Overuse of colonoscopy in Ontario Canada, a population-based cohort study

Lieke Hol, MD, PhD[1,2], Rinku Sutradhar, PhD[1,3], Sumei Gu, MSc [1,3], Nancy N. Baxter, MD, PhD[1,4], Linda Rabeneck, MD, MPH[1,5], Jill M. Tinmouth, MD, PhD[1,6], Lawrence F. Paszat, MD, MS[1, 6]

On behalf of the investigators of the Ontario Cancer Screening Research Network.

[1] Institute for Clinical Evaluative Sciences,

[2] Department of gastroenterology and Hepatology, Erasmus University Medical Centre, Rotterdam, The Netherlands.

[3] Dalla Lana School of Public Health, University of Toronto,

[4] Department of Surgery and Li Ka Shing Research Institute, St. Michael's Hospital, Toronto, Ontario, Canada,

[5] Prevention and Cancer Control, Cancer Care Ontario,

[6] Sunnybrook Health Sciences Centre, Toronto, Ontario.

Correspondence:

Lawrence F. Paszat, MD, MS

Institute for Clinical Evaluative Sciences,

G1 06, 2075 Bayview Avenue

Toronto, Ontario M4N 3M5

Email: lawrence@ices.on.ca

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Abbreviations:

CCI	Canadian Classification of Interventions
CCP	Canadian Classification of Procedures
CIHI	Canadian Institute for Health Information
CRC	Colorectal carcinoma
DAD	Discharge Abstract Database
ERC	Early repeated colonoscopy
ICD-9	International Classification of Diseases 9th Revision
ICD-10	International Classification of Diseases 10th Revision
OHIP	Ontario Health Insurance Plan
OCR	Ontario Cancer Registry
RPDB	Registered Persons Database (RPDB)
IBD	Inflammatory bowel disease

Abstract

Background: Current guidelines recommend a ten year interval for repeat colonoscopy after negative findings at baseline colonoscopy. Limited data suggests overutilization of surveillance colonoscopies, especially in patients at low risk for colorectal cancer. We therefore evaluated utilization of surveillance colonoscopies in low risk patients aged 50 to 79 years old and associated patient and endoscopist-related factors.

Methods: All patients aged 50-79 years of age who underwent a complete negative outpatient colonoscopy between 2000-2007 were identified by using the Ontario Health Insurance Plan database. A colonoscopy within 5.5 years of follow-up after the index colonoscopy was considered an early repeat colonoscopy (ERC). Patient, endoscopist, and endoscopy setting characteristics were recorded and their association with an ERC was determined using an extended Cox model.

Results: The study cohort consisted of 546,476 patients, 55.4% women with a mean age of 61.1 years (95%CI:61.1-61.2). The cumulative percentage of ERC after 5.5 years was 33.7%. The rate of ERC decreased significantly between 2000-2007 (HR:0.35;95%CI:0.34-0.36). General surgeons had a higher hazard of ERC than gastroenterologists (HR:1.26;95%CI:1.25-1.28) . Endoscopists practising in a non-hospital based setting had a 1.26 times higher hazard of ERC than those working in a hospital (95%CI1.22-1.30).

Interpretation: This study demonstrates overutilization of surveillance colonoscopies in more than 30% of patients at low risk for CRC. The hazard of ERC decreased significantly between 2000-2007 suggesting more awareness of current surveillance guidelines, but was still greater than 20% in 2007. Our findings can be used to develop targeted educational interventions amongst subgroups of endoscopists with a higher rate of ERC.

WORDS: 246 (max 250)

No works left for data on open-access

Introduction

Patients with adenoma(s) have a higher risk of developing metachronous adenoma or colorectal cancer (CRC) and surveillance colonoscopy is recommended (1-4). Current international guidelines recommend intervals for follow-up colonoscopy based on the most advanced finding at baseline (5-8).

The number of colonoscopies performed for screening and surveillance is likely to grow in the next decade. Avoiding unnecessary colonoscopy is vital in an era of limited colonoscopy capacity and excessive health care costs. Surveillance colonoscopies in excess of current guidelines has been reported (9-16) and involves surveillance of individuals with a low probability of net benefit (e.g. individuals over 85 years or with severe comorbidities) or frequent surveillance colonoscopies in people with no or low risk findings at baseline colonoscopy. Overutilization undermines costs-effectiveness of CRC surveillance programs and results in more complications of excessive colonoscopies (17, 18). Moreover, overuse may result in prolonged wait times for patients with an appropriate indication for colonoscopy.

Surveys revealed that general practitioners as well as specialists recomment that patients at low risk for CRC undergo colonoscopy more frequently than stated in the guidelines (9, 10, 13, 15). Studies based on administrative data in the US reported that over 20% of surveillance colonoscopies performed in a Medicare population aged over 65 years old was unnecessary (12, 19) and a proportion of colonoscopies could have been avoided (12).

Population-based data on overuse of surveillance colonoscopies and factors contributing to it, including all patients in age groups (50-79 years) eligible for screening, are lacking. Moreover, no studies on overuse of surveillance colonoscopies has been performed in Canada. Our goal was to determine the frequency of early repeated colonoscopies (ERC), defined as a colonoscopy within 5.5 years of a complete and negative colonoscopy, among patients aged 50 to 79 years old in Ontario, Canada and the associated patient and endoscopist-related factors.

Methods

Study design

This is a population-based cohort study of patients who underwent a complete negative outpatient colonoscopy in Ontario Canada between January 1st 2000 and December 31st 2007. All patients were followed for 5.5 years after inclusion until the first occurrence of: an early repeated colonoscopy (ERC), death, colon resection, development of CRC or inflammatory bowel disease (IBD) or the end of follow-up.

Administrative Data Sources

Data were obtained from five data sources that have been described in detail elsewhere (20-22): (1) the Canadian Institute for Health Information (CIHI) national database Discharge Abstract Database (DAD); (2) Ontario Health Insurance Plan (OHIP) database; (3) The Ontario Cancer Registry; (4) The Registered Persons Database (RPDB); (5) The ICES Physicians Database.

Study cohort

Patients 50 to 79 years who underwent an outpatient negative complete colonoscopy between January 1st, 2000 and December 31st, 2007 were identified using OHIP. The inclusion period ended on December 31st, 2007 to obtain adequate follow-up of 5.5 years until July 2013. A complete colonoscopy was defined by OHIP procedure codes indicating that the cecum or the terminal ileum was reached. A colonoscopy was considered negative if no colorectal biopsy or polypectomy was performed on the date of the colonoscopy. This first colonoscopy during the study period was defined as the index colonoscopy. Patients who had a diagnosis of CRC, IBD a or colonic resection between 6 months and 10 years prior to the index colonoscopy were identified by using CIHI and OHIP billing codes and were excluded from the cohort. Patients who had a colonoscopy or colon resection, who were diagnosed with CRC or inflammatory bowel disease (IBD) or who died within six months of the index colonoscopy were excluded from the cohort, as these findings might have been related to findings at the index colonoscopy and the index colonoscopy could therefore not be considered “negative” (21).

Identification of early repeated colonoscopies (ERC)

The primary outcome of this study was time to an ERC between six months and 5.5 years after the index colonoscopy based on OHIP physician claims data. Events occurring during the first six months after the index colonoscopy were not captured in the model as these patients were excluded from the analyses. Time was measured in days starting from six months after the index colonoscopy. Patients were censored at death (last date of contact was used as date of death), diagnosis of CRC or IBD, colon resection, loss to follow-up (e.g. no Ontario Health care coverage), or at the end of the follow-up period at 5.5 years after the index colonoscopy.

Covariates

Patient characteristics

Patient age, sex, aggregated diagnosis groups (ADGs) Johns-Hopkins comorbidity score (23) (based on ICD9/10 diagnosis code within each of the 32 ADGs in the year before the index colonoscopy), a proxy for socioeconomic status (median neighborhood income quintile of patient's postal code area).

Endoscopy characteristics

Endoscopist characteristics are known to influence occurrence of an ERC (19). We therefore recorded the characteristics of the initial endoscopist, including sex and specialty (gastroenterologist, general surgeon, internist and other specialties) derived from the ICES Physicians Database. The main practice location of the endoscopist (hospital-based, non-hospital-based or mixed) was determined based on the setting (hospital or non-hospital) of each colonoscopy billed in the year prior to the index colonoscopy. Main practice location of the endoscopist was defined as mixed if more than ten colonoscopies per year were performed in both settings. Quality indicators including colonoscopy volume (irrespective of completeness), polypectomy (proportion of colonoscopies with addition billing code for polypectomy) and completion rate (proportion of colonoscopy with accompanying billing code for intubation of the cecum or terminal ileum) were determined based on OHIP billings claims of the endoscopist in the year prior to the index colonoscopy.

The colonoscopy was considered hospital-based if the dates of the CIHI admission record overlapped with the date of the procedure in OHIP and non-hospital-based if there was no overlapping CIHI admission record.

Hospital-based setting was subdivided into academic or community hospital based on the hospital code. In cases where no consultations were recorded 12 months before index colonoscopy it was considered open access.

Analysis

We calculated the descriptive statistics for all covariates included in the study. Risk of ERC was estimated by the Kaplan-Meier method. To assess the association of patient and endoscopy related factors with the hazard of ERC, we used an extended Cox model (24). The patient was the unit of analysis and time to ERC was the outcome. Patients were censored at time of death, los to follow-up, colon resection, diagnosis of CRC or IBD or the end of follow-up, depending on what occurred first. Covariates including patient age group (50-54, 55-59, 60-64, 65-69, 70-74, 75-79 years old), sex, socioeconomic status (categorized per quintiles in urban areas and rural), co-morbidigy (ADG as a continuous variable), the year (2000-2007) and setting (hospital/non-hospital) of the index colonoscopy and whether it was an open access colonoscopy and specialty (general surgeon, gastroenterologist, internist, other specialities) and main practice location (hospital, non-hospital-based or mixed) obtained at the time of the index colonoscopy. Hazard ratios (HR) with 95% confidence interval (95% CI) and their associated p-values were calculated. Based on the univariate analyses and survival plots, we handled any violation of the proportional hazards assumptions by incorporating interactions with time into the model (25). Specifically, we included an interaction with endoscopy related covariates (setting/open access) and time, where time was categorized as 6-35months and 36-66 months after index colonoscopy. For the analyses we used SAS version 9.3 (SAS Institute, Inc, Cary, NC). All statistical tests were 2 sided, and *P* values less than .05 were considered statistically significant.

Results

Between 2000 and 2007 622,633 patients aged 50-79 years old had a complete negative outpatient colonoscopy. In total 57,977 patients with missing data or who were diagnosed with colorectal cancer or IBD, underwent a colon resection were excluded from further analyses. Furthermore, patients with a colonoscopy within six months of the index colonoscopy were excluded (prior n=2,957, after n=5,120) as well patients diagnosed with colorectal cancer within six months after the index colonoscopy (n=10,103). The study cohort consisted of 546,476 patients (fig. 1), 55.4% women with a mean age of 61.1 years (95% CI 61.1-61.2). The number of complete negative colonoscopies increased by year of inclusion (Table 1).

In total 1,002 endoscopists performed at least one index colonoscopy. The majority of colonoscopies were performed in a hospital setting (81.0%), and mainly by general surgeons (53.1%). In 34.4% the colonoscopy was open-access. Most endoscopists practiced only in a hospital (72.4%). For the endoscopist performing the index colonoscopy the median colonoscopy volume over one year was 501 (IQR 318-716), the completeness rate was 0.97 (IQR:0.05) and the polypectomy rate 0.22 (IQR:0.14).

During the 5.5 years of follow-up 18,602 (3.4%) patients died, 653 (0.1%) were diagnosed with IBD and 519 (0.1%) were diagnosed with CRC or underwent a colon resection (0.4%) and were censored. The cumulative percentage of ERC after 5.5 years based on the KM-analyses was 33.7%. Figure 2a demonstrates the cumulative percentage of patients with an ERC by year of index colonoscopy.

Multivariate Cox regression analysis showed that patient-related factors including age 65-69 years old, male sex and greater comorbidity (ADG) were associated with an ERC. The rate of ERC decreased significantly with every subsequent index year from 45.6% in 2000 to 20.5% 2007 (HR:0.35;95%CI:0.34-0.36).

Patients undergoing an index colonoscopy by a general surgeon had a 1.26 (95%CI:1.25-1.28) times higher hazard of an ERC than if the index colonoscopy was carried out by a gastroenterologist (fig.2b). An index colonoscopy performed in a non-hospital based setting was more likely to be repeated than if performed in a hospital (HR:1.05;95%CI:1.02-1.07). If the index colonoscopy was performed by an endoscopists practising only in a non-hospital-based setting, patients were more likely to undergo an ERC compared to patients whose index colonoscopy was performed by an endoscopist practising only in a hospital (HR:1.26;95%CI:1.22-1.30). The hazard

of an ERC was similar among endoscopists with a mixed practice compared to those with a hospital-based practice (HR:1.00;95%CI:0.98-1.01).

A colonoscopy performed in a non-hospital based setting was more likely to be followed by ERC (1.05 (1.02-1.07) than a hospital based colonoscopy. As seen in fig 2c. the association between open-access index colonoscopy and hazard of ERC was not proportional over time. Within 6-35 months after an index colonoscopy, the hazard of an ERC for a patient with an open-access index colonoscopy was 1.24 (95%CI:1.21-1.26) times higher than a patient with a non-open-access index colonoscopy. This hazard ratio further increased to 1.55 (95%CI:1.51-1.59) during 36-66 months after index colonoscopy.

Discussion

In this study we report the results of a population-based cohort study of 546,476 patients with a complete and negative outpatient colonoscopy in Ontario, Canada between 2000-2007. In total 33.7% of patients had a ERC within 5.5 years of a the index colonoscopy, substantially earlier than recommended by current guidelines (5-7). Our data demonstrated a lower hazard of ERC with every subsequent year of inclusion. Additionally, endoscopist related factors were associated with the probability of an ERC.

We found that one third of our cohort had an colonoscopy within 5.5 years of a negative colonoscopy. More aggressive surveillance than once every ten years in low-risk patients is unlikely to be cost-effective and may even be harmful (17). More efficient utilization of colonoscopy resources is therefore required, as surveillance colonoscopies already impact substantively on colonoscopy capacity and financial resources (26). Two smaller population-based cohort studies carried out in a subgroup of the U.S. Medicare population reported a similar rate of ERC in patients aged over 65 years with a negative index colonoscopy (12, 19). In contrast to these studies, we included the entire target population of Ontario, Canada eligible for screening (50-79 years old) making our results generalizable to a surveillance program. Furthermore, our data add significantly to the understanding of patient and endoscopist-related factors associated to ERC.

In this study, 44% of patients with an index colonoscopy in 2000 had an ERC; this proportion decreased to only 20% by 2007. In a U.S. Medicare population a similar trend was seen with a reported ECR of 43% within 2001 to 2003 (11) and 23% within 2008 to 2009 (12). The reduction in ERC over time is encouraging as it may suggest greater awareness of current surveillance guidelines.

A key factor in patterns of repeat colonoscopy is the endoscopist's recommendation about when to return for surveillance, which is known to be highly variable (27). In this study we found that general surgeons had a significantly higher hazard of ERC compared to gastroenterologists. As we excluded patients with CRC, overrepresentation of patients having a repeat colonoscopy after colorectal surgery for CRC among general surgeons cannot explain this finding. Patient selection based on indication for colonoscopy seems unlikely, as surgeons performed more than 50% of all colonoscopies included in this study. In keeping with our findings a survey in the US reported a significant larger proportion of surgeons than gastroenterologists recommending more frequent surveillance in low-risk patients than indicated by guidelines (15). Furthermore, a higher hazard of ERC

was observed among endoscopists practicing in a non-hospital based setting only compared to those working in a hospital based setting or those working in both settings. Factors affecting physician behaviour may include lack of experience or knowledge of guidelines (13, 15), regional difference in practice and financial incentives (15).

In the current study, an open-access index colonoscopy was associated with a higher hazard of ERC as compared to non-open-access. Our findings are in keeping with data reporting shortened surveillance interval as the most common reason for an inappropriate colonoscopy in an open-access endoscopy unit (28). This may be explained by inadequate communication between the endoscopist and the referring physician responsible for continued care and referral for repeated colonoscopy (29). Adequate endoscopy reporting systems are therefore essential, especially as open-access colonoscopies account for a significant proportion of all colonoscopies (30, 31). Interestingly, the difference between open- and non-open access colonoscopy was not proportional over time. The higher hazard of an ERC after three years of follow-up may indicate that in a larger proportion of cases after an open-access compared to a non-open access colonoscopy the ERC has been routinely scheduled 3-5 years after a negative colonoscopy.

The use of administrative data has limitations. We could not determine the indication for the ERC. However, it is unlikely that our results would differ as only significant complaints (e.g. lower gastrointestinal bleeding) would justify a ERC as these complains only accounts for a small proportion of all colonoscopies (26). The chance of finding important pathology is low in those with minor complaints (e.g. change in bowel habits) within 10 years of a complete negative colonoscopy (6) and repeating the colonoscopy should be considered as inappropriate surveillance (32). Appropriate reasons for an ERC are inadequate bowel preparation or the resection of a large polyp, which was left in situ during the index colonoscopy (5-7). In both cases we would incorrectly consider the colonoscopy as a complete negative examination based on the administrative data, which did not include data on bowel preparation. In order to address this potential misclassification, we therefore excluded all patients with a repeated colonoscopy within six months of index colonoscopy.

In conclusion, in this large population-based study of 546,467 patients who underwent outpatient colonoscopy, we demonstrated overutilization of surveillance colonoscopies in more than 30% of patients at low risk for CRC. The probability of an ERC decreased significantly between 2000 and 2007 suggesting more awareness of current surveillance guidelines, but was still more than 20% in 2007. Our findings can be used to develop

targeted educational interventions amongst subgroups of endoscopists with a higher rate of ERC. In addition, based on the higher hazard of ERC after an open-access colonoscopy effort should be made to improve communication between endoscopists and referring physicians.

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Disclosure:

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A contributor's statement:

Lieke Hol, Rinku Sutradhar, Nancy N. Baxter, Linda Rabeneck, Jill M. Tinmouth, Lawrence F. Paszat contributed substantially to conception and design. Sumei Gu performed the data extraction. Data analyses were performed by Sumei Gu and Lieke Hol. Statistical support was provided by Rinku Sutradhar. Interpretation of data was done by Lieke Hol, Rinku Sutradhar, Nancy N. Baxter, Linda Rabeneck, Jill M. Tinmouth and Lawrence F. Paszat. The article was drafted by Lieke Hol and revised critically for important intellectual content by all co-authors. Lawrence F. Paszat gave final approval of the version to be published. Lawrence F. Paszat agreed to act as guarantor of the work .

Supplementary material

	Diagnostic codes
Inflammatory bowel disease (IBD)	At least five times physician claims or hospitalization for IBD
	ICD-9 555, 556
	ICD-10 K50, K51
Colorectal cancer (CRC)	ICD-9 153.0-153.4,153.6-154.1
	ICD-10 C180, C182-189,C19,C20
Polypectomy	Z571 Excision of the first polyp ≥ 3mm through the colonoscope
	E720 Each additional polyp ≥ 3mm
	Z764/ Z765 Excision of obstructive tumor or stricture through colonoscope
	E687 with laser debulking
	E685 total excision of very large sessile polyp (>3cm) through colonoscope
Cecal intubation	E747 to cecum
	E705 into terminal ileum

STROBE Statement—Checklist of items that should be included in reports of ***cohort studies***

	Item No	Recommendation
Title and abstract	1	(*a*) The study design is stated in both title and abstract.
		(*b*) An abstract is provided (page 3)
Introduction		
Background/rationale	2	The scientific background and rationale for the investigation is reported in the introduction section (Page 4)
Objectives	3	The objective of the study is stated on page 4 (Paragraph 4)
Methods		
Study design	4	The key elements are described at first in the method section (Page 5, Study design)
Setting	5	The setting is described on page 5 (paragraph 1), locations on page 5 (paragraph 1), and relevant dates including periods of recruitment on page 5 (paragraph 1), follow-up on page 5 (paragraph 1), and data collection on page 5 (2-3), page 6 (paragraph 1-3)
Participants	6	(*a*) The eligibility criteria and the sources and methods of selection of participants are described on page 5 (paragraph 3). The follow-up method and end-point are described on page 6 (paragraph 1).
		(*b*) n/a
Variables	7	Outcome is defined on page 6 (paragraph 1; early repeated colonoscopy), predictors potential confounders /effect modifiers are stated on page 6 (paragraph 2-3; patient, endoscopy and endoscopists related factors). Diagnostic criteria: n/a
Data sources/ measurement	8*	Sources of data and details of methods of assessment of each variable are described on page 6 (paragraph 2-3; patient, endoscopy and endoscopists related factors). Comparability of assessment methods: n/a
Bias	9	Efforts to address potential sources of bias are described on page 6 (paragraph 1)
Study size	10	The study size is based on the time frame of inclusion stated on page 5 (paragraph 3)
Quantitative variables	11	Handling of quantitative variables in the analyses and groupings chosen are described on page 7 (paragraph 1, statistics).
Statistical methods	12	(*a*) Stated on page 7 paragraph 1 (statistics)
		(*b*) Stated on page 7 paragraph 1 (statistics)
		(*c*) Stated on page 6 paragraph 1 (Identification of early repeated colonoscopies (ERC)
		(*d*) Stated on page 6 paragraph 1 (Identification of early repeated colonoscopies (ERC)
		(*e*) Sensitivity analyses: n/a
Results		
Participants	13*	(a) Report numbers of individuals at each stage of study is stated in figure 1.
		(b) Non-participation at each stage of study is stated in figure 1.
		(c) Flow diagram (see figure 1)
Descriptive data	14*	(a) Characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders are stated in table 1 and page 1 paragraph 2..
		(b) The number of participants with missing data for each variable of interest is indicated in table 1.
		(c) Summarise follow-up time: n/a.
Outcome data	15*	Numbers of outcome events is stated on page 8 paragraph 3.

Main results	16	(*a*) Unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval) are described on page 8 (paragraph 4-5) and in table 2.
		(*b*) Report category boundaries when continuous variables were categorized: n/a
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period: n/a.
Other analyses	17	Other analyses included the interaction with time in the extended cox model described on page 9 paragraph 1.
Discussion		
Key results	18	The key results are summarise on page 10 paragraph 1.
Limitations	19	The limitations of the study taking into account sources of potential bias or imprecision are discussed on page 11 (paragraph 2). The direction and magnitude of any potential bias are discussed in the same paragraph.
Interpretation	20	A cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence are stated on page 10 (paragraph 1-3) and page 11 (paragraph 1).
Generalizability	21	The generalizability of the study results is discussed on page 10 (paragraph 2)
Other information		
Funding	22	The source of funding is stated on page 16.

*Give information separately for exposed and unexposed groups.

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STROBE Statement—Checklist of items that should be included in reports of ***cohort studies***

	Item No	Recommendation
Title and abstract	1	(*a*) The study design is stated in both title and abstract.
		(*b*) An abstract is provided (page 3)
Introduction		
Background/rationale	2	The scientific background and rationale for the investigation is reported in the introduction section (Page 4)
Objectives	3	The objective of the study is stated on page 4 (Paragraph 4)
Methods		
Study design	4	The key elements are described at first in the method section (Page 5, Study design)
Setting	5	The setting is described on page 5 (paragraph 1), locations on page 5 (paragraph 1), and relevant dates including periods of recruitment on page 5 (paragraph 1), follow-up on page 5 (paragraph 1), and data collection on page 5 (2-3), page 6 (paragraph 1-3)
Participants	6	(*a*) The eligibility criteria and the sources and methods of selection of participants are described on page 5 (paragraph 3). The follow-up method and end-point are described on page 6 (paragraph 1).
		(*b*) n/a
Variables	7	Outcome is defined on page 6 (paragraph 1; early repeated colonoscopy), predictors potential confounders /effect modifiers are stated on page 6 (paragraph 2-3; patient, endoscopy and endoscopists related factors). Diagnostic criteria: n/a
Data sources/ measurement	8*	Sources of data and details of methods of assessment of each variable are described on page 6 (paragraph 2-3; patient, endoscopy and endoscopists related factors). Comparability of assessment methods: n/a
Bias	9	Efforts to address potential sources of bias are described on page 6 (paragraph 1)
Study size	10	The study size is based on the time frame of inclusion stated on page 5 (paragraph 3)
Quantitative variables	11	Handling of quantitative variables in the analyses and groupings chosen are described on page 7 (paragraph 1, statistics).
Statistical methods	12	(*a*) Stated on page 7 paragraph 1 (statistics)
		(*b*) Stated on page 7 paragraph 1 (statistics)
		(*c*) Stated on page 6 paragraph 1 (Identification of early repeated colonoscopies (ERC)
		(*d*) Stated on page 6 paragraph 1 (Identification of early repeated colonoscopies (ERC)
		(*e*) Sensitivity analyses: n/a
Results		
Participants	13*	(a) Report numbers of individuals at each stage of study is stated in figure 1.
		(b) Non-participation at each stage of study is stated in figure 1.
		(c) Flow diagram (see figure 1)
Descriptive data	14*	(a) Characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders are stated in table 1 and page 1 paragraph 2..
		(b) The number of participants with missing data for each variable of interest is indicated in table 1.
		(c) Summarise follow-up time: n/a.
Outcome data	15*	Numbers of outcome events is stated on page 8 paragraph 3.

Main results	16	(*a*) Unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval) are described on page 8 (paragraph 4-5) and in table 2.
		(*b*) Report category boundaries when continuous variables were categorized: n/a
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period: n/a.
Other analyses	17	Other analyses included the interaction with time in the extended cox model described on page 9 paragraph 1.
Discussion		
Key results	18	The key results are summarise on page 10 paragraph 1.
Limitations	19	The limitations of the study taking into account sources of potential bias or imprecision are discussed on page 11 (paragraph 2). The direction and magnitude of any potential bias are discussed in the same paragraph.
Interpretation	20	A cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence are stated on page 10 (paragraph 1-3) and page 11 (paragraph 1).
Generalizability	21	The generalizability of the study results is discussed on page 10 (paragraph 2)
Other information		
Funding	22	The source of funding is stated on page 16.

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Table 1: Demographic information of patients at the time of inclusion and characteristics of the index colonoscopy and its endoscopist.

Total number		**546,467**
Year of inclusion (n)	2000	44,376
	2001	52,555
	2002	59,036
	2003	60,007
	2004	67,536
	2005	74,140
	2006	87,526
	2007	101,291
Age (n-%)	50-54	139,331 (25.5%)
	55-59	126,750 (23.2%)
	60-64	100,667 (18.4%)
	65-69	79,504 (14.5%)
	70-74	60,459 (11.1%)
	75-79	39,756 (7.3%)
Sex (n-%)	Male	243,659 (44.6%)
	Female	302,808 (55.4%)
Comorbidity (ADG JH) (median-IQR)		5 (2)
Socioeconomic status (%)*	Urban bottom 20th ‰	62,218 (11.4%)
	Urban 60th to 80th ‰	79,618 (14.6%)
	Urban 40th to 60th ‰	88,385 (16.2%)
	Urban 20th to 40th ‰	102,214 (18.7%)
	Urban top 20th ‰	139,977 (25.6%)
	Rural	73,650 (13.5%)
Endoscopy		
Setting (n-%)	Community hospital	365,620 (66.9%)
	Academic hospital	77,236 (14.1%)
	Non-hospital	103,470 (18.9%)
Open-Access (n-%)		188,175 (34.4%)
Endoscopist		
Male sex (n-%)		501,808 (91.8)
Specialty (n-%)	General Surgeon	290,412 (53.1%)
	Gastroenterologist	123,268 (22.6%)
	Internist	122,701 (22.5%)
	Other	10,086 (1.8%)
Main practice location (n-%)	Hospital	395,497 (72.4%)
	Private clinic / office	70,730 (12.9%)
	Mixed	78,035 (14.3%)
1-year colonoscopy volume (n-IQR)		501 (318-713)
1-year cecal intubation rate (n-IQR)		0.97 (0.05)
1-year polyp removal rate (n-IQR)		0.22 (0.14)

Abbreviation: ADG JH: Aggregated Diagnosis Groups John Hopkins, CI: confidence interval, IQR: interquartile range.
* No data on SES in 456 (0.1%) patients

Table 2: Multivariate Cox regression model, probability on a follow-up colonoscopy.

		HR (95% CI)
Year of inclusion	2000	1 (referent)
	2001	0.93 (0.91-0.95)
	2002	0.85 (0.83-0,87)
	2003	0.78 (0.76-0.79)
	2004	0.69 (0.68-0.71)
	2005	0,62 (0.60- 0.63)
	2006	0,50 (0.49-0.51)
	2007	0.35 (0.34-0.36)
Age	50-54	1 (referent)
	55-59	1.08 (1.07-1.10)
	60-64	1.17 (1,15-1,19)
	65-69	1.21 (1.19-1.22)
	70-74	1.12 (1.10-1.14)
	75-79	0.91 (0.89-0.93)
Sex	Male	1 (referent)
	Female	0.90 (0,89-0,91)
Comorbidity (ADG JH)		1.25 (1,23-1,28)
Socioeconomic status (%)*	Urban bottom 20th ‰	1 (referent)
	Urban 60th to 80th ‰	1.24 (1.21-1.26)
	Urban 40th to 60th ‰	1.04 (1.02-1.06)
	Urban 20th to 40th ‰	1.04 (1.02-1.05)
	Urban top 20th ‰	1.02 (1.01-1.04)
	Rural	1.12 (1.10-1.14)
Setting	Hospital	1 (referent)
	Non-hospital	1.05 (1.02-1.07)
Open-Access <36months	No	1 (referent)
	Yes	1.24 (1.21-1.26)
Open-Access ≥36months	No	1 (referent)
	Yes	1.55 (1.51-1.59)
Specialty	Gastroenterologist	1 (referent)
	General Surgeon	1.27 (1.25-1.28)
	Internist	1.05 (1.03-1.06)
	Other	1.21 (1.17-1.25)
Main practice location	Hospital	1 (referent)
	Private clinic / office	1.26 (1.22-1.30)
	Mixed	1.00 (0.98-1.01)

Abbreviation: ADG JH: Aggregated Diagnosis Groups John Hopkins, HR: Hazard ratio,CI: confidence interval.

Figure 1: flow diagram of study cohort identification.

Figure 2: probability on an early repeated colonoscopy (ERC) comparing year of index colonoscopy (A) specialty of the endoscopist (B) open-access vs. non-open-access (C). Follow-up starts 6 months after the index colonoscopy as events within 6 months after the index colonoscopy were not captured in the model, as these findings were likely to be associated to the findings at the index colonoscopy and the index colonoscopy could therefore not be considered “negative”.

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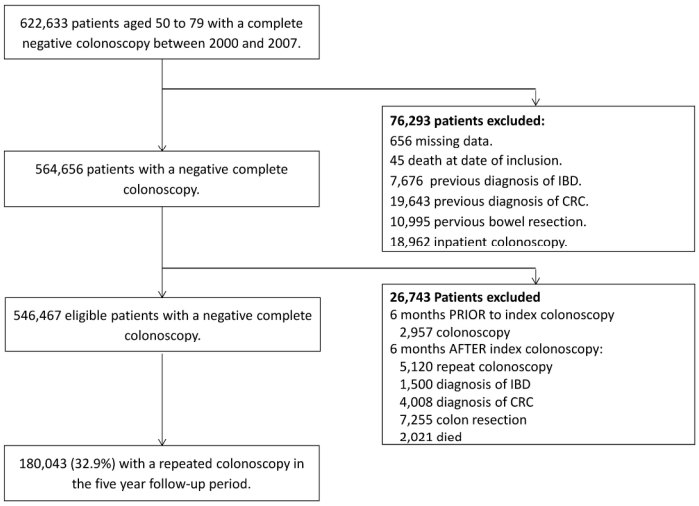

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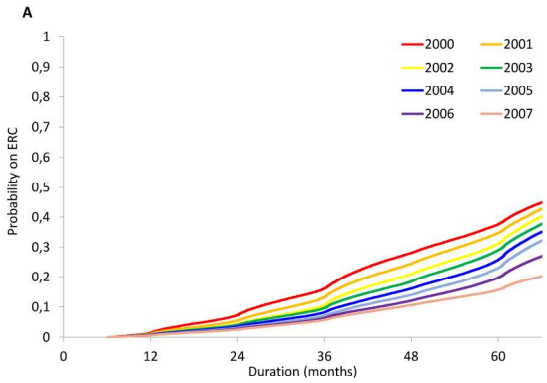

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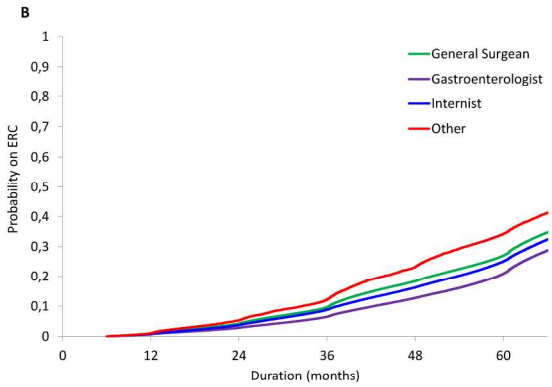

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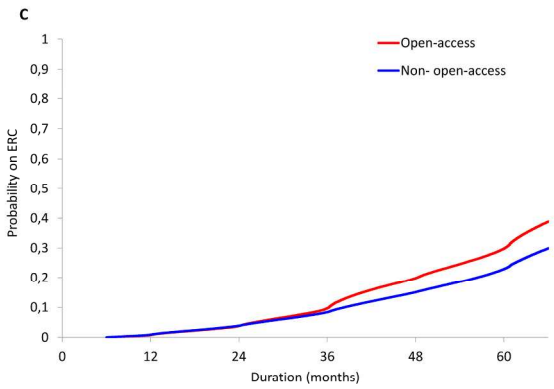

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