central	453	386	46.1	32.9	43	27	59	84
Central East	509	459	46.9	39.3	41	25	59	83
Central West	202	182	53.6	36.4	46	33	66	85
Champlain	394	347	63.0	50.0	52	33	78	120
Erie St. Clair	278	235	55.9	35.8	54	35	73	91
Hamilton Niagara	587	506	54.3	41.0	49.5	34	67	91
Mississauga Halton	260	230	53.4	39.4	48.5	33	67	88
North East	206	188	46.9	34.3	43	28	63	76
North Simcoe Muskoka	179	157	52.6	48.7	42	28	62	85
North West	89	77	48.9	44.7	40	28	61	88
South East	178	163	62.5	39.6	54	39	75	97
South West	378	322	60.8	38.6	55	40	75	103
Toronto Central	325	281	56.9	45.9	49	33	69	103
Waterloo Wellington	247	225	50.0	43.3	41	26	61	85
Overall	4,285	3,758	53.7	41.1	48	31	67	92

[a]Ontario was broken down into 14 geographic regions called Local Health Integration Networks, where healthcare was administered and funded independently.