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Uptake of colorectal cancer screening tests by Ontario physicians.

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Abstract

This population-based study used administrative healthcare data to examine the uptake of tests recommended for colorectal cancer screening by eligible Ontario physicians and non-physicians, and to examine if testing of primary care physicians is associated with greater testing in their patients. Physicians (n=11,434) were matched 1:4 to non-physicians (n=45,736) on age, sex, and geographic location as of April 21, 2016. Uptake of colorectal tests was similar in physicians (67.9%, 95% CI, 67.0–68.7%) and non-physicians (66.6%, 95% CI, 66.2–67.1%). Physicians were more likely than non-physicians to undergo colonoscopy and less likely to undergo fecal occult blood testing. Uptake of colorectal tests by primary care physicians was associated with greater testing in their patients (adjusted prevalence ratio, 1.10; 95% CI, 1.08–1.12). These results highlight the opportunity for greater screening of physicians, who may in turn positively influence screening in their patients.

Keywords

Colorectal cancer, cancer screening, secondary prevention, public health, physician health, fecal occult blood test, flexible sigmoidoscopy, colonoscopy.

Lay summary

This study used several databases to examine the uptake of colorectal cancer screening among 11,434 physicians and 45, 736 screen-eligible non-physicians in Ontario. Overall uptake of colorectal tests was similar in physicians (67.9%) and non-physicians (66.6%). Physicians were more likely than non-physicians to undergo colonoscopy and less likely to undergo fecal occult blood testing. Patients were also more likely to be tested if their family physician was tested. These results highlight the opportunity for greater screening of physicians, who may in turn positively influence screening in their patients.

Co-authorship Statement

The study presented in this thesis was primarily designed and executed by Owen Litwin. This includes but is not limited to study conception, data creation plan production, data analysis and manuscript production and editing. Regular feedback was provided by the supervisory committee (Drs. Amit Garg, Jessica Sontrop and Blayne Welk). Mr. Eric McArthur assisted with data analysis. All co-authors contributed to study conception and design, data interpretation and revising the manuscript associated with this thesis.

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Table of contents

List of tables

List of figures

List of appendices

List of abbreviations

CCI = Canadian Classification of Health Interventions

CCP = Canadian Classification of Diagnostic, Therapeutics, and Surgical Procedures

CI = Confidence interval

CIHI-DAD = Canadian Institute for Health Information – Discharge Abstracts Database

CPSO = College of Physicians and Surgeons of Ontario

CT = Computed tomography

CTFPHC = Canadian Task Force on Preventive Health Care

FOBT = Fecal occult blood test

ICD-9 = International Classification of Diseases, Ninth Revision

ICD-10 = International Classification of Diseases, Tenth Revision ICES = Institute for Clinical Evaluative Sciences

ICES = Institute for Clinical Evaluative Sciences

NNS = Number needed to screen

OHIP = Ontario Health Insurance Plan

PR = Prevalence ratio

RCT = Randomized controlled trial

RPDB = Registered Persons Database

USPSTF = United States Preventive Services Task Force

Chapter 1

1 Introduction

Colorectal cancer is a significant source of morbidity and mortality in Canada, accounting for 13% of all cancers nationally, and 12% of all cancer deaths (26,800 cases and 9,400 deaths in 2017).[1] Fortunately, several screening tests are available that have been demonstrated to reduce colorectal cancer mortality.[2–4] While recommendations for screening average-risk individuals vary by country, most guidelines recommend a fecal occult blood test (FOBT) every 1–2 years, and some recommend flexible sigmoidoscopy every five years or colonoscopy every ten years (recommendations from six organizations are summarized in **Table 1**.[2,5–11]

Table 1: Recommendations for colorectal cancer screening in average-risk individuals.

Country	Organization	Year	Age	Fecal occult blood testing	Flexible sigmoidoscopy	Colonoscopy	Computed tomographic colonography
Canada	Canadian Task Force on Preventive Health Care†,‡	2001	50 to 74	Annual or biennial	At periodic health examinations	No recommendation*	Not recommended
		2016	50 to 74	Biennial	Every 10 years	Not recommended	Not recommended
	Cancer Care Ontario§	2016	50 to 74	Biennial	Every 10 years	Not recommended	Not recommended
United States	U.S. Preventive Services Task Force ∥ ,¶	2008	50 to 75	Annual	Every 5 years	Every 10 years	No recommendation*
		2016	50 to 75	Annual	Every 5 years	Every 10 years	Every 5 years
England	National Health Service**	2015	60 to 74	Biennial	One time after age 55	Not recommended	Not recommended
Australia	National Bowel Cancer Screening Program††	2015	50 to 74	Biennial	Not recommended	Not recommended	Not recommended
Ireland	National Screening Service‡‡	2012	60 to 69	Biennial	Not recommended	Not recommended	Not recommended

*****Insufficient evidence to recommend the inclusion or exclusion of this screening modality for colorectal cancer.
†Canadian Task Force on Preventive Health Care. Colorectal cancer screening. Recommendation statement from the Canadian Task Force on Preventive Health Care. *CMAJ*. 2001;165:206-208.
‡ Canadian Task Force on Preventive Care. Recommendations on screening for colorectal cancer in primary care. *CMAJ*. 2016;188:340-348.
§ Cancer Care Ontario. ColonCancerCheck (CCC) Screening Recommendations Summary—April 2016. www.cancercareontario.ca/sites/ccocancercare/files/assets/CCCScreeningRecommendations.pdf.
∥ U.S. Preventive Services Task Force. Screening for Colorectal Cancer: U.S. Preventive Services Task Force Recommendation Statement. *Ann Intern Med*. 2008;149:627.
¶ U.S. Preventive Services Task Force. Screening for Colorectal Cancer US Preventive Services Task Force Recommendation Statement. *JAMA*. 2016;315:2564-2575.
** National Health Service. Bowel cancer screening. 2015. www.nhs.uk/conditions/bowel-cancer-screening/.
††Australian Government Department of Health. National Bowel Cancer Screening Program. 2015. www.health.gov.au/internet/screening/publishing.nsf/Content/bowel-screening-1.
‡‡ National Screening Service. Bowel Screening. 2012. www.screeningservice.ie/bowel-screening.html

Despite the evidence in support of routine colorectal cancer screening, physician support for screening remains variable.[12–15] For instance, a survey of family physicians in Saskatchewan found that although 87.5% of physicians believe that colorectal cancer screening is beneficial in people without a family history of colorectal cancer, only 77% of physicians routinely recommend screening for patients without a family history of colorectal cancer.[13] This variable physician support for screening has important implications given that population-level screening participation in Ontario is consistently suboptimal (approximately 30% participation for FOBT).[16] Strategies to increase provincial screening participation, including public media awareness campaigns and the use of pay-for-performance incentives for physicians, have unfortunately not resulted in a sustained increase in screening.[17,18]

There is evidence that when physicians are compliant with cancer screening recommendations, their patients are significantly more likely to be compliant too,[19] and this represents a unique opportunity for physicians to lead from the front in cancer prevention. However, most studies of physicians' personal screening behaviors consist of surveys that may be limited by recall and social desirability biases.[14,15,20,21] Indeed, there has never been a comprehensive analysis of a group of North American physicians' screening behaviors assessing the actual tests they had performed.

We used health administrative data to conduct a population-based, cross-sectional study, with the aim of comparing uptake of colorectal tests in physicians and non-physicians in Ontario. We also aimed to identify and quantify physician characteristics that are associated with testing, and to determine whether patients are more likely to undergo testing when their own family physician is tested.

The following thesis consists of six chapters. Chapter 2 contains a review of the relevant cancer screening literature. Chapter 3 contains the rationale for investigating cancer testing uptake in physicians, as well as the specific objectives and hypotheses of this thesis. Chapter 4 describes the methodology used to address the objectives. Chapter 5 contains the results of the analysis, and Chapter 6 contains a discussion and interpretation of the findings, and suggestions for future studies.

Chapter 2

2 Literature Review

A review of English language scientific articles was conducted. This literature review included evidence cited in guidelines and systematic reviews from the Canadian Task Force on Preventive Health Care (CTFPHC), Cancer Care Ontario and the United States Preventive Services Task Force (USPSTF), as well as articles identified through searching PubMed and Google Scholar, and from searching the reference lists of articles cited by the aforementioned organizations.

2.1 Colorectal cancer

Colorectal cancer is the 2nd most frequently diagnosed cancer in Ontario. In 2017 there were 10,400 new colorectal cancer diagnoses (5,700 men and 4,700 women), and it caused 3,250 deaths (1,750 men, and 1,500 women).[1]

In Ontario between 1982 and 2012, the age-standardized incidence rate of colorectal cancer in males decreased from 82.1 per 100,000 to 80.2 per 100,000, and, among females, decreased from 65.3 per 100,000 to 57.7 per 100,000. During this time, the age-standardized colorectal cancer mortality rate among males decreased from 46 per 100,000 to 29 per 100,000, and, among females, decreased from 34.2 per 100,000 to 18.2 per 100,000.

One of the established risk factors for colorectal cancer is older age, as 93% of cases are diagnosed in people age 50 or older.[22] Other non-modifiable risk factors include having a personal or family history of colorectal cancer, inflammatory bowel disease, or colorectal polyps.[23–25] Having a first-degree relative with a history of colorectal cancer is associated with a two to three-fold increased risk of developing colorectal cancer.[26] Modifiable risk factors for colorectal cancer include a high intake of processed and red meat, low fiber intake, obesity, diabetes, physical inactivity, as well as tobacco and alcohol use.[23–25,27]

Colorectal cancer begins as an adenomatous polyp in the lumen of the colon or rectum.[28] Genetic mutations and abnormal cell divisions can result in formation of a polyp. Colorectal polyps are relatively common, and one chart review found that 58% of

asymptomatic patients aged 50-59 had a colorectal polyp found using colonoscopy.[29] Moreover, the 10-year cumulative risk of cancerous transformation of polyps is 25% (in a 55 year old),[30] and pre-cancerous polyps generally take 10 to 15 years to transform into adenocarcinomas.[31]

Symptoms of colorectal cancer may include weight loss, blood in the stool, fatigue, bowel movement irregularities, and a change in the shape and consistency of stool.[23,24] The presence of these symptoms, or other findings that result in a high index of suspicion of colorectal cancer should prompt an intensive diagnostic work-up, usually consisting of endoscopy followed by the histologic analysis of a colorectal biopsy sample.[31] Treatment options for colorectal cancer are tailored to individual patients, and may include colorectal resection (most common initial treatment modality), potentially followed by chemotherapy, and external radiation beam therapy.[23,24] The prognosis for colorectal cancer is lower than the prognosis for breast or cervical cancer: the five-year age-standardized net survival in Canada is 64%.[1]

2.2 Principles of screening

The goal of screening for a disease is to prevent morbidity and mortality due to that particular disease. Cancer screening is categorized as a type of secondary prevention, meaning that the goal is to identify cancer early in the course of disease (pre-cancerous colorectal polyps) and to afford an opportunity for subsequent interventions to prevent disease progression (e.g. removal of the polyps in a procedure called a polypectomy). In contrast, primary prevention includes interventions in people who do not have the disease in question (chickenpox vaccination for people without prior exposure to varicella zoster virus), while tertiary prevention aims to reduce the impact of disease symptoms on one's life, as in the use of beta blockers post-myocardial infarction.[32]

Organized screening is characterized by a central coordination of screening efforts. This includes screening invitations and follow-up after screening. An example of this is Ontario's Colon Cancer Check program, which launched in 2008. Conversely, in opportunistic screening, there is no centralized coordination of screening, and screening tests are ordered at the discretion of one's physician. Prior to 2008, colorectal cancer

screening in Ontario was done opportunistically. Screening high-risk individuals often involves more frequent screening, and the use of different screening modalities. For example, magnetic resonance imaging is used to supplement mammography in the high-risk Ontario Breast Screening Program, whereas women at average-risk of breast cancer only receive mammography. Lastly, mass screening involves screening of people without regard for risk profiles, an example of which is screening for hypertension in all adults (age>18) at periodic health examinations.

There are several factors that determine whether a screening test will be effective when used in the general public.[33] These factors are known as Wilson's criteria, which consist of the following 10 requirements: 1) the condition should be an important health problem, 2) there should be a treatment for the condition, 3) facilities for diagnosis and treatment should be available, 4) there should be a latent stage of the disease that cannot be detected by means other than screening (i.e. if all colorectal polyps caused symptoms, then all patients with polyps would be worked-up with diagnostic testing, which would negate the need for screening), 5) there should be a reliable test or examination for the condition, 6) the test should be acceptable to the population, 7) the natural history of the disease should be adequately understood, 8) there should be an agreed policy on whom to treat, 9) the total cost of finding a case should be economically balanced in relation to medical expenditure as a whole, and 10) case-finding should be a continuous process in all eligible individuals, and should be actively promoted.

Important operating characteristics of screening tests include sensitivity and specificity. Sensitivity is the probability that the test will be positive in people with the disease being screened, whereas specificity is the probability of a negative test in people without the disease.[32] For screening tests, high test sensitivity will enable clinicians to exclude diagnoses in non-diseased people. Conversely, high test specificity will enable clinicians to confirm diagnoses in people with the disease being investigated. Sensitivity and specificity are inherent characteristics of a test, and do not depend on the prevalence of the disease in the screen-eligible population.

Sometimes false positive and false negative test results occur, and this has serious

implications for patient care.[23] Consequences of a false-positive test result may lead to increased anxiety after receiving a positive test result and undergoing unnecessary diagnostic testing and treatment. Conversely, the implications of a false-negative result may include delayed diagnosis, greater disease progression, and more extensive treatment required for a more advanced disease.

Another important characteristic of screening tests is the number needed to screen (NNS). This measure indicates the number of people who need to be screened in order to prevent a death due to the disease.

2.3 Colorectal cancer testing modalities

There are three main tests used for colorectal cancer screening: FOBT, flexible sigmoidoscopy, and colonoscopy. While recommendations for screening average-risk individuals vary by country, most guidelines recommend an FOBT every 1–2 years, and some recommend flexible sigmoidoscopy every five years or colonoscopy every ten years (recommendations from six organizations are summarized in **Table 1**). These tests are discussed in section 2.3.1 to 2.3.4, and guidelines are discussed in sections 2.4 and 2.5.

2.3.1 Fecal occult blood tests

Colorectal cancer screening tests such as FOBTs are used to detect lesions in the large intestine and rectum.[23,24] FOBT identifies hemoglobin in the stool, which may be present due to ruptured vasculature on the surface of polyps or carcinomas, and a positive finding would be an indication for further investigations to determine whether an individual has any gastrointestinal pathology.[23,24,34] Guaiac FOBTs (gFOBT) can be completed in patients' homes, and involves collecting a series of stool samples and placing them onto the surface of absorbent, guaiac-embedded paper.[34,35] Upon exposure to hydrogen peroxide, the presence of occult blood in the stool will cause the guaiac-paper to turn blue due to the peroxidase activity of hemoglobin.[23,24,34]

The CTFPHC conducted a meta-analysis of four moderate quality RCTs with a combined sample size of 313,180 that showed a significant decrease in colorectal cancer mortality for individuals who were randomized to receive a FOBT vs no screening (RR 0.82 [95%

CI 0.73-0.92]).[23] The CTFPHC also conducted a meta-analysis of two moderate quality RCTs (combined sample size of 220,283) and found a significant decrease in the incidence of late-stage colorectal cancer for individuals who were randomized to receive an FOBT vs no screening (RR 0.92 [95% CI 0.85-0.99]).[23] Additionally, the CTFPHC examined a number of studies and found that the median sensitivity of gFOBT was 47.1%, and the median specificity was 96.1%. For this test, the mean NNS to prevent one death from colorectal cancer is 597.[23] In comparison, for mammography, the mean NNS in women aged 50-59 to prevent one breast cancer death is 1,500, and to prevent one death from melanoma, 25,000 people would need to undergo a whole-body skin check.[36]

There is no direct risk associated with the FOBT given that it is a non-invasive test. However, there is a risk of receiving a false-positive result that could lead to unnecessary invasive procedures, such as colonoscopy or biopsy. Specifically, one study found that after 10 years of annual FOBTs, the probability of having a false-positive result was 23.0% (95% CI 18.2%-27.0%).[37] Dietary and medication restrictions in the 72 hours prior to stool collection for FOBT are important in order to avoid false-positive and false-negative FOBT results. False positives may be increased in patients who consume red meat, turnips, broccoli, cauliflower, and radishes.[38] Food and drinks containing vitamin C should also be avoided in order to avoid false negatives. It is less clear as to whether aspirin should be withheld prior to stool collection to minimize the possibility of a false positive result.[39]

A number of barriers to undergoing FOBTs have been identified in the literature, and these include a fear of handling stool, confusion regarding how to conduct FOBTs, logistical issues surrounding the shipping and storage of stool samples, and the need for follow-up testing if the FOBT yields a positive result.[40]

Related to FOBT is fecal immunochemical testing (FIT), which is an assay that uses an antibody that specifically detects human hemoglobin. FIT is more sensitive and specific than FOBT and does not require any dietary restrictions in the 72 hours before stool collection, unlike FOBT. FIT is also faster to complete than FOBT, as it only requires a single stool collection, whereas FOBT requires stool collection on three separate

occasions.

2.3.2 Flexible sigmoidoscopy

Flexible sigmoidoscopy is a form of lower bowel endoscopy that is used to directly visualize the anus, rectum, sigmoid colon and descending colon (up to the splenic flexure), and may be used to identify lesions and perform biopsies.[5,23] The CTFPHC conducted a meta-analysis of four RCTs to assess the impact of receiving a flexible sigmoidoscopy (versus no screening) on colorectal cancer mortality. The combined sample size of the RCTs was 413,955 and there was a significant decrease in colorectal cancer mortality for those who were randomized to receive a flexible sigmoidoscopy compared to those who were not (RR 0.72 [95% CI 0.65-0.81]), and the NNS was 850.[23] The sensitivity of flexible sigmoidoscopy was estimated to be 40-60%, and the specificity was estimated to be 94%.[41]

Another meta-analysis of three RCTs with a combined sample size of 243,917 examined the impact of flexible sigmoidoscopy (compared with no screening) on the incidence of late-stage colorectal cancer and found a significant decrease in the incidence of late-stage colorectal cancer for individuals who received a flexible sigmoidoscopy compared to those who did not (RR 0.75 [95% CI 0.66-0.86]); the NNS was 577.[23]

Possible complications of flexible sigmoidoscopy include bleeding, perforation of the rectum or large intestine, and the risk of having an adverse reaction to sedatives.[23,42] Studies have noted that barriers to undergoing flexible sigmoidoscopy include the fear of being awake during the procedure, the dissatisfaction with only examining the distal colon, the invasiveness of the procedure, and the burden of achieving satisfactory bowel preparation.[40,43]

2.3.3 Colonoscopy

Colonoscopy is a form of lower bowel endoscopy that is used to directly visualize the anus, rectum, sigmoid colon, descending colon, transverse colon, ascending colon, cecum, and terminal ileum.[23,44] Performed by either a gastroenterologist or a general surgeon, the procedure typically involves sedating a patient, followed by inserting a

several-foot-long endoscope through the anus, and through the lumen of the rectum and large bowel. Endoscopists may also elect to inspect the terminal ileum in selected cases, namely in Crohn's disease, microscopic colitis, chronic diarrhea, and lower gastrointestinal bleeding. For experienced endoscopists, the anus-to-cecum time ranges from 7 to 20 minutes, and the withdrawal time (an important quality indicator) is approximately 7 minutes.[44]

Endoscopists may also perform biopsies of intestinal mucosa for the diagnosis of colorectal pathologies, and grading of biopsied carcinoma tissue may then be performed.[44] During these biopsy procedures, the endoscopist may also perform a polypectomy, and may use India ink staining to mark the location of lesions. In case of lower gastrointestinal bleeding, colonoscopy is an important therapeutic modality that can be used to achieve hemostasis: submucosal epinephrine injection, clipping, cauterization and band ligation therapy are possible endoscopic therapeutic options.

Both screening and diagnostic indications exist for colonoscopy.[23,44] It may be used for colorectal cancer screening in eligible asymptomatic individuals, but is also commonly employed for the diagnostic work-up of symptoms like gastrointestinal bleeding, constipation, diarrhea, unexplained fatigue, all of which could be symptoms of serious underlying gastrointestinal pathology. It is important to emphasize that screening colonoscopies require adequate bowel cleansing, with the use of hyperosmotic agents such as polyethylene glycol to adequately visualize the intestinal mucosa.[45]

Although colonoscopy has the potential to provide clinical benefit, its exact efficacy in relation to FOBT and flexible sigmoidoscopy has not yet been determined through RCTs. This is particularly important considering that wait times for colonoscopy have increased over time, and considering the high resource burden of performing colonoscopies in terms of personnel (gastroenterologists, nurses, anesthesiologists, general surgeons), endoscopy suite availability, equipment and maintenance costs.[2,46] Indeed, the lack of RCT evidence was a critical factor in the CTFPHC's recommendation that colonoscopy should not be used as a primary screening test for colorectal cancer.[2]

Due to the lack of RCTs comparing colonoscopy to FOBT or flexible sigmoidoscopy, the

next best study designs to evaluate colonoscopy efficacy are the prospective cohort study and meta-analyses of observational studies. A prospective cohort study that helped form the basis of the USPSTF recommendation that colonoscopy can be used as a first-line screening test followed 88,902 women over a period of 22 years.[47] This long follow-up time is important, given that it takes an average lag time of 10 years for a precursor lesion to transform into cancer. A significant decrease in colorectal cancer mortality was observed in people who underwent colonoscopy compared to people who did not (HR, 0.32 [95% CI, 0.24 to 0.44]). As with all cohort studies, there may have been unmeasured confounders present, including income, education level, and use of over-the counter medications (such as aspirin), hormone therapy, unknown family history of colorectal cancer or hereditary polyposis syndromes.[48] The USPSTF judged that it remains unclear whether the mortality benefit resulted from a single colonoscopy, or from multiple colonoscopies, or from screening and surveillance colonoscopies.[49] It is also unclear as to how frequently people should be undergoing colonoscopy in order to attain a benefit.

A meta-analysis assessing colonoscopy versus no screening involved 19 studies and included a total of 2,858,087 participants. Colonoscopy resulted in a 61% reduction in colorectal cancer mortality (RR 0.39; 95% CI, 0.31-0.50) and resulted in a greater mortality benefit than FOBT and flexible sigmoidoscopy.[50] The sensitivity and specificity of colonoscopy for detecting adenomas approaches 100%.[51]

Colonoscopy carries a greater degree of risk than flexible sigmoidoscopy. The risk of intestinal perforation is 0.061% (vs 0.001% for flexible sigmoidoscopy), minor bleeding (0.27% vs 0.05%), major bleeding (0.11% vs 0.009%), and death (0.035% vs 0.015%).[23] However, the risk of colonoscopy may be lower when performed for screening indications in average-risk individuals, since there may be a greater risk of intestinal perforation in people with intestinal diseases, such as in Crohn’s disease and ulcerative colitis.[52]

2.3.4 Other colorectal cancer screening modalities

Computed tomography (CT) colonography is a technology that some patients may elect to undergo after consultation with their physician. Benefits of CT colonography include:

non-invasiveness, avoidance of sedation, and no driving restrictions after the procedure.[23] Its efficacy has not been fully characterized, and the risks of extra-colonic CT findings (i.e. overdiagnosis) are not yet completely understood, as it is a relatively new screening technology and is not widely available.[49] However, quinquennial CT colonography is currently recommended by the USPSTF.[49]

No clear mortality benefit was found in one systematic review for barium enemas, digital rectal examinations, serologic tests, or fecal DNA testing or other tests.[23]

2.4 Canadian Task Force on Preventive Health Care recommendations

The CTFPHC is an independent group of physicians and scientists who develop various preventive health guidelines. The task force indicates the quality of evidence (high, medium, low) that informs their recommendations, based on factors such as randomization procedure, limitations, and the size of the confidence interval of studies identified in systematic reviews.

The CTFPHC indicates the strength of each of its recommendations (strong vs weak). The strength of the recommendation is based on weighing the benefits vs harms, the range of values and preferences of patients, and the resource requirements of the recommendation.

The 2001 CTFPHC colorectal cancer screening guidelines are applicable for people who are at average-risk of colorectal cancer, and the Task Force made the following recommendations: 1) There is good evidence to screen asymptomatic individuals age 50 or older with annual or biennial FOBTs.[5] 2) There is fair evidence to screen asymptomatic individuals age 50 or older with flexible sigmoidoscopy in the periodic health examination. There was no specific suggested screening frequency for flexible sigmoidoscopy.[5]

In 2016, the CTFPHC updated their recommendations based on changes in screening technology and practice since 2001: 1) adults aged 50 to 59 should be screened with FOBT every two years or with flexible sigmoidoscopy every 10 years (weak

recommendation, moderate-quality evidence); 2) adults aged 60 to 74 should be screened with FOBT every two years or with flexible sigmoidoscopy every 10 years (strong recommendation; moderate-quality evidence); 3) adults aged 75 and older should not be screened for colorectal cancer (weak recommendation; low-quality evidence); 4) colonoscopy should not be used as a screening test for colorectal cancer (weak recommendation; low-quality evidence).[2] These recommendations only apply to individuals who are at average-risk for colorectal cancer i.e. not applicable for people with a prior diagnosis of colorectal cancer or polyps, Crohn's disease or ulcerative colitis, signs or symptoms of colorectal cancer, or a family history of colorectal cancer in one or more first-degree relatives.

Despite the lack of randomized trial evidence, the USPSTF recommended screening for adults 50 to 70 years of age with FOBT, sigmoidoscopy, or colonoscopy, which may in part reflect them putting a lower value on the lack of direct RCT evidence for colonoscopy, and on the potential for the benefits of colonoscopy to outweigh its harms.[49] This is in contrast to the CTFPHC guidelines, which places a higher value on the lack of RCT evidence for colonoscopy, and thus did not recommend colonoscopy as a first-line screening test. Additionally, Cancer Care Ontario indicated that colonoscopy may be used for the screening of people at increased risk of colorectal cancer, and for people who are unaware of whether they have a family history of colorectal cancer.[6] However, it is important to note that the CTFPHC made a weak recommendation regarding colonoscopy, meaning that patient values and preferences must be emphasized during the screening decision-making process.

2.5 Colorectal cancer screening in Ontario

Prior to April 2008, colorectal cancer screening in Ontario was opportunistic (since there was no organized, provincial screening program), and the responsibility for patient education and implementation of screening was primarily held by family physicians, who would recommend screening during patient visits, along with specialist support for colonoscopy screening and follow-up when necessary. Since April 2008, Ontario's Colon Cancer Check program has provided population-based, organized colorectal cancer screening for eligible Ontarians.[22] The launch of Colon Cancer Check was done in

conjunction with an intense public media campaign, pay-for-performance incentives for physicians, as well as physician-specific education regarding the Colon Cancer Check program and evidence supporting the use of primary FOBT for population-based screening.[17,22] People can access the Colon Cancer Check program through their primary care physician, as it is a provider-led program. For individuals who are not rostered to a family medicine practice, FOBT kits can be obtained from community laboratories in Ontario, and the Colon Cancer Check program will link these unrostered individuals to a family physician for test interpretation and follow-up.[22] To be eligible for participation in Colon Cancer Check's average-risk screening program, individuals must be ages 50 to 74, not have a first-degree relative diagnosed with colorectal cancer, and not have a history of colorectal polyps or inflammatory bowel disease.[22] The Colon Cancer Check recommends biennial FOBT, and flexible sigmoidoscopy every 10 years, but there was not sufficient evidence in the literature to recommend colonoscopy as a first-line screening test (apart from people who do not know whether they are at increased risk by virtue of having a family history, or in people with established risk factors for colorectal cancer). Despite not recommending colonoscopy for average-risk screening, it has been estimated that there are at least 67,000 colonoscopies performed in Ontario each year.[53]

As of 2003, approximately 15% of eligible Ontarians were compliant with biennial FOBT, and that number has increased to approximately 30% as of 2012.[22,54] Despite this increasing trend in FOBT participation, uptake has remained markedly lower than the provincial minimum target of 36%,[22] and the rate of increase in participation plateaued following the introduction of the Colon Cancer Check program.[18] Additionally, in composite analyses performed in the year 2014 of FOBT, flexible sigmoidoscopy and colonoscopy, approximately 40% of average-risk Ontarians (1.6 million people) were overdue for colorectal cancer screening.[55]

Factors associated with decreased colorectal cancer screening compliance among screen-eligible people in the general Ontario population include: an age of 50 to 54 (versus 70 to 74), living in rural or very remote regions (versus urban regions), and residing in a neighborhood with a lower income quintile (versus higher neighborhood income quintile).[22]

2.6 Physician attitudes, beliefs and preferences regarding colorectal cancer screening

Existing studies provide valuable insight into physicians' beliefs and preferences about colorectal cancer screening. However, most of these studies are cross-sectional surveys, consisting of self-reported data that are subject to recall and social desirability biases. Most of these studies also do not have a comparator group of non-physicians in which to put the results into context.[56,57]. Notwithstanding those potential limitations, these studies suggest that most physicians (76%) support colorectal cancer screening and believe it is an important component of preventive health care.[58]

A recent qualitative study conducted in 2012 surveyed 65 family physicians in Ontario and found that physicians strongly favored colonoscopy over FOBT for average-risk individuals.[59] Comments from physicians included:

> "In my opinion, the fecal occult blood has failed me many times…I continue to use it…for…completeness…but for the most part I recommend…colonoscopy."
>
> "With colonoscopies being so easy to perform and so accurate and so safe, I never had a mishap. I prefer…that route…no false positives and basically no false negatives."
>
> "To me, the frustration is some patients who feel it's [the FOBT kit]…a dirty thing to do and they don't want to do it."

Physicians preferences for screening patients

In Alberta, 70% of 187 specialists who were surveyed indicated that they recommend colonoscopy for average-risk patients, 47% recommend flexible sigmoidoscopy, and 65% recommend FOBT (some physicians recommended more than one screening modality).[60] Given that 65% of physicians recommended FOBT for their patients, and yet only 16% of physicians would undergo only FOBT for their own screening,[60] some physicians may believe that FOBT is acceptable for the general population, but not for themselves.

Further, in a survey of 965 Albertan family doctors conducted in 2002, only 9.4% of respondents thought that FOBT was an excellent or very good screening test, and 19.2% rated it as a poor test.[61] Additionally, 88.2% of physicians reported that the sensitivity and specificity of FOBT is an important barrier that prevents them from recommending FOBT to their patients.

In a survey of 563 family doctors and specialists in Calgary, only 58% of physicians recommend colorectal cancer screening (with any screening modality) for age-eligible patients who present to the clinic without a family history of colorectal cancer.[62]

Physicians preferences for their own screening

A survey of 187 specialist physicians in Alberta, 70% of whom indicated that they would never undergo any colorectal cancer screening other than colonoscopy.[60]

Aligning with other studies,[14,60] 64.1% of 965 surveyed Albertan family doctors indicated that they prefer colonoscopy for their own screening.[61]

A lack of physician support for FOBT and their personal preference for invasive highly sensitive tests has also been observed in Ontario. A cross-sectional survey of 465 family doctors in Ontario showed that 50.8% of respondents preferred colonoscopy once every 10 years for their own colorectal cancer screening, while 39.6% preferred biennial FOBT, and 0.4% preferred flexible sigmoidoscopy once every five years.[14] In addition, 54.4% of physicians believed that colonoscopy was associated with the greatest decrease in mortality relative to all other colorectal cancer screening modalities. This study also found that when physicians believe FOBT to be highly sensitive, they are more likely to prefer FOBT versus colonoscopy for their own screening.

A study of 1,121 Canadian specialist physicians showed that among physicians who did not receive colorectal cancer screening, 14% of them believed that there was not enough data to warrant colorectal cancer screening using any screening modality. However, the most commonly cited barrier to screening (49%) was lack of time.[15]

2.7 Factors associated with cancer screening

2.7.1 Age

Older age is a recognized correlate of higher colorectal cancer screening uptake in both physicians and non-physicians. One cross-sectional survey of Canadian specialist physicians showed that the proportion of physicians who received FOBTs increased from 25% for doctors aged 50 to 64, to 30% for those aged 65 or older.[15] These findings were corroborated in a study of 138 family physicians in southern Israel who exhibited more than a 4-fold increase in FOBT screening for physicians over age 50, compared to those younger than 50.[65] These findings are also consistent with population-based data from Ontario indicating that older individuals are more likely to be compliant with FOBT recommendations compared to younger individuals.[16]

2.7.2 Sex

Numerous studies have shown that females are more likely than males to participate in colorectal cancer screening, both among physicians and the general public. Qualitative research suggests that men appear to be less knowledgeable about colorectal cancer screening than women.[40] As well, men commonly cite that a key barrier to undergoing lower bowel endoscopy is the threat that procedure poses to their sense of masculinity.[66] However, this psychosexual barrier would not necessarily apply to FOBT, and unlike males in the general population, we do not expect male physicians to have low knowledge about colorectal cancer screening.

One cross-sectional survey of Canadian physicians showed that 37% of females chose FOBT as a first-line screening test, compared to only 26% of males.[15] This difference in colorectal cancer screening compliance appeared to be less pronounced in the general Ontario population, as one study showed that in 2011, 42.9% of screen-eligible females were up-to-date with colorectal cancer screening, compared to 39.5% of males.[18] More recent data from 2014 show that a greater proportion of screen-eligible men in Ontario were overdue for colorectal cancer screening compared to women (43% vs 37%, respectively).[16]

In one study, patients of female physicians were 1.37 times more likely to participate in

colorectal cancer screening compared to patients of male physicians.[67]

2.7.3 Income level

It has been demonstrated that higher-income individuals are more likely to be compliant with cancer screening compared to lower-income individuals. In Ontario, from 2005 to 2011, screening in the general population increased in each income quintile, but the difference in colorectal cancer screening in the highest versus lowest income quintiles also increased.[18] In 2011, approximately 10% more screen-eligible Ontarians in the highest income quintile underwent colorectal cancer screening compared to people in the lowest income quintile.[18]

The potential association between income and cancer screening compliance in physicians has not been thoroughly examined, presumably in part due to a lack of access to information regarding physician compensation in most jurisdictions, as well as an assumption that most physicians have a high after-tax income. However, this assumption is likely not uniformly true, particularly among salaried residents and fellows, and among physicians who work part-time.

2.7.4 Residential status

Residential status provides information regarding geographic disparities in access to cancer screening. This is particularly important given that Ontario has a large geographical area. To operationalize residential status, studies from Ontario generally dichotomize geographic location into rural (less than 10,000 people in a given municipality) versus urban,[68] and some studies use the rurality index measure which accounts for the distance to healthcare facilities.[69]

Analyses from Ontario show that a higher proportion of screened individuals live in urban, compared to rural or remote regions, although in some analyses this difference is marginal.[16] One study showed that among average-risk Ontarians aged 50-74, screening participation was similar in people living in rural versus residential areas for FOBT (14.7% versus 15%, respectively), and for the composite of two-year FOBT participation, or five-year large bowel endoscopy (flexible sigmoidoscopy or colonoscopy)

participation (rural 40.2% versus 41.7%, respectively).[18] These results suggest that there may not be a clear geographic disparity among the general Ontario population with respect to accessing FOBT or large bowel endoscopy. Studies examining the potential association between screening and residential status in physicians are lacking.

2.7.5 Foreign medical graduate status

Physicians who have trained and practiced in foreign countries have exposure to health care systems that may use cancer screening protocols that differ from CTFPHC guidelines, and this may influence their own cancer screening behaviors, and how they counsel patients.[70,71] In some regions of the world, a lack of health care infrastructure and inadequate financial resources are important barriers that may contribute to low screening in the general population, as well as minimal physician experience using modern screening technologies.[70,72]

Although prior work has shown that physicians practicing in Canada who graduated from medical school in the Middle East or South Asia are much less likely to screen their patients for colorectal cancer relative to Canadian medical school graduates,[67] there is no single study that clearly addresses the potential association between physicians' personal cancer screening behaviors and their country of medical school graduation.

2.7.6 Physician specialty

Specialty-specific guidelines can influence physicians' attitudes and practices regarding cancer screening.[12] One study of Canadian specialists demonstrated inter-specialty variability in cancer screening behaviors: 41% of psychiatrists versus 28% of radiologists selected FOBT for their colorectal cancer screening.[15] In contrast, among gastroenterologists (who have expert knowledge in colorectal cancer screening, diagnosis and treatment) only 5% chose to undergo FOBT, while 91% of them preferred higher-sensitivity screening methods like colonoscopy, despite the increased time requirement and invasive nature of colonoscopy versus FOBT.

Another study of physicians in the United States suggested that family physicians and general internal medicine physicians were more likely to recommend colorectal cancer

screening for their patients than physicians in other specialties, suggesting that there may be a differential focus on prevention between specialties.[73] Additional quantitative and qualitative studies are needed to fully understand the nature of these inter-specialty differences.

2.7.7 Accessing general medical care

Accessing physician services more frequently increases one's opportunity to engage in preventive health behaviors, including secondary cancer prevention. A study of 12,776 individuals used data from the Canadian Community Health Survey and found that compared to people who did not access physician services in the year before the survey, people who had one to two physician contacts in the year preceding the survey were significantly more likely to undergo colorectal cancer screening (OR 1.97 [95% CI, 1.56–2.48]).[74] Having regular primary care physician visits are especially important in the case of provider-led screening programs such as the Ontario Cervical Screening Program, since the only way to receive Pap testing is directly from a physician, whereas FOBTs may be obtained from community pharmacies across Ontario.

2.8 The influence of physicians' screening behavior on screening uptake in their patients

It has been shown that patients are more likely to undergo screening if their physician undergoes screening themselves. This includes not only colorectal cancer screening; it extends to mammography, pneumococcal and influenza vaccination, and hypertension screening.[19] For instance, in a cross-sectional study of 1,488 primary care physicians in Israel and their 1,886,791 patients, analysis of administrative data showed that 50% of patients underwent colorectal cancer screening if their physician underwent colorectal cancer screening, versus 45.6% for patients of unscreened physicians.[19]

It has even been suggested that patients of female physicians are more likely to undergo colorectal, breast, and cervical screening compared to patients of male physicians.[19,67] Additionally, patients of Canadian medical school graduates are more likely to undergo colorectal cancer screening compared to patients of non-Canadian medical school

graduates.[67]

This small but important body of research underscores a fundamental principle: physicians who take care of their own health may have more credibility when advising patients if they disclose their screening status to their patients, and may develop better patient relationships, which can result in more active patient participation in cancer screening. When physicians lead from the front in preventive health care, not only does it improve their own health; their patients benefit too.

2.9 Conclusion

The burden of colorectal cancer is substantial, and yet despite physicians' self-reported support for cancer screening, population-level cancer screening participation remains suboptimal, given that 39% of eligible Ontarians were overdue for screening as of 2015. Furthermore, surveys of physicians' personal cancer screening behaviors show variable results, and are subject to recall and social desirability biases. There is also evidence that factors such as older age, female sex, higher income quintile, urban residential status, graduation from a Canadian medical school, and higher frequency of physician visits may be associated with a higher rate of cancer screening behaviors. Medical specialty may also influence cancer screening rates (varies by specialty and by screening test, as described above). The aforementioned factors have not been extensively evaluated in physicians using health administrative databases.

Chapter 3

3 Rationale and research objectives

3.1 The need for research

There are several important limitations in existing literature on physicians' colorectal cancer screening behaviors. To date, there has not been an analysis of North American physicians' cancer screening behaviors that leverages health administrative databases. Prior studies primarily consist of surveys that rely on self-reported information,[14,15,20,75] and therefore are subject to recall and social desirability biases. Many of these studies have small sample sizes, focussed on limited geographic areas, or did not specifically evaluate screening among average-risk physicians. Additionally, these studies have shown variable physician support for different screening modalities. Given that physicians are uniquely positioned to positively influence colorectal cancer screening in their patients, the aforementioned limitations and findings of prior studies warrants an examination of physicians' uptake of colorectal tests using health administrative databases. It is also interesting to note that physician support for other screening tests, like Pap smears for cervical cancer and mammography for breast cancer, is more uniformly high compared to support for different colorectal cancer screening modalities. This further strengthens our rationale for studying colorectal cancer screening among physicians.

3.2 Research questions and hypotheses

3.2.1 Primary research question

What is the uptake of colorectal tests (FOBT, flexible sigmoidoscopy, colonoscopy) in physicians compared to matched non-physicians in Ontario?

Hypothesis: Uptake of colorectal tests will be greater in physicians compared with non-physicians, although a substantial proportion of both physicians and non-physicians will be up-to-date with their testing. Physicians will be less likely to undergo FOBT than non-physicians, and will be more likely to undergo large bowel endoscopy.

3.2.2 Secondary research questions

1) Which physician-level factors are associated with colorectal test uptake?

Hypothesis: Physicians with the following characteristics will be more likely to undergo colorectal testing: older age; females (versus males); specializing in general surgery or gastroenterology (versus family medicine); graduating from a Canadian medical school (versus graduating from a non-Canadian medical school); living in an urban residential area (versus a rural area); being in a higher income quintile (versus a lower income quintile); and accessing care from a primary care physician in the year before the observation window (versus not having accessed care from a family doctor in the year before the observation window).

2) Are screen-eligible patients more likely to undergo colorectal testing if their primary care physician undergoes testing?

Hypothesis: Patients are more likely to be tested if their primary care physician was also tested.

To answer these questions, we conducted a population-based study using administrative healthcare data. We examined uptake of colorectal tests as a proxy for colorectal cancer screening in physicians and matched non-physicians. We assessed which physician level factors are associated with colorectal test uptake. We further examined whether patients were more likely to be tested if their primary care physician was tested.

Chapter 4

4 Methods

4.1 Study design and setting

We conducted a population-based, cross-sectional study using the anonymized administrative databases held at the Institute for Clinical Evaluative Sciences (ICES) in Ontario, Canada. Ontario has the largest population of all provinces and territories, with approximately 13.4 million people as of 2016, 5.4 million of whom were 50 to 74 years old. Emigration out of Ontario is less than 1% per year.[76] Ontario has a universal, single-payer healthcare system, which provides coverage for medically necessary physician and lab services, including screening for colorectal, breast and cervical cancer.

The study was done according to an established protocol approved by the Health Science Research Ethics Board at The University of Western Ontario (London, Canada) (**Appendix A**). Participant informed consent was not required since ICES is a prescribed entity for the purposes of section 45 of Ontario's Personal Health Information Privacy Act. This research described in this thesis was conducted and reported according to REporting of studies Conducted using Observational Routinely-collected health Data (RECORD) guidelines (**Appendix B**).[77]

4.2 Timeframe

Exposure status (physician vs. non-physician) and outcomes were ascertained on the index date of April 21, 2016, as we had information on physicians' CPSO registration status as of this date. In accordance with CTFPHC and Cancer Care Ontario recommendations, as well as other analyses of cancer screening in Canada,[2,5,18,35] the observation windows during which outcomes were evaluated extended up to two years before the index date for FOBT, five years before the index date for flexible sigmoidoscopy, and ten years before the index date for colonoscopy. Baseline characteristics and healthcare utilization for physicians and non-physicians were evaluated within the five years before the index date (see **Table 2a** and **Table 2b** for details).

4.3 Data sources

Administrative databases allow for the investigation of clinical questions using population-based data.[78] This study used six data holdings at ICES to evaluate baseline characteristics, exclusion criteria, covariates and colorectal test uptake. These databases were linked using unique encoded identifiers (ICES Key Numbers) at ICES.

The Registered Persons Database (RPDB) contains demographic and vital status data for every Ontario resident who has ever been issued a health card number, not including refugee claimants and certain classes of non-immigrants. The RPDB is updated bimonthly after ICES receives information from Ontario's Ministry of Health and Long Term Care. We used the RPDB to ascertain age, sex, postal code, and vital status information, and the date of last contact with Ontario's health care system. Postal codes are linkable to other geographic data such as dissemination area, which can be linked to census-derived, neighborhood-level data. The dissemination area is the smallest geographic area (approximately 400 to 700 people) for which census data relevant to our study were made available. ICES has dissemination area-level information on residential status and neighborhood income quintile. Quintiles are created for each census metropolitan area, census agglomeration, or residual area before being aggregated to the provincial level. The exact financial values of each quintile varies between dissemination areas, and those values are not made available during the analytic process.

Average after-tax incomes were used to rank dissemination areas within each census metropolitan area, census agglomeration and provincial residual area, and the distribution of these neighborhood incomes was used to create income quintiles.[79] The Postal Code Conversion File was used to assign individuals to neighborhood income quintiles by linking census postal codes to dissemination areas.[79]

Rural or urban residence was also assigned using the Postal Code Conversion File, and was based on whether people lived in towns and municipalities outside the commuting zones of large urban centers (i.e. outside the commuting zone of centres with a population of 10,000 or more).[80]

We used the Ontario Cancer Registry to ascertain prior cancer diagnoses. The Ontario Cancer Registry contains information on all Ontario residents who received a cancer diagnosis since 1964, and it captures over 95% of cancer diagnoses in the province, but does not include non-melanoma skin cancers. Approximately 400,000 records containing patient demographic, cancer diagnosis and mortality information are added to the Ontario Cancer Registry annually, and this data comes from: hospital discharge and day surgery summaries that include a diagnosis of cancer; pathology reports with any mention of cancer; records of patients referred to one of Cancer Care Ontario's eight regional cancer centres in Ontario; and death certificates that list cancer as the underlying cause of death.

The CIHI-DAD contains summarized hospital discharge information for patient-level demographic (age, sex, postal code) administrative (dates and length of stay, institution number) and clinical data (diagnoses, procedures) for all individuals hospitalized in Ontario since 1988, including up to 25 unique diagnosis codes per hospitalization (post-2002). This includes people who were discharged, died, transferred, or signed out of acute, chronic, rehabilitation, and day surgery institutions in Ontario, and does not include inpatient care in designated psychiatry beds. The diagnosis codes are from the International Classification of Diseases, 9th revision (ICD-9, and the Canadian Classification of Diagnostic, Therapeutic, and Surgical Procedures-CCP; pre-April 2002) and the 10th revision (ICD-10, and the Classification of Health Interventions-CCI; post-April 2002). CIHI-DAD codes were used to assess baseline characteristics and were used for cohort construction.

The ICES Physician Database comprises information on physician demographics in Ontario, and was used to ascertain information on country of medical school graduation, year of medical school graduation, field of specialization. The IPDB incorporates information provided by the Ontario Physician Human Resource Data Centre (which conducts annual telephone surveys of Ontario's physicians), the Corporate Provider database, and the Ontario Health Insurance Plan (OHIP) database of physician billings.

The OHIP database includes claims for inpatient, outpatient and long-term care physician and laboratory services that were billed in Ontario since 1991. OHIP records identify the

physician, patient, diagnosis responsible for the claim, services provided, and the date of the service. We evaluated OHIP fee codes to evaluate colorectal test uptake and other procedures, as well as OHIP diagnostic codes to evaluate exclusion criteria and baseline comorbidities.

The National Ambulatory Care Reporting System contains data on patient visits to emergency departments. Each record contains patient identifiers, the date of the visit, and clinical information.

Additionally, ICES entered into a Data Sharing Agreement with the CPSO, enabling the transfer of a dataset from the CPSO to ICES, providing us with a list of publicly available information on physicians who were active members of the CPSO as of April 21, 2016. The three data elements included in this dataset were physicians' first name, last name and CPSO number.

Given that some administrative databases held at ICES were not originally designed for research applications, their data must be analyzed cautiously, and the research question must be specified accordingly. In order to ensure results from database studies are sound, it has been recommended that robust descriptions of data tables are provided, that diagnostic/procedural codes used are validated whenever possible, and that differentiation is made between clinical versus statistical significance.[78]

4.4 Study population

We established a cohort of physicians and non-physicians who were residing in Ontario, Canada as of April 21, 2016. People were classified as physicians if they were active members of the CPSO on the index date, as this was the most recent date of active membership for the physicians (the linkage procedure is described in Section 4.5). This list of active members includes physicians with independent and restricted licenses, as well as residents/fellows who have a post-graduate education license. Everyone else residing in Ontario who was not an active member of the CPSO on April 21, 2016 was classified as a non-physician.

Before matching, we excluded people whose RPDB record had missing or invalid personal identifiers, individuals who died on or before the study entry date, and people who were not a resident in Ontario, which was defined as the absence of a health care record in the databases between 2009 and 2016 (a definition consistent with prior ICES studies).[18] We then restricted the cohort of physicians and non-physicians to people ages 52 to 74 as of the index date, to ensure that individuals had at least two years in the age-eligible observation window, in accordance with guidelines.[2,5,81] In order to approximate an average-risk cohort, and to align with guidelines and prior studies,[2,5,18,35,67,81] we excluded individuals with a prior diagnosis of invasive colorectal cancer or anal cancer, inflammatory bowel disease, large bowel/rectal resections, or colectomy (**Figure 1a**). These individuals are more likely to be undergoing FOBT, flexible sigmoidoscopy and colonoscopy for surveillance of ongoing disease, and/or for the investigation of gastrointestinal symptoms, which falls outside the purview of average-risk colorectal cancer screening.

4.5 Linkage procedure

Datasets were linked at ICES using unique, anonymized identifiers. Physicians' first and last names, CPSO number, and registration status are publicly available on the CPSO website, however, a complete list of physicians is not easily obtainable. Therefore, the CPSO provided to ICES a list of first and last names of all active members as of April 21, 2016, as well as their CPSO number. Physicians were linked probabilistically to RPDB using their first and last names, enabling linkage to other ICES data holdings using ICES Key Numbers. Of the 37,125 physicians on the CPSO list, 29,802 (80.3%) were linked to records in the ICES databases. Then the CPSO number was linked to IPDB to obtain certain physician-specific characteristics.

4.6 Matching

We greedy matched physicians to non-physicians without replacement using a 1:4 ratio on the basis of age as of April 21, 2016 ($\pm$ 2 years), sex, and Forward Sortation Area (first three digits of postal codes-average population size 8,000) which accounts for both socioeconomic status and region of residence. These factors have been used to match

physicians and non-physicians studies of cancer screening.[82] Using SAS, two types of matching methods were considered for this analysis, greedy matching and optimal matching. In greedy matching, a set of cases is matched to a set of controls, and once a match is made, the match is not reconsidered, and the match is the closest match available. Conversely, in optimal matching, previous matches are considered before making each match. Greedy matching was chosen since it is more efficient to run compared with optimal matching, and optimal matching does not perform better in terms of balancing characteristics between groups.[83]

Unmatched individuals were excluded from the primary analysis. A matching ratio of 1:4 was used in order to optimize statistical power; ratios greater than 1:4 do not result in further increases in statistical power.[84] Each non-physician served as a control for no more than one physician, and a unique identification value was assigned to each matched group.

4.7 Selection of primary care physicians and their patients

To determine which non-physicians were patients of primary care physicians, OHIP claims from all primary care physicians in the unmatched cohort were reviewed in the three-year period before April 21, 2016 (**Figure 1b**). The primary care physician who submitted the most claims for a particular non-physician (i.e. patient) was defined as that patient's primary care physician. This facilitated an additional analysis where we determined whether physicians' uptake of colorectal tests was associated with test uptake in their patients. Primary care physicians were selected for this analysis since they have primary responsibility for the front-line implementation of the Colon Cancer Check program.

4.8 Outcomes

The primary outcome of colorectal test uptake was defined as a binary variable at the individual level in physicians and non-physicians. In accordance with the 2001 CTFPHC recommendations that were in effect during the study period,[5] and for consistency with

prior reports from Cancer Care Ontario and other studies,[18,35] test uptake was assessed by looking for a record of any of the following as of April 21, 2016: i) FOBT in the past two years, ii) flexible sigmoidoscopy in the past five years, or iii) colonoscopy in the past 10 years. FOBT, flexible sigmoidoscopy and colonoscopy were evaluated as a composite outcome, and individually.

Colorectal test uptake was evaluated using OHIP claims codes (**Appendix C**). Approximately 95% of physicians in Ontario submit claims to OHIP within the fee-for-service system. An algorithm of claims codes was used to evaluate colorectal test uptake.[85] The sensitivity and positive predictive value of procedure claims codes, such as those used for colonoscopy, have been demonstrated to be high (up to 98.6% sensitivity and 96.5% specificity for colonoscopy).[86] Although not every code used in our algorithm has been formally validated, they are all expected to have high sensitivity and specificity, similar to other fee-for-service codes.[87] The codes were also selected based on the clinical expertise of cancer screening experts, and an understanding of colorectal cancer screening billing practices. Furthermore, although there is some variation in the literature regarding algorithms used to define colorectal test uptake,[18,35,88] we used a more comprehensive algorithm compared to some prior analyses in order to achieve higher sensitivity.

People who are not rostered to a family medicine practice may receive FOBT kits at community pharmacies, and in order to capture this we also assessed laboratory-submitted claims codes. It is likely that many primary care physicians have FOBT kits in their office stock, which they could potentially access for personal use. However, clinical expertise and discussions with primary care physicians and specialists suggests that most would still submit the test for analysis and interpretation (captured in our algorithm), and a positive FOBT would likely lead to an endoscopy procedure (also captured in our algorithm).

4.9 Statistical analyses

After matching, we assessed the distribution of baseline characteristics (see **Table 2a** and **Table 2b** for details) between physicians and non-physicians using standardized

differences, since this metric is less sensitive to a large sample size than traditional hypothesis tests.[89] Standardized differences describe differences between group means relative to the pooled standard deviation (values greater than 10% represent a meaningful difference between physicians and non-physicians). We expressed continuous variables as medians and interquartile ranges due to the potential for skewed distributions and categorical variables as proportions.

Prevalence ratios and prevalence differences were used to compare uptake of colorectal tests between physicians and non-physicians. Modified Poisson regression was used to calculate prevalence ratios and their 95% confidence intervals, which was favored over logistic regression because odds ratios tend to overstate the prevalence ratio in cross-sectional studies.[90] Prevalence differences and their 95% confidence intervals were calculated using binomial regression models with an identity link function. Generalized estimating equations were used to account for the correlation structure within matched sets.

An interaction term was used to evaluate potential differences in prevalence ratios by sex, and by age group (52-59, 60-69, 70-74 years), since existing literature demonstrates that testing is more likely in older age categories, and in women versus men.[18]

Multivariable regression models were adjusted for the following pre-specified covariates, measured as of April 21, 2016, and chosen based on consultation with cancer screening experts and/or because in previous studies they were shown to be correlates of colorectal test uptake: age (52-59, 60-69, 70-74), sex, urban vs. rural residential status (rural defined as a population <10,000), neighborhood-income quintile, physician specialty (13 categories), country of medical school graduation (Canadian vs. elsewhere), and the number of primary care physician visits in the five years before the index date (0, 1-2, 3-4, >5).[18,35,74]

The association between uptake of colorectal tests in primary care physicians and their patients was examined using a modified Poisson regression model, using generalized estimating equations to account for the correlation structure within primary care physicians. Models were adjusted for the following patient-level variables: age, sex,

rurality, neighborhood-income quintile, and the number of primary care visits in the five years before the index date.

For all analyses we interpreted two-tailed p-values less than 0.05 as statistically significant. All statistical analyses were conducted using SAS version 9.3 (SAS Institute, Cary, North Carolina).

4.10 Missing data

Data were near-complete for all variables in this study. Due to the small amount of missing data, and in the absence of any reason to suspect that the data were missing systematically, single imputation was used. Variables were imputed as the mode value when missing. Residential status was imputed as urban for <0.5% of physicians and non-physicians. Country of medical school graduation was imputed as Canada for 1% of physicians. Physician specialty was imputed as primary care physician for 1% of physicians. Information on all other variables was complete.

Chapter 5

5 Results

5.1 Baseline characteristics

After the exclusions were applied (**Figure 1a** and **Figure 1b**), 11,447 physicians and 3,524,725 non-physicians remained in the cohort. After matching, we retained 11,434 physicians and 45,736 non-physicians. The distribution of baseline characteristics between physicians and non-physicians was relatively consistent after matching. The median age of physicians on the index date was identical in non-physicians 60 years (interquartile range [IQR] 56 to 65). A large proportion of the physicians and non-physicians were male (70.5%). The greatest proportion of physicians and non-physicians were in the highest income quintile (61%), and most resided in urban areas (~93%). Also, 70.2% of physicians graduated from Canadian medical schools, and 46.3% were primary care doctors.

Physicians had significantly fewer comorbidities than non-physicians. In the five years before the index date, physicians were more likely to have no visits to a primary care doctor than non-physicians (19.8% vs. 6.5%), and were more likely to have no visits to an emergency department (72.0% vs. 63.0%). The number of hospital admissions was similar between physicians and non-physicians.

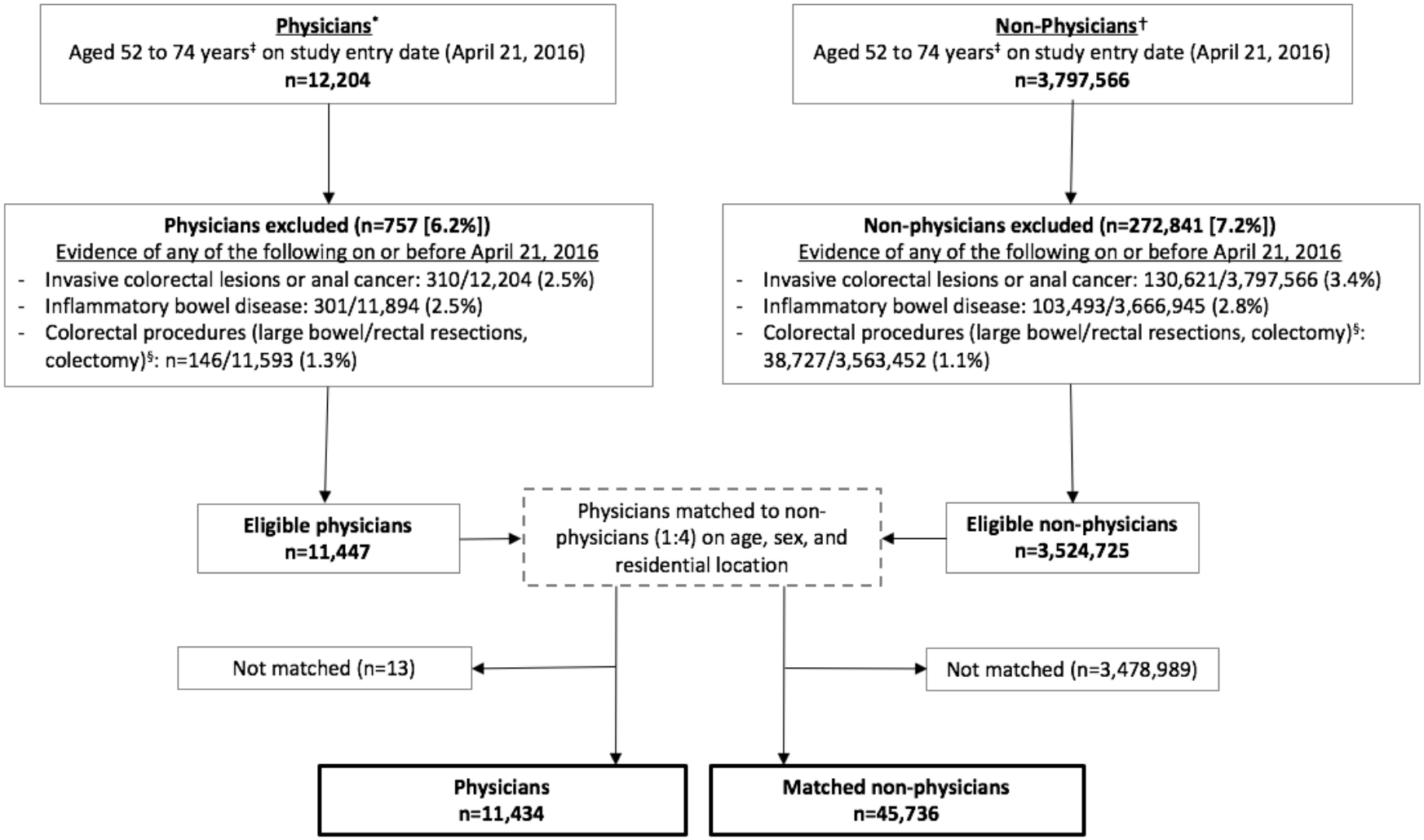

Figure 1a: Sample flow.

* The sample of 12,204 physicians (drawn from 29,802 physicians registered with the College of Physicians and Surgeons of Ontario as of April 21, 2016 and successfully linked to databases at the Institute for Clinical Evaluative Sciences) includes those aged 52–74 years as of April 21, 2016 with valid identifiers (i.e. a valid patient identifier, date of birth,

sex, medical school graduation date, and at least one health care encounter between 2009 and 2016 [residents do not need to inform Ontario's Ministry of Health and Long-Term Care upon emigrating from the province, and this criterion is used a proxy to exclude those who have emigrated]).
† The sample of 3,797,566 non-physicians (drawn from the Ontario Registered Persons Database) includes all residents of Ontario aged 52–74 years as of April 21, 2016 with valid identifiers (i.e. a valid patient identifier, valid data on date of birth and sex, and at least one health care encounter between 2009 and 2016 [residents do not need to inform Ontario's Ministry of Health and Long-Term Care upon emigrating from the province, and this criterion is used a proxy to exclude those who have emigrated]).
‡ The age restriction was applied to ensure that all persons in our study had screening tests assessed for at least two years before the study entry date (screening is recommended to begin at age 50, so individuals who were age 52 on April 21, 2016 would be assessed for screening starting from their 50th year).
§ These individuals are more likely to be symptomatic and undergoing long-term surveillance for colorectal disease.

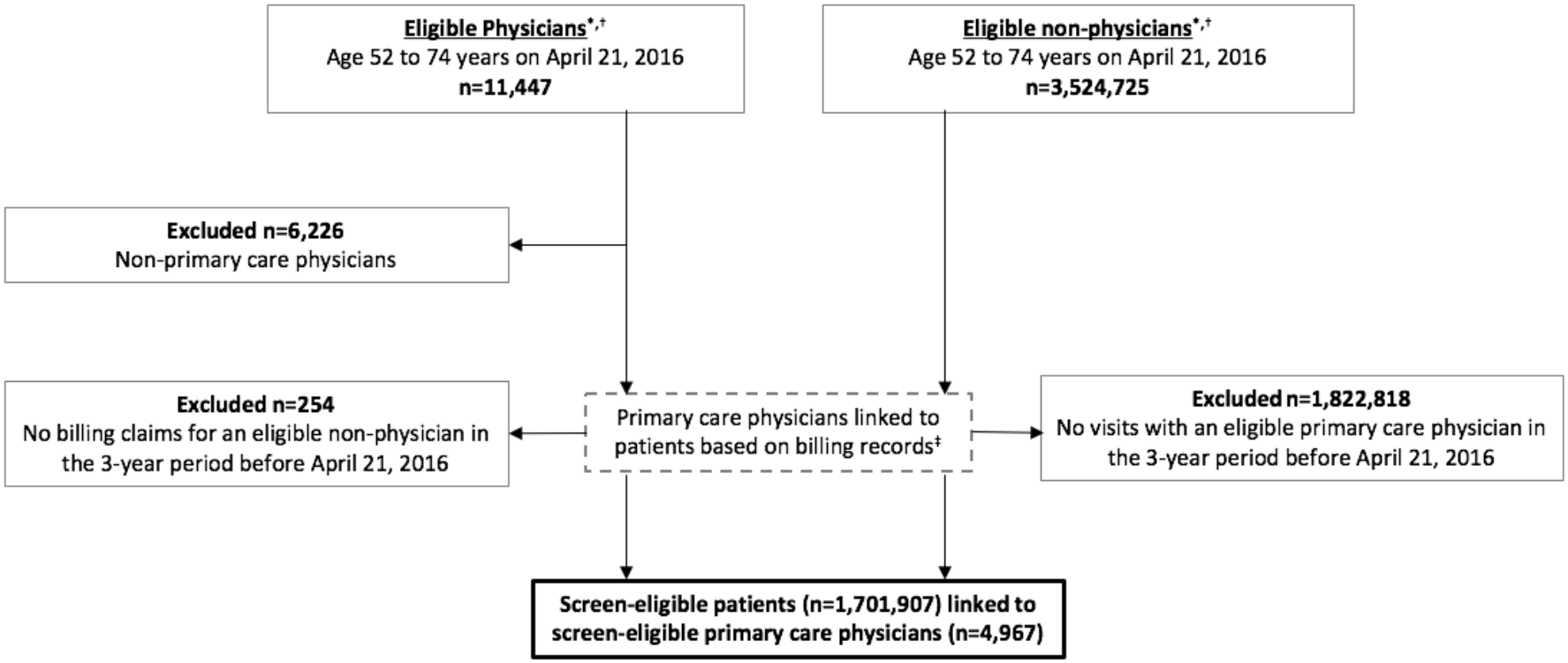

Figure 1b: Cohort build for the analysis of primary care physicians and their patients.

* As described in Figure 1a, this sample included all residents of Ontario aged 52–74 years as of April 21, 2016 with a valid patient identifier, valid data on date of birth and sex, and at least one health care encounter between 2009 and 2016 (residents do not need to inform Ontario's Ministry of Health and Long-Term Care upon emigrating from the province, and this criterion is used a proxy to exclude those who have emigrated). Physicians were identified by linkage with the College of Physicians and Surgeons of Ontario (we excluded <5 whose medical school graduation occurred after April 21, 2016). The age restriction was applied to ensure that all persons in our study had screening compliance assessed for at least two years before the study entry date (screening is recommended to begin at age 50, so individuals who were age 52 on April 21, 2016 would be assessed for screening from age 50–52).

† From Figure 1a: no evidence of any of the following before April 21, 2016: invasive colorectal lesions or anal cancer, inflammatory bowel disease, or colorectal procedures (large bowel/rectal resections; colectomy).

‡ To link patients with their primary care physicians, we reviewed all billing claims of primary care physicians during the 3-year period before April 21, 2016; the physician with the most submitted claims for a particular patient was defined as that patient's primary care physician.

Table 2a: Characteristics of matched physicians and non-physicians*,†,‡,§

	Physicians (N = 11 434)	Non-physicians (N = 45 736)	Standardized difference (%)‖
Age, years			
Median (IQR)	60 (56 to 65)	60 (56 to 65)	0
52–59	5181 (45.3)	20 726 (45.3)	0
60–69	5084 (44.5)	20 333 (44.5)	0
70–74	1169 (10.2)	4677 (10.2)	0
Sex			
Men	8056 (70.5)	32 224 (70.5)	0
Women	3378 (29.5)	13 512 (29.5)	0
Urban vs rural residence¶			
Urban	10 649 (93.2)	42 466 (92.8)	1
Rural	785 (6.9)	3270 (7.1)	1
Neighborhood income quintile**			
1 (lowest)	827 (7.2)	3308 (7.2)	0
2	655 (5.7)	2620 (5.7)	0
3	1077 (9.4)	4308 (9.4)	0
4	1904 (16.7)	7616 (16.7)	0
5 (highest)	6971 (61.0)	27 884 (61.0)	0
No. visits to a family physician††			
Median (IQR)	3 (1 to 7)	9 (4 to 15)	.
0	2268 (19.8)	2993 (6.5)	40
1–2	2715 (23.7)	4385 (9.6)	30
3–4	2143 (18.7)	5053 (11.0)	18
≥5	4308 (37.7)	33 305 (72.8)	4
No. visits to the emergency department††			
Median (IQR)	0 (0 to 1)	0 (0 to 1)	.
0	8234 (72.0)	28 811 (63.0)	19
1–2	2692 (23.5)	12 786 (28.0)	5
≥3	370 (3.2)	2669 (5.8)	9
No. hospital admissions††			
Median (IQR)	0 (0 to 0)	0 (0 to 0)	.
0	10 350 (90.5)	40 872 (89.4)	4
≥1	1084 (9.5)	4864 (10.6)	4
Comorbidities††			
Hypertension	2906 (25.4)	17 323 (37.9)	27
Liver disease	217 (1.9)	1731 (3.8)	11
Diabetes	1151 (10.1)	7985 (17.5)	22
Charlson comorbidity score‡‡			
Median (IQR)	0 (0 to 0)	0 (0 to 0)	.
0	11 085 (96.9)	43 585 (95.3)	9
≥1	349 (3.1)	2151 (4.7)	9

Abbreviations: IQR, Interquartile range (25^{th}–75^{th} percentile).
* All values are reported as No. (%) unless otherwise specified.
† Physicians registered with the College of Physicians and Surgeons of Ontario as of April 21, 2016.

‡ Physicians were matched to non-physicians using a 1:4 ratio based on age, sex and the first three digits of residential postal code (i.e. Forward Sortation Area [average population size 8000]), which was used to match on neighborhood characteristics and income.

§ Characteristics as of April 21, 2016 (the index date) unless otherwise specified.
// Standardized differences are less sensitive to sample size than traditional hypothesis tests. They provide a measure of the difference between group means relative to the pooled standard deviation. A value greater than 10% is considered a meaningful difference.
¶ Urban was defined as living in a municipality with a population ≥10 000; missing data was imputed as urban for <0.5% of physicians and non-physicians.
** Quintiles of neighborhood income, adjusted for household size. Missing data (<0.5% of physicians and non-physicians) was imputed with the mode.
†† Assessed in the 5-year period before the index date (April 21, 2016).
‡‡ Calculated using 5 years of hospitalization data preceding the index date. “No hospital admissions” received a score of 0.

Table 2b: Additional characteristics in physicians*

	No. physicians (N=11 434)
Years since medical school graduation	
Median (IQR)	35 (30 to 40)
Years since first billing claim	
Median (IQR)	29 (24 to 34)
Medical school†	
Canadian	8028 (70.2)
Non-Canadian	3406 (29.8)
Specialty‡	
Anesthesiology	482 (4.2)
Radiology§	404 (3.5)
Emergency medicine //	310 (2.7)
Gastroenterology	114 (1.0)
Family medicine	5299 (46.3)
Internal medicine¶	1389 (12.1)
Oncology**	173 (1.5)
Other††	70 (0.6)
Pathology	281 (2.5)
Pediatrics‡‡	542 (4.7)
Psychiatry	1007 (8.8)
General Surgery	238 (2.1)
Other Surgery§§	1138 (9.9)

Abbreviations: IQR, Interquartile range (25^{th}–75^{th} percentile).
* All values are reported as No. (%) unless otherwise specified.
† Missing values for country of medical school graduation were imputed as Canadian for 1% of physicians.
‡ Missing values for specialty were imputed as family physician for 1% of physicians.
§ Included diagnostic radiologists and nuclear medicine specialists.
// Included physicians whose specialty was classified in the ICES Physician Database as family physicians/emergency medicine.
¶ Included general internal medicine and all internal medicine subspecialties, aside from gastroenterology and oncology, which are presented separately.
** Included medical oncologists, radiation oncologists, and gynecologic oncologists.
†† Included fellows, occupational medicine specialists, and community medicine/public health physicians.
‡‡ Included general pediatrics, all pediatric medical and surgical subspecialties, and neonatal/perinatal medicine.
§§ Included all surgical subspecialties (other than general surgery), including obstetrics and gynecology.

5.2 Primary analysis

Uptake of colorectal tests (FOBT in the past two years, flexible sigmoidoscopy in the past five years, or colonoscopy in the past 10 years) was 67.9% (95% CI, 67.0 to 68.7%) in physicians and 66.6% (95% CI, 66.2 to 67.1%) in non-physicians (prevalence ratio for physicians, 1.02; 95% CI, 1.00 to 1.03; P=0.01) (**Table 3**). Physicians were significantly less likely to undergo FOBT than non-physicians (11.6% vs. 26.2%; prevalence ratio for physicians, 0.44; 95% CI, 0.42 to 0.47; P<0.001), and more likely to undergo colonoscopy (60.1% vs. 48.6%; prevalence ratio for physicians, 1.24; 95% CI, 1.22 to 1.26; P<0.001). Uptake of flexible sigmoidoscopy was similar between the two groups.

Table 3: Uptake of colorectal tests in matched physicians and non-physicians*,†,‡

	No. tested	Total no. individuals	Proportion tested (prevalence) %, (95% CI)	Prevalence difference %, (95% CI)	Prevalence ratio*,§ (95% CI)	P Value
FOBT, flexible sigmoidoscopy or colonoscopy						
Physicians	7762	11 434	67.9 (67.0 to 68.7)	1.2 (0.3 to 2.2)	1.02 (1.00 to 1.03)	.01
Non-physicians	30 480	45 736	66.6 (66.2 to 67.1)	reference	1.00 [reference]	
FOBT						
Physicians	1326	11 434	11.6 (11.0 to 12.2)	-14.6 (-15.3 to -13.9)	0.44 (0.42 to 0.47)	<.001
Non-physicians	11 993	45 736	26.2 (25.8 to 26.6)	reference	1.00 [reference]	
Flexible sigmoidoscopy						
Physicians	132	11 434	1.2 (1.0 to 1.4)	-0.2 (-0.4 to 0.0)	0.85 (0.71 to 1.02)	.09
Non-physicians	621	45 736	1.4 (1.3 to 1.5)	reference	1.00 [reference]	
Colonoscopy						
Physicians	6872	11 434	60.1 (59.2 to 61.0)	11.5 (10.5 to 12.5)	1.24 (1.22 to 1.26)	<.001
Non-physicians	22 213	45 736	48.6 (48.1 to 49.0)	reference	1.00 [reference]	

Abbreviations: CI, confidence interval; FOBT, fecal occult blood test.

* Physicians were matched to non-physicians using a 1:4 ratio based on age, sex and the first three digits of residential postal code (i.e. Forward Sortation Area [average population size 8000]), which was used to match on neighborhood characteristics and income.

† Uptake was defined by a record of the following as of April 21, 2016: (i) a fecal occult blood test in the past two years, (ii) flexible sigmoidoscopy in the past five years, or (iii) colonoscopy in the past 10 years.

‡ Individuals who received multiple tests during the screening period were counted only once for the composite outcome of fecal occult blood test, flexible sigmoidoscopy, or colonoscopy.

§ Prevalence ratios were derived from modified Poisson regression models using generalized estimating equations to account for the correlation structure within match sets.

5.3 Secondary analyses

Factors associated with colorectal test uptake in physicians

In multivariable modelling, colorectal test uptake was significantly higher in older physicians, in physicians residing in urban (vs. rural) areas, in physicians in the highest income quintile (vs. the middle quintile), in anesthesiologists, radiologists, gastroenterologists and general surgeons (vs. primary care physicians), in graduates of Canadian (vs. non-Canadian) medical schools, and in those who visited a primary care doctor in the five years before the index date (vs. those with no visits) (**Table 4**).

Table 4: Predictors of colorectal test uptake in physicians (N = 11 434).[*, †]

Characteristics	Percentage tested (prevalence) (%)	Adjusted prevalence ratio[‡] (95% CI)	P Value
Age category			
52–59 years	3446 (66)	0.96 (0.92 to 1.00)	.06
60–69 years	3520 (69)	1.00 (0.96 to 1.04)	.94
70–74 years	804 (69)	1.00 [reference]	
Sex			
Men	5398 (67)	1.01 (0.98 to 1.03)	.60
Women	2372 (70)	1.00 [reference]	
Rural vs urban residence			
Rural	508 (65)	0.94 (0.89 to 0.99)	.01
Urban[§]	7262 (68)	1.00 [reference]	
Neighborhood income quintile [‖]			
1 (lowest)	553 (66)	1.04 (0.98 to 1.11)	.22
2	422 (64)	0.99 (0.93 to 1.06)	.82
3	695 (65)	1.00 [reference]	
4	1264 (66)	1.03 (0.98 to 1.08)	.30
5 (highest)	4836 (69)	1.07 (1.02 to 1.12)	.003
Specialty			
Anesthesiology	364 (76)	1.17 (1.11 to 1.23)	<.001
Radiology	294 (73)	1.09 (1.03 to 1.16)	.01
Emergency medicine	209 (67)	1.01 (0.93 to 1.09)	.80
Gastroenterology	82 (72)	1.14 (1.02 to 1.28)	.02
Family medicine	3562 (67)	1.00 [reference]	
Internal medicine	896 (65)	1.01 (0.97 to 1.05)	.74
Oncology	119 (69)	1.08 (0.98 to 1.19)	.10
Other	49 (70)	1.02 (0.88 to 1.19)	.78
Pathology	191 (68)	1.04 (0.96 to 1.13)	.30

Characteristics	Percentage tested (prevalence) (%)	Adjusted prevalence ratio‡ (95% CI)	P Value
Pediatrics	355 (66)	0.99 (0.93 to 1.05)	.68
Psychiatry	722 (72)	1.02 (0.98 to 1.07)	.30
General surgery	172 (72)	1.15 (1.07 to 1.24)	<.001
Other surgery	755 (66)	1.03 (0.98 to 1.07)	.27
Medical school			
Canadian	5722 (70)	1.17 (1.14 to 1.21)	<.001
Non–Canadian	2048 (62)	1.00 [reference]	
No. family physician visits¶			
0	1059 (47)	1.00 [reference]	
1–2	1765 (65)	1.39 (1.32 to 1.47)	<.001
3–4	1577 (74)	1.59 (1.51 to 1.67)	<.001
≥5	3369 (78)	1.71 (1.63 to 1.79)	<.001

* Physicians registered with the College of Physicians and Surgeons of Ontario as of April 21, 2016.

† Characteristics as of April 21, 2016 (the index date) unless otherwise specified.

‡ A multivariable modified Poisson regression model was used and included all of the above characteristics.

§ Urban was defined as living in a municipality with a population ≥10 000.

// Quintiles of neighborhood income, adjusted for household size.

¶ Assessed in the 5-year period before the index date.

Uptake of colorectal tests in primary care physicians and their patients

Patients were more likely to undergo testing if their primary care physician was tested (prevalence ratio for physicians, 1.11; 95% CI, 1.09 to 1.12; P<0.001) (**Table 5**). This was observed for the composite of FOBT, flexible sigmoidoscopy, or colonocsopy, as well as for FOBT and colonoscopy individually. Additionally, patients were more likely to complete a fecal occult blood test if their primary care physician completed this test (prevalence ratio, 1.27; 95% CI, 1.21 to 1.33), and the same pattern was observed for colonoscopy (prevalence ratio, 1.24; 95% CI, 1.21 to 1.27).

Table 5: Uptake of colorectal tests in family physicians and their patients[*,†]

Family physicians (n=4967)	Patients (n=1 701 907)				
	No. patients tested	Total no. patients	Proportion Tested (%) (prevalence)	Prevalence ratio (95% CI)	
				Unadjusted[‡]	Adjusted[‡,§]
FOBT, flexible sigmoidoscopy or colonoscopy[†]					
Yes (n=3337 [67.2%])	779 396	1 134 909	68.7	1.11 (1.09 to 1.12)	1.10 (1.08 to 1.12)
No (n=1630 [32.8%])	352 397	566 998	62.2	1.00 [reference]	1.00 [reference]
FOBT					
Yes (n=594 [12.0%])	64 748	175 324	36.9	1.27 (1.21 to 1.33)	1.27 (1.21 to 1.33)
No (n=4373 [88.0%])	445 263	1 526 583	29.2	1.00 [reference]	1.00 [reference]
Colonoscopy					
Yes (n=2896 [58.3%])	493 344	1 000 967	49.3	1.24 (1.21 to 1.27)	1.22 (1.20 to 1.25)
No (n=2071 [41.7%])	279 162	700 940	39.8	1.00 [reference]	1.00 [reference]

Abbreviations: CI, confidence interval; FOBT, fecal occult blood test.

* All family physicians and patients met the study's eligibility criteria (Figure 1b); to identify patients' family physicians, we reviewed the billing claims of family physicians in the physician cohort (Figure 1a/1b) during the 3-year period before April 21, 2016; the physician with the most submitted claims for a particular patient was defined as that patient's family physician.

† Individuals with a record of any of the following as of April 21, 2016 were considered up-to-date: (i) a fecal occult blood test in the past two years, (ii) flexible sigmoidoscopy in the past five years, or (iii) colonoscopy in the past 10 years. Individuals who received multiple tests during the screening period were counted only once for the composite outcome of fecal occult blood testing, flexible sigmoidoscopy, or colonoscopy.

‡ Data were analyzed using a modified Poisson regression model using generalized estimating equations to account for the correlation structure within family physicians.

§ In order to account for potential confounders, we adjusted for several prespecified patient-level variables: age (52–59, 60–69 and 70–74 years), sex, urban residence (urban [population ≥10 000] vs rural [population <10 000]), neighborhood-income quintile, and the number of family physician visits (0, 1–2, 3–4, ≥5 visits) in the 5 years before the index date (April 21, 2016).

Subgroup analyses for age and sex

In subgroup analyses, a significant interaction was found for age, but not sex (**Appendix D** and **Appendix E**). In the youngest age group (52-59), uptake of colorectal tests was higher in physicians than non-physicians (prevalence difference, 4.7%; 95% CI, 3.3 to 6.1%), but in the oldest age group (70 to 74), uptake of colorectal tests was lower in physicians than non-physicians (prevalence difference, -4.4%; 95% CI, -7.4 to -1.5%); interaction p-value<0.001.

5.4 Conclusion

Uptake of colorectal tests was 68% in physicians and 67% in non-physicians. Physicians were less likely to undergo FOBT than non-physicians, and more likely to undergo colonoscopy. Patients were more likely to undergo colorectal testing if their primary care physician was tested, and they were more likely to receive the same test as their physician.

Chapter 6

6.0 Discussion

6.1 Summary and interpretation of findings

In this population-based study, uptake of colorectal tests was 68% in physicians and 67% in matched non-physicians. Phrased another way, about one third of physicians and non-physicians in this screen-eligible cohort were overdue for colorectal cancer screening. Physicians were more likely than non-physicians to undergo colonoscopy and less likely to undergo FOBT. Testing in primary care physicians was associated with greater testing in their patients, and patients were more likely to have the same type of test as their physician.

Traditionally, physician support for colorectal cancer screening modalities such as FOBT has been low,[14,15,91] and so our finding that physicians were less than half as likely to undergo FOBT compared to non-physicians was not unexpected. We observed that 11.6% of physicians completed a FOBT. In comparison, previous surveys of Canadian physicians report that between 27% and 39.6% completed this test,[14,15] suggesting that prior surveys may have overestimated physician support for FOBT, in part due to recall and social desirability biases, which we avoided due to the use of administrative data. Prior research indicated that only 20.9% of family doctors in Ontario believe biennial FOBT is associated with the greatest reduction in colorectal cancer mortality (relative to other screening modalities), which may be due to their perception that the sensitivity of FOBT is inadequate.[14] This lack of support for FOBT is also reflected in Wilson's criteria i.e. support for screening among physicians is not particularly strong when they believe it has inferior sensitivity, specificity and efficacy, relative to other available screening modalities.

Physicians were 24% more likely to undergo colonoscopy than non-physicians, and in absolute terms almost two-thirds of physicians underwent colonoscopy. This is consistent with prior research showing that physicians prefer colonoscopy for their own screening, which may be due to its superior sensitivity relative to FOBT.[14] Physicians may have easier access to colonoscopy services than non-physicians in Ontario if they can bypass

standard referral processes.

Physicians had similar uptake of flexible sigmoidoscopy compared to non-physicians, and uptake was approximately 59% lower than colonoscopy uptake, and 10% lower than FOBT uptake. Although flexible sigmoidoscopy reduces mortality from colorectal cancer,[23] it has a lower sensitivity than colonoscopy (40-60% vs 100%, respectively) by virtue of the fact that it cannot detect lesions proximal to the splenic flexure.[41,51] Research has shown that physicians place a high value on the operating characteristics of screening tests,[14,15] which may explain their preference for colonoscopy over flexible sigmoidoscopy. Despite low flexible sigmoidoscopy uptake, it is likely a good option for patients in nurse practitioner-led clinics who wish to undergo endoscopy, but do not want to experience long wait times associated with colonoscopy. This would be particularly relevant for individuals living in rural and remote regions where nurse practitioner clinics are more common.

The average physician income in Ontario is several times the average income for the general Ontario population.[92] In multivariable analyses, we found that higher neighborhood income physicians were more likely to be tested than lower-income physicians, although it is difficult to make conclusions as to why this occurred given physicians' high incomes. Nevertheless, this trend is consistent with observations from the general population.[35]

We also showed that physicians living in rural areas were significantly less likely to be tested than physicians living in urban areas. This highlights the need to ensure that rural regions of Ontario are adequately supported with financial and health human resources, to ensure geographic parity for access to cancer screening services for physicians and their patients. This finding is in contrast to prior analyses from Ontario that did not show a difference in screening uptake between people living in rural versus urban areas.[16,18] Especially considering the ease of distribution of FOBT kits, residential status should not be a barrier to colorectal cancer screening for physicians or patients.

We noted significantly greater colorectal test uptake among anesthesiologists, radiologists, gastroenterologists and general surgeons, relative to family doctors. There is

very limited data available in the literature on screening preferences of physicians in different specialties. However, it was unsurprising to find that gastroenterologists and general surgeons had high test uptake, since they are frequently involved in the screening, treatment, and long-term follow-up of people diagnosed with colorectal cancer. This finding is also consistent with a prior study of Canadian doctors' screening preferences.[15] It is unclear as to why the proportion of family doctors tested was not as high as some other specialists, given that they are responsible for front-line implementation of colorectal cancer screening in Ontario.

We also found that Canadian graduates were significantly more likely than non-Canadian graduates to undergo testing. Non-Canadian graduates may have varying levels of exposure to evidence-based cancer screening throughout their training, and in some jurisdictions, this may be a function of the high cost of screening technologies.[70,72] Diverse cultural practices and religious beliefs may also be important determinants of colorectal testing in international medical graduates.[67] Furthermore, given that patients of non-Canadian graduates are less likely to undergo cancer screening compared to patients of Canadian graduates,[67] targeted efforts should be made to inform international medical graduates regarding up-to-date, evidence-based cancer screening recommendations when they begin practicing in Canada.

As expected, we found that physicians who visited a family doctor at least once in the five years prior to the index date were significantly more likely to undergo testing compared to physicians who did not visit a family doctor. A greater number of visits was associated with greater test uptake, and this is consistent with prior literature.[74] More frequent contact with family doctors increases opportunities for goal-setting in relation to secondary cancer prevention. Accordingly, all physicians should be encouraged to maintain regular contact with their own family physicians.

Uptake of colorectal tests in primary care physicians was associated with greater uptake in their patients. A direct correlation between physicians' and patients' preventive health behaviours has been demonstrated previously, including for vaccination, cancer screening, exercise, and smoking cessation.[19] Since patients were more likely to undergo

the same type of colorectal test as their physician, this suggests that physicians' personal testing preferences and biases are influencing their recommendations to patients. Given that physicians prefer colonoscopy over FOBT, despite the fact that colonoscopy is more resource-intensive, has a greater degree of risk, and is not supported by randomized trial evidence, this may have direct implications for patient care and healthcare system costs. This also represents an opportunity to increase physician education about evidence-based colorectal cancer screening, through Cancer Care Ontario materials, continuing medical education, departmental training sessions and physician health programs.

Cancer prevention should be promoted throughout physicians' careers, starting from the time they are junior trainees. Medical schools across North America have taken steps to address this by integrating personal health and wellness topics into curricula.[93] Moreover, the Canadian medical education framework, CanMEDS, recognizes that maintaining one's personal health is a central component of medical professionalism.[94] However, an important caveat is that the majority of medical school graduates become age-eligible for colorectal cancer screening several decades following graduation, and so there is a need to ensure that physicians are continuously exposed to cancer prevention information.

Existing infrastructure in provincial physician health programs could be leveraged to support specific subgroups of physicians who we identified as having relatively low test uptake, and reaffirming support for physician health as a core professional value may help cultivate a more active culture of cancer prevention. Continuous monitoring of screening compliance will also be important in verifying whether we are deriving the maximum potential benefit from organized cancer screening programs.

6.2 Strengths and limitations

The primary strength of this study was the use of linked, population-based databases that contain information on 13.4 million Ontarians who are eligible for universal healthcare. The use of administrative databases allowed us to avoid the recall and social desirability biases that are inherent in surveys that rely on self-reported information. Moreover, our large sample size enabled good precision, and our representative sample makes our results generalizable to screen-eligible physicians and non-physicians throughout North

America, and in other countries with access to modern screening technologies. Additionally, the contemporary nature of the data that was used will enable health system administrators to design timely and appropriate interventions targeted towards subgroups of physicians who have suboptimal test uptake.

This study has some limitations. First, the use of administrative healthcare data meant we were unable to exclude all high-risk individuals including those with a family history of colon cancer. As well, the use of claims codes did not allow us to discern whether a test was done for screening purposes or for another reason (colonoscopy in particular may be performed in response to patient symptoms or unexplained iron-deficiency anemia, for diagnostic testing, or as a treatment for some other condition), although previously used claims codes were used when available. To minimize the inclusion of higher risk and symptomatic individuals, we excluded individuals with a history of invasive colorectal lesions or anal cancer, inflammatory bowel disease, large bowel or colorectal resection, or colectomy. Although individuals who completed tests for non-screening indications would still be considered up-to-date with colon cancer screening, the proportion tested will overestimate the true screening participation rate for an asymptomatic average-risk population, which ranges from 50% to 65% in the U.S and Canada. Nonetheless, this does little to alter our main finding that about one third of physicians and non-physicians in this screen-eligible cohort were overdue for colorectal cancer screening.

Additionally, our use of OHIP claims did not allow us to discern between flexible sigmoidoscopies versus incomplete colonoscopies that were terminated at the splenic flexure, which would have led to an overestimation of flexible sigmoidoscopy uptake, and an underestimation of colonoscopy uptake. However, we expect the frequency of incomplete colonoscopies to be low,[95] and the effect of this potential limitation is likely to be small, since uptake of flexible sigmoidoscopy in physicians and non-physicians was only 1.2% and 1.4%, respectively.

It is also possible that primary care doctors may have easy access to FOBT kits from their office stock, which could have had a differential impact on FOBT uptake between physicians and non-physicians, and could have led to an underestimate of testing uptake

in physicians. However, the impact of this on our estimates is likely minimal. Clinical expertise and discussions with cancer screening specialists suggested that most physicians would still submit the test for analysis and interpretation (captured in our algorithm). Additionally, a positive FOBT would likely lead to an endoscopy procedure (also captured in our algorithm).

Similar to other observational studies, residual confounding may be impacting our findings. Specifically, factors such as smoking, alcohol, family history may be impacting our results, and these factors are either not available or are poorly coded in administrative data.

6.3 Recommendations for future research

Given the clear benefits of colorectal testing, our study highlights that there is an opportunity for greater screening participation in physicians, who may in turn positively influence screening in their patients. Programs that promote recommended health behaviors in physicians warrant consideration. Physicians are uniquely positioned to influence preventive health behaviours in their patients, and intuitively, physicians who practice healthy behaviours may be more effective at counseling their patients to do the same. This 'healthy doctor–healthy patient' effect ('do as I do') has been demonstrated for other preventive health behaviours, including vaccination and screening practices, exercise, and quitting smoking.[19,73,96,97] If a physician feels comfortable to share they were screened, they may be more believable and motivating to their patients.[98,99] Conversely, many physicians report difficulty counseling patients about behaviors they themselves do not practice.[100,101] Interventions aimed at increasing physician and patient screening uptake could also be evaluated using RCTs. If physicians' advertise the fact that they underwent screening (such as through posters in hospital corridors, waiting rooms) this may encourage patients and other doctors to follow suit, and may increase physicians' credibility.

Future studies could also investigate potential barriers to testing within specific subgroups of physicians, such as those who do not regularly visit primary care

physicians, and graduates of non-Canadian medical schools. Qualitative research methods may be warranted to investigate this.

6.4 Conclusion

In summary, our findings highlight that there is an opportunity for physicians to strengthen their role in colorectal cancer prevention. Healthcare system leaders should emphasize a culture of disease prevention, including a focus on physician health and wellness, so that physicians can live healthier lives while providing high quality patient care. Physicians are uniquely positioned to lead from the front in preventive healthcare, and we hope that renewed physician leadership in this area will lead to increased screening uptake among all eligible Canadians.

References

1. Canadian Cancer Society's Advisory Committee on Cancer Statistics. Canadian Cancer Statistics 2016. Toronto, ON: Canadian Cancer Society; 2016. Accessed August 14, 2018.
2. CTFPHC. Recommendations on screening for colorectal cancer in primary care. CMAJ 2016;188(5):340–8.
3. Lin JS, Piper MA, Perdue LA, et al. Screening for Colorectal Cancer: Updated Evidence Report and Systematic Review for the US Preventive Services Task Force. JAMA 2016;315(23):2576–94.
4. Tinmouth J, Vella ET, Baxter NN, et al. Colorectal Cancer Screening in Average Risk Populations: Evidence Summary. Can J Gastroenterol Hepatol 2016;2016:2878149.
5. CTFPHC. Colorectal cancer screening: Recommendation statement from the Canadian Task Force on Preventive Health Care. CMAJ 2001;165(2):206–208.
6. Cancer Care Ontario. Colon Cancer Check (CCC) Screening Recommendations Summary—April 2016. [Internet]. 2016 [cited 2018 Aug 14];Available from: https://www.cancercareontario.ca/sites/ccocancercare/files/assets/CCCScreeningRecommendations.pdf
7. United States Preventive Services Task Force. Screening for Colorectal Cancer: U.S. Preventive Services Task Force Recommendation Statement. Ann Intern Med 2008;149(9):627.
8. Screening for Colorectal Cancer: U.S. Preventive Services Task Force Recommendation Statement. JAMA 2016;315(23):2564–2575.
9. National Health Service. Bowel cancer screening. 2015. www.nhs.uk/conditions/bowel-cancer-screening/.
10. Australian Government Department of Health. National Bowel Cancer Screening Program. 2015. www.health.gov.au/internet/screening/publishing.nsf/Content/bowel-screening-1.
11. National Screening Service. Bowel screening. [Internet]. [cited 2017 Jul 6];Available from: https://www.bowelscreen.ie/bowel-screening.130.html
12. Miller JW, Baldwin LM, Matthews B, Trivers KF, Andrilla CH, Lishner D GB.

Physicians' beliefs about effectiveness of cancer screening tests: a national survey of family physicians, general internists, and obstetrician-gynecologists. Prev Med 2014;69:37–42.

13. Deobald R, Graham P, Chad J, et al. Colorectal cancer screening practices in Saskatchewan: Survey of family physicians. Can Fam Physician 2013;59(12):e558-63.
14. Zettler M, Mollon B, Da Silva V, Howe B, Speechley M, Vinden C. Family physicians' choices of and opinions on colorectal cancer screening modalities. Can Fam Physician 2010;56(9):338–44.
15. Raza M, Bernstein CN IA. Canadian physicians' choices for their own colon cancer screening. Can J Gastroenterol 2006;20(4):281–4.
16. CSQI. Colorectal Cancer Screening Participation [Internet]. [cited 2017 Feb 6];Available from: http://www.csqi.on.ca/by_patient_journey/screening/colorectal_screening_participation/
17. Kiran T, Wilton AS, Moineddin R, Paszat L, Glazier RH. Effect of payment incentives on cancer screening in Ontario primary care. Ann Fam Med 2014;12(4):317–23.
18. Honein-AbouHaidar GN, Baxter NN, Moineddin R, Urbach DR, Rabeneck L, Bierman AS. Trends and inequities in colorectal cancer screening participation in Ontario, Canada, 2005-2011. Cancer Epidemiol 2013;37(6):946–56.
19. Frank E, Dresner Y, Shani M VS. The association between physicians' and patients' preventive health practices. CMAJ 2013;185(8):649–53.
20. Frank E, Segura C. Health practices of Canadian physicians. Can Fam Physician 2009;55:810-1.e1-7.
21. Rosvold EO, Hjartaker A, Bjertness E LE. Breast self-examination and cervical cancer testing among Norwegian female physicians A nation-wide comparative study. Soc Sci Med 2001;52:249–58.
22. Cancer Care Ontario. ColonCancerCheck 2010 Program Report. Toronto, Canada, 2012.
23. CTFPHC. Screening for colorectal cancer systematic review. 2014.

24. Lin JS, Piper MA, Perdue LA, Rutter C, Webber EM, O'Connor E, Smith N, Whitlock EP. Screening for Colorectal Cancer: A Systematic Review for the U.S. Preventive Services Task Force. Evidence Synthesis No. 135. AHRQ Publication No. 14-05203-EF-1. Rockville.
25. American Cancer Society. Cancer Facts and Figures 2013. Atlanta: American Cancer Society; 2013.
26. Kory W. Jasperson, Thérèse M. Tuohy, Deborah W. Neklason RWB. Hereditary and Familial Colon Cancer. Gastroenterology 2010;138(6):2044–58.
27. Cancer Quality Council of Ontario. Colorectal cancer. [Internet]. [cited 2017 Feb 26];Available from: http://www.csqi.on.ca/by_type_of_cancer/colorectal_cancer/
28. Bond J. Colon polyps and cancer. Endoscopy 2003;35(1):27–35.
29. Heitman SJ, Ronksley PE, Hilsden RJ, Manns BJ, Rostom A HB. Prevalence of adenomas and colorectal cancer in average risk individuals: a systematic review and meta-analysis. Clin Gastroenterol Hepatol 2009;7(12):1272–8.
30. Brenner H, Hoffmeister M, Stegmaier C, Brenner G, Altenhofen L HU. Risk of progression of advanced adenomas to colorectal cancer by age and sex: estimates based on 840 149 screening colonoscopies. Gut 2007;56(11):1585–9.
31. Rudy D, Zdon M. Update on Colorectal Cancer. Am Fam Physician 2000;61(6):1759–70.
32. Gordis L. Epidemiology. Fourth. Elsevier Canada; 2008.
33. Sheehy AM, Coursin DB, Gabbay RA. Back to Wilson and Jungner: 10 Good Reasons to Screen for Type 2 Diabetes Mellitus. Mayo Clin Proc 2009;84(1):38–42.
34. Timothy M. Geiger RR. Screening Options and Recommendations for Colorectal Cancer. Clin Colon Rectal Surg 2009;22(4):209–17.
35. Ontario Cancer Screening Performance Report 2016. Toronto: 2016.
36. Gelfand J. Behind the Numbers: Number Needed to Screen [Internet]. NEJM J. Watch. 2011 [cited 2018 Aug 15];Available from: https://www.jwatch.org/jd201112220000002/2011/12/22/behind-numbers-number-needed-screen
37. Hubbard R, Johnson E, Hsia R, Rutter CM. The cumulative risk of false-positive

fecal occult blood test after 10 years of colorectal cancer screening. Cancer Epidemiol Biomarkers Prev 2013;22(9):1612–1619.

38. Narula N, Ulic D, Al-Dabbagh R, et al. Fecal occult blood testing as a diagnostic test in symptomatic patients is not useful: A retrospective chart review. Can J Gastroenterol Hepatol 2014;28(8):421–6.
39. Konrad G, Katz A. Are medication restrictions before FOBT necessary? Practical advice based on a systematic review of the literature. Can Fam Physician 2012;58(9):939–48.
40. Jones RM, Devers KJ, Kuzel AJ WS. Patient-Reported Barriers to Colorectal Cancer Screening: A Mixed-Methods Analysis. Am J Prev Med 2010;38(5):508–16.
41. Brown K, Burrows C. Cost Effectiveness of Alternative Work-up Strategies in Screening for Colorectal Cancer.
42. Levin T, Conell C, Shapiro J, Chazan S, Nadel M, Selby J. Complications of screening flexible sigmoidoscopy. Gastroenterology 2002;123(6):1786–92.
43. Austin K, Power E, Solarin I, Atkin W, Wardle J, Robb K. Perceived barriers to flexible sigmoidoscopy screening for colorectal cancer among UK ethnic minority groups: a qualitative study. J Med Screen 2009;16(4):174–9.
44. Romagnuolo J, Enns R, Ponich T, Springer J, Armstrong D, Barkun A. Canadian credentialling guidelines for colonoscopy. Can J Gastroenterol 2008;22(1):17–22.
45. Lichtenstein G. Bowel preparations for colonoscopy: a review. Am J Heal Syst Pharm 2009;66(1):27–37.
46. Leddin D, Armstrong D, Borgaonkar M, et al. The 2012 SAGE wait times program: Survey of Access to GastroEnterology in Canada. Can J Gastroenterol 2013;27(2):83–9.
47. Nishihara R, Wu K, Lochhead P, et al. Long-Term Colorectal-Cancer Incidence and Mortality after Lower Endoscopy. N Engl J Med 2013;369(12):10.1056/NEJMoa1301969.
48. Goodman M, Fletcher RH, Doria-Rose, et al. Observational methods to assess the effectiveness of screening colonoscopy in reducing right colon cancer mortality risk: SCOLAR. J Comp Eff Res 2015;4(6):541–51.

49. USPSTF. Final Recommendation Statement Colorectal Cancer: Screening [Internet]. 2017 [cited 2018 Aug 15];Available from: https://www.uspreventiveservicestaskforce.org/Page/Document/RecommendationStatementFinal/colorectal-cancer-screening2
50. Zhang J, Cheng Z, Ma Y, He C, Lu Y, Zhao Y, Chang X, Zhang Y, Bai Y CN. Effectiveness of Screening Modalities in Colorectal Cancer: A Network Meta-Analysis. Clin Color Cancer 2017;16(4):252–63.
51. K G, Ø H, M LMK, HO A, M. B. Current status of screening for colorectal cancer. Ann Oncol 2013;24(8):1963–72.
52. Makkar R, Bo S. Colonoscopic Perforation in Inflammatory Bowel Disease. Gastroenterol Hepatol 2013;9(9):573–83.
53. Rabeneck L, Paszat L, Hilsden R, et al. Bleeding and perforation after outpatient colonoscopy and their risk factors in usual clinical practice. Gastroenterology 2008;135:1899–906.
54. Rabeneck L, Tinmouth JM, Paszat LF, Baxter NN, Marrett LD, Ruco A, Lewis N GJ. Ontario's ColonCancerCheck: results from canada's first province-wide colorectal cancer screening program. Cancer Epidemiol Biomarkers Prev 2014;23(3):508–15.
55. Cancer Screening: Breast, Cervical and Colorectal [Internet]. Cancer Qual. Counc. Ontario. [cited 2018 Aug 15];Available from: http://www.csqi.on.ca/cms/One.aspx?portalId=351209&pageId=354179
56. Jeanne M. Ferrante, Pamela Ohman-Strickland, Karissa A. Hahn, Shawna V. Hudson, Eric K. Shaw, Jesse C. Crosson BFC. Self-report versus Medical Records for Assessing Cancer-Preventive Services Delivery. Cancer Epidemiol Biomarkers Prev 2008;17(11):2987–2994.
57. Lipkus IM, Rimer BK, Lyna PR, Pradhan AA, Conoway M W-PC. Colorectal cancer screening patterns and perceptions of risk among African American users of community health center. J Community Heal 1996;26:409–27.
58. Cornuz J, Ghali WA, Carlantonio DD, Pecoud A PF. Physicians' attitudes towards prevention: importance of intervention-specific barriers and physicians' health habits. Fam Pract 2000;17(6):535–40.

59. Tinmouth J, Ritvo P, McGregor E, et al. ColonCancerCheck Primary Care Invitation Pilot project. Family physician perceptions. Can Fam Physician 2012;58:e570–7.
60. Hilsden RJ, McGregor E, Murray A, Khoja S BH. Colorectal cancer screening: practices and attitudes of gastroenterologists, internists and surgeons. J can chir 2005;48(6):434–40.
61. McGregor SE, Hilsden RJ, Murray A, Bryant HE. Colorectal cancer screening: Practices and opinions of primary care physicians. Prev Med (Baltim) 2004;39(2):279–85.
62. Mack LA, Stuart H TW. Survey of colorectal cancer screening practices in a large Canadian urban centre. Can J Surg 2004;47(3):189–94.
63. Colquhoun P, Weiss E, Efron J, Nogueras J, Vernava A, Wexner S. Colorectal Cancer Screening: Do We Practice What We Preach? Surg Innov 2006;13(2):81–5.
64. Bazargan M, Makar M, Bazargan-Hejazi S, Ani C WK. Preventive, Lifestyle, and Personal Health Behaviors Among Physicians. Acad Psychiatry 2009;33(4):289–95.
65. Peleg R, A O, V G, E P. Screening tests among family doctors: do we do as we preach? Public Health 2013;127:282–9.
66. Shannon M. Christy, Catherine E. Mosher SMR. Integrating Men's Health and Masculinity Theories to Explain Colorectal Cancer Screening Behavior. Am J Mens Heal 2014;8(1):10.1177/1557988313492171.
67. Lofters AK, Ng R, Lobb R. Primary care physician characteristics associated with cancer screening: a retrospective cohort study in Ontario, Canada. Cancer Med 2015;4(2):212–23.
68. Vahabi M, Lofters A, Kumar M, Glazier R. Breast cancer screening disparities among urban immigrants: a population-based study in Ontario, Canada. BMC Public Health 2015;15:679.
69. Guilcher SJT, Lofters A, Glazier RH, Jaglal SB, Voth J BA. Level of disability, multi-morbidity and breast cancer screening: Does severity matter? Prev Med (Baltim) 2014;67:193–8.

70. KH S. Knowledge, attitudes, and practices regarding cervical cancer screening among physicians in the Western Region of Saudi Arabia. Saudi Med J 2011;32(11):1155–60.
71. KH S. Attitudes, knowledge, and practices in relation to cervical cancer and its screening among women in Saudi Arabia. Saudi Med J 2009;30(9):1208–12.
72. K.-M. E, M.A. G, B. F, et al. Current knowledge, attitudes and practices of women on breast cancer and mammography at mulago hospital [Internet]. Pan Afr. Med. J. 2010;5. Available from: http://www.panafrican-med-journal.com/content/article/5/9/pdf/9.pdf%5Cnhttp://ovidsp.ovid.com/ovidweb.cgi?T=JS&PAGE=reference&D=emed9&NEWS=N&AN=2011056700
73. Erica Frank, Richard Rothenberg, Charles Lewis BFB. Correlates of Physicians' Prevention-Related Practices. Findings From the Women Physicians' Health Study. Arch Fam Med 2000;9:359–67.
74. Zarychanski R, Chen Y, Bernstein CN, Hébert PC. Research Frequency of colorectal cancer screening and the impact of family physicians on screening behaviour. 2007;177(6):7–11.
75. Frank E, Oberg E, Segura C, Clarke A SH. The physical and mental health status and health practices of physicians in British Columbia. BC Med J 2010;52(7):349–55.
76. Ontario Ministry of Finance. Ontario Population Projections Update, 2009-2036. Toronto: ServiceOntario Publications; 2010.
77. Benchimol E, Smeeth L, Guttmann A, et al. The REporting of studies Conducted using Observational Routinely-collected health Data (RECORD) Statement. PLoS Med 2015;12:1–22.
78. Walraven C van, Austin P. Administrative database research has unique characteristics that can risk biased results. J Clin Epidemiol 2012;65(2):126–31.
79. Canadian Institute for Health Information. Trends in Income-Related Health Inequalities in Canada: Methodology Notes. Ottawa, ON: CIHI; 2015.
80. Rural and Small Town Canada Analysis Bulletin. Vol. 3, No.3. 2001.
81. Lofters A, Vahabi M, Glazier RH. The validity of self-reported cancer screening history and the role of social disadvantage in Ontario, Canada. BMC Public

Health 2015;15(1):28.

82. Hsu Y-H, Kung P-T, Wang Y-H, Chang Y-M, Tsai W-C. A comparison of the stages at which cancer is diagnosed in physicians and in the general population in Taiwan. CMAJ 2015;187(13):E412–8.
83. Gu XS, Rosenbaum PR. Comparison of Multivariate Matching Methods: Structures, Distances, and Algorithms. J Comput Graph Stat. 2013;2(4):405–20.
84. Wacholder S, Silverman DT, McLaughlin JK, Mandel JS. Selection of controls in case-control studies. III. design options. Am J Epidemiol 1992;135:1042-50.
85. Honein-AbouHaidar GN, Baxter NN, Moineddin R, Urbach DR, Rabeneck L BA. Trends and inequities in colorectal cancer screening participation in Ontario, Canada, 2005-2011. Cancer Epidemiol 2013;37(6):946–56.
86. Tinmouth J, Baxter NN, Rabeneck L, Paszat L, Sutradhar R, Saskin R. Validation of 5 key colonoscopy-related data elements from Ontario health administrative databases compared to the clinical record: A cross-sectional study. C Open 2018;(In Press).
87. Williams JI, Young W. A summary of studies on the quality of health care administrative databases in Canada. In: Goel V WJ, Anderson GM, Blacksterin-Hirsch P, Fooks C, Naylor CD, editor. Patterns of Health Care in Ontario: The ICES Practice AtlasOttawa: C.
88. Hadlock S, Rabeneck L, Paszat LF, et al. Open-access colonoscopy in Ontario: associated factors and quality. Can J Gastroenterol 2013;27:341-6.
89. Austin PC. Balance diagnostics for comparing the distribution of baseline covariates between treatment groups in propensity-score matched samples. Stat Med 2009;28(25):3083–3107.
90. J Z, Yu K. What's the relative risk? A method of correcting the odds ratio in cohort studies of common outcomes. JAMA 1998;280(19):1690–1.
91. Battista RN, Palmer CS, Marchand BM, Spitzer WO. Patterns of preventive practice in New Brunswick. Can Med Assoc J 1985;132(9):1013–5.
92. Canadian specialty profiles [Internet]. [cited 2017 Mar 5];Available from: https://www.cma.ca/En/Pages/specialty-profiles.aspx
93. Dobkin PL, Hutchinson TA. Teaching mindfulness in medical school: Where are

we now and where are we going? Med Educ 2013;47(8):768–79.

94. Frank JR, Snell L, Sherbino J, editors. CanMEDS 2015 Physician Competency Framework. Ottawa: Royal College of Physicians and Surgeons of Canada; 2015.

95. Bressler B, Paszat LF, Vinden C, Li C, He J, Rabeneck L. Colonoscopic miss rates for right-sided colon cancer: A population-based analysis. Gastroenterology 2004;127(2):452–6.

96. Frank E, Segura C, Shen H, Oberg E. Predictors of Canadian physicians' prevention counseling practices. Can J Public Heal 2010;101(5):390–5.

97. Oberg E, Frank E. Physicians' health practices strongly influence patient health practices. J R Coll Physicians Edinb 2009;39(4):290–1.

98. Frank E. Physician Health and Patient Care. JAMA 2004;291(5):637–637.

99. Frank E, Breyan J, Elon L. Physician disclosure of healthy personal behaviors improves credibility and ability to motivate. Arch Fam Med 2000;9(3):287–90.

100. Vickers KS, Kircher KJ, Smith MD, Petersen LR, Rasmussen NH. Health behavior counseling in primary care: provider-reported rate and confidence. Fam Med 39(10):730–5.

101. Oberg EB, Frank E. Physicians' health practices strongly influence patient health practices. J R Coll Physicians Edinb 2009;39(4):290–1.

Appendices

Appendix A: Western University Health Science Research Ethics Board approval.

Western Research

Research Ethics

Western University Health Science Research Ethics Board
HSREB Delegated Initial Approval Notice

Principal Investigator: Dr. Amit Garg
Department & Institution: Schulich School of Medicine and Dentistry\Epidemiology & Biostatistics, London Health Sciences Centre

Review Type: Delegated
HSREB File Number: 106775
Study Title: Preventive healthcare among physicians
Sponsor:

HSREB Initial Approval Date: August 11, 2015
HSREB Expiry Date: August 11, 2016

Documents Approved and/or Received for Information:

Document Name	Comments	Version Date
Western University Protocol		2015/07/24
Data Collection Form/Case Report Form	ICES data collection form- V1	2015/06/26

The Western University Health Science Research Ethics Board (HSREB) has reviewed and approved the above named study, as of the HSREB Initial Approval Date noted above.

HSREB approval for this study remains valid until the HSREB Expiry Date noted above, conditional to timely submission and acceptance of HSREB Continuing Ethics Review.

The Western University HSREB operates in compliance with the Tri-Council Policy Statement Ethical Conduct for Research Involving Humans (TCPS2), the International Conference on Harmonization of Technical Requirements for Registration of Pharmaceuticals for Human Use Guideline for Good Clinical Practice Practices (ICH E6 R1), the Ontario Personal Health Information Protection Act (PHIPA, 2004), Part 4 of the Natural Health Product Regulations, Health Canada Medical Device Regulations and Part C, Division 5, of the Food and Drug Regulations of Health Canada.

Members of the HSREB who are named as Investigators in research studies do not participate in discussions related to, nor vote on such studies when they are presented to the REB.

The HSREB is registered with the U.S. Department of Health & Human Services under the IRB registration number IRB 00000940.

[redacted]

Ethics Officer, on behalf of Dr. Marcelo Kremenchutzky, HSREB Vice Chair

Ethics Officer to Contact for Further Information

Erika Basile	Grace Kelly	Mina Mekhail	Vikki Tran
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Appendix B: RECORD and STROBE checklist.

	Item No.	STROBE items	RECORD items	Reported
Title and abstract	1	(a) Indicate the study's design with a commonly used term in the title or the abstract. (b) Provide in the abstract an informative and balanced summary of what was done and what was found.	(1.1) The type of data used should be specified in the title or abstract. When possible, the name of the databases used should be included. (1.2) If applicable, the geographic region and time frame within which the study took place should be reported in the title or abstract. (1.3) If linkage between databases was conducted for the study, this should be clearly stated in the title or abstract.	Title and abstract
Introduction				
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported.		Introduction
Objectives	3	State specific objectives, including any prespecified hypotheses.		Introduction
Methods				
Study design	4	Present key elements of study design		Study design

		early in the paper.		
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection.		Study design
Participants	6	(a) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up. (b) For matched studies, give matching criteria and number of exposed and unexposed.	(6.1) The methods of study population selection (such as codes or algorithms used to identify subjects) should be listed in detail. If this is not possible, an explanation should be provided. (6.2) Any validation studies of the codes or algorithms used to select the population should be referenced. If validation was conducted for this study and not published elsewhere, detailed methods and results should be provided. (6.3) If the study involved linkage of databases,	Study population

			consider use of a flow diagram or other graphical display to demonstrate the data linkage process, including the number of individuals with linked data at each stage.	
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable.	(7.1) A complete list of codes and algorithms used to classify exposures, outcomes, confounders, and effect modifiers should be provided. If these cannot be reported, an explanation should be provided.	Data Sources, Appendix
Data sources/measurement	8	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group.		Data sources
Bias	9	Describe any efforts to		Methods, Discussion

		address potential sources of bias.		
Study size	10	Explain how the study size was arrived at.		Not applicable; use of existing health records
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why.		Other measures, Results
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding. (b) Describe any methods used to examine subgroups and interactions. (c) Explain how missing data were addressed. (d) If applicable, explain how loss to follow-up was addressed. (e) Describe any sensitivity analyses.		Statistical analysis, Results

Data access and cleaning methods		N/A	(12.1) Authors should describe the extent to which the investigators had access to the database population used to create the study population. (12.2) Authors should provide information on the data cleaning methods used in the study.	Data sources, Results
Linkage		N/A	(12.3) State whether the study included person-level, institutional-level, or other data linkage across two or more databases. The methods of linkage and methods of linkage quality evaluation should be provided.	Methods
Results				
Participants	13	(a) Report numbers of individuals at each stage of study--e.g. numbers potentially eligible, examined for eligibility, confirmed eligible, included 13 in the study,	(13.1) Describe in detail the selection of the persons included in the study (i.e., study population selection), including filtering based on data quality, data availability, and linkage. The selection of included persons	Study population, Results

		completing follow-up, and analyzed. (b) Give reasons for non-participation at each stage. (c) Consider use of a flow diagram.	can be described in the text and/or by means of the study flow diagram	
Descriptive data	14	(a) Give characteristics of study participants (e.g. demographic, clinical, social) and information on exposures and potential confounders. (b) Indicate number of participants with missing data for each variable of interest. (c) Summarize follow-up time (e.g. average and total amount).		Results
Outcome Data	15	Report numbers of outcome events or summary measures over time.		Results

Main results	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (e.g. 95% confidence interval). Make clear which confounders were adjusted for and why they were included (b) Report category boundaries when continuous variables were categorized. (c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period.		Results
Other analyses	17	Report other analyses done (e.g. analyses of subgroups and interactions, and sensitivity analyses).		Results, Appendix
Key results	18	Summarize key results with reference to study objectives.		Results, Discussion
Limitations	19	Discuss limitations of	(19.1) Discuss the implications	Discussion

		the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias.	of using data that were not created or collected to answer the specific research question(s). Include discussion of misclassification bias, unmeasured confounding, missing data, and changing eligibility over time, as they pertain to the study being reported.	
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence.		Discussion
Generalizability	21	Discuss the generalizability (external validity) of the study results.		Discussion
Other information				
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which		Funding/Support; Financial disclosure

		the present article is based.		
Accessibility of protocol, raw data, and programming code		N/A	(22.1) Authors should provide information on how to access any supplemental information such as the study protocol, raw data, or programming code.	N/A

Appendix C: Codes used to define colorectal tests.

Outcome	Dates	Codes used in study
Fecal occult blood test	**OHIP:** 1991 to 3 months ago	**OHIP feecode:** Any one of i) to v) i) L179, ii) Q152, iii) L181, iv) G004, v) Q133.
Flexible sigmoidoscopy	**OHIP:** 1991 to 3 months ago	**OHIP feecode:** Any one of i) to xi) and ABSENCE of the following 3 codes on the date the code below is present: E741 or E747 or E705. i) Z580 ii) Z555 iii) Z491 iv) Z492 v) Z493 vi) Z494 vii) Z495 viii) Z496 ix) Z497 x) Z498 xi) Z499
Colonoscopy	**OHIP:** 1991 to 3 months ago	**OHIP feecode:** Any one of i) to x) i) Z555 and (E741 or E747 or E705) ii) Z491 and (E741 or E747 or E705) iii) Z492 and (E741 or E747 or E705) iv) Z493 and (E741 or E747 or E705) v) Z494 and (E741 or E747 or E705) vi) Z495 and (E741 or E747 or E705) vii) Z496 and (E741 or E747 or E705) viii) Z497 and (E741 or E747 or E705) ix) Z498 and (E741 or E747 or E705) x) Z499 and (E741 or E747 or E705)

Abbreviations: OHIP, Ontario Health Insurance Plan.

Appendix D: Uptake of colorectal tests in matched physicians and non-physicians: Subgroup analysis by age. [*,†]

Age group	Physicians	Non-physicians	Prevalence difference (%) (95% CI)	Prevalence ratio‡ (95% CI)	Interaction P value§
	No. tested/ total no. (%)	No. tested/ total no. (%)			
52 to 59	3444/5181 (66.5)	12 803/20 726 (61.8)	4.7 (3.3 to 6.1)	1.08 (1.05–1.10)	
60 to 69	3517/5084 (69.2)	14 269/20 333 (70.2)	-1.0 (-2.4 to 0.4)	0.99 (0.97–1.01)	<0.001
70 to 74	801/1169 (68.5)	3408/4677 (72.9)	-4.4 (-7.4 to -1.5)	0.94 (0.90–0.98)	

Abbreviations: CI; confidence interval.

[*] Uptake was defined by a record of any the following as of April 21, 2016: (i) a fecal occult blood test in the past two years, (ii) flexible sigmoidoscopy in the past five years, or (iii) colonoscopy in the past 10 years.

† Individuals who received multiple tests during the screening period were counted only once for the composite outcome of fecal occult blood testing, flexible sigmoidoscopy, or colonoscopy.

‡Prevalence ratios were derived from modified Poisson regression models using generalized estimating equations to account for the correlation structure within matched sets.

§ The P value was calculated using an interaction term in the modified Poisson regression model.

Appendix E: Uptake of colorectal tests in matched physicians and non-physicians: Subgroup analysis by sex. [*,†]

Sex	Physicians	Non-physicians	Prevalence difference (%) (95% CI)	Prevalence ratio (95% CI) ‡	Interaction P value§
	No. tested/ total no. (%)	No. tested/ total no. (%)			
Men	5391/8056 (66.9)	21 268/32 224 (66.0)	0.9 (-0.2 to 2.1)	1.01 (1.00–1.03)	0.31
Women	2371/3378 (70.2)	9212/13 512 (68.2)	2.0 (0.3 to 3.7)	1.03 (1.00–1.06)	

Abbreviations: CI; confidence interval.

[*] Uptake was defined by a record of any the following as of April 21, 2016: (i) a fecal occult blood test in the past two years, (ii) flexible sigmoidoscopy in the past five years, or (iii) colonoscopy in the past 10 years.

† Individuals who received multiple tests during the screening period were counted only once for the composite outcome of fecal occult blood testing, flexible sigmoidoscopy, or colonoscopy.

‡ Prevalence ratios were derived from modified Poisson regression models using generalized estimating equations to account for the correlation structure within matched sets.

§ The P value was calculated using an interaction term in the modified Poisson regression model.

Curriculum vitae

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	The University of Western Ontario London, Ontario, Canada 2015-2019 M.Sc., Epidemiology & Biostatistics
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