Evaluating the Uptake and Disparities in Colorectal Cancer Screening in Canada: A Cross-sectional Study Using Data from the Canadian Community Health Surveys

By

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Abstract

Background: Colorectal cancer (CRC) screening is recognised as a critical public health tool in reducing incidence and mortality of CRC, yet participation rates in Canada exhibit significant regional, racial, and sociodemographic disparities. Understanding these disparities and the various factors influencing screening behaviour is essential for developing targeted interventions and policies to increase equitable screening uptake and reduce the burden of CRC.

Aim: This thesis explores the complexities of CRC screening uptake in Canada by examining regional variations, racial and sociodemographic disparities, and concurrent participation in multiple cancer screenings.

Methods: Three studies were conducted using data from multiple cycles of the Canadian Community Health Survey (CCHS). The first study analysed CRC screening uptake in the Atlantic Provinces, focusing on changes in barriers and predictors of screening post-implementation of provincial CRC screening programs across the four provinces in the region. This study uses the 2010 and 2017 CCHS datasets, the most recent CCHS surveys with CRC screening data for all provinces. The second study explored racial and sociodemographic disparities in CRC screening at the national level, assessing participation rates across the different population groups, using the 2017 CCHS datasets. The third study investigated the factors influencing concurrent participation in breast, cervical, and CRC screenings among Canadian women eligible for all three screening programs, using the 2017 CCHS datasets. The methodologies for the studies all included cross-sectional analyses and in-depth statistical evaluations of survey data.

Results: The first study found an increase in CRC screening uptake in the Atlantic Provinces from an average of 42% in 2010 to 54% in 2017, post-implementation of CRC screening programs, but with notable variations across the different provinces. The second study revealed a national CRC screening participation rate of 59.8%, with lower rates among lower income, immigrants, and certain minority groups, particularly South-East Asians and South Asians. The third study found that participation in both cervical and breast cancer screening (64%) was notably higher than CRC screening (53.7%), and only 27% of women participated in all three cancer screenings, with socioeconomic status and lifestyle factors being significant predictors of concurrent screening behaviors.

Conclusions: This research provides a general understanding of CRC screening participation in Canada, highlighting the need for region-specific strategies, culturally sensitive health promotion, and integrated screening approaches. The findings underscore the importance of addressing both regional and sociodemographic disparities in CRC screening. This thesis contributes to public health knowledge by identifying key areas for intervention and future research, ultimately aiming to improve CRC screening uptake and reduce disparities in cancer care.

Key Words: colorectal cancer, screening, healthcare disparities, sociodemographic factors, public health, Canada, regional variations, concurrent screening.

General Summary

Colorectal cancer (CRC) is a major public health concern and a leading cause of cancer-related deaths. Early detection through screening is crucial for reducing mortality rates. However, despite the availability of screening programs, participation rates vary widely across Canada. This thesis aimed to explore these variations in CRC screening, focusing on three critical aspects: regional differences, racial and sociodemographic differences, and the participation in multiple cancer screenings among Canadian women who are eligible for multiple screening programs.

The first part of the thesis examined the effect of CRC screening programs in Canada's Atlantic Provinces. Prior to these programs, CRC screening rates were relatively low in this region. The introduction of organised screening programs aimed to increase participation. The study found that although screening rates improved from 42% to 54% on average, they still fell short of the national target of 60%. Notably, there was differences in progress across these provinces, highlighting the necessity of targeted strategies that cater to each province's distinct demographic and healthcare characteristics.

The second study shifted focus to a broader national perspective, exploring racial and sociodemographic variations in CRC screening across Canada. The study found that while the overall national screening rate was almost 60%, participation varied among different population sub-groups. Lower income, immigrants, and certain minority ethnic groups, especially those from South-East Asian and South Asian backgrounds, participated less in CRC screening. This suggests that barriers like cultural differences, language issues, and systemic challenges are influential and highlight the need for culturally sensitive, inclusive health communication and educational approaches.

The third part investigates the simultaneous involvement of eligible Canadian women in breast, cervical, and CRC screenings. Surprisingly, only a quarter participate in all three, with those of higher income and healthier lifestyles being more likely to screen.

Together, this research offers broader view of CRC screening in Canada, identifying key gaps and opportunities for improvement. It suggests that local-focused health policies and inclusive communication strategies are crucial for effectively engaging diverse populations.

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List of Abbreviations

APC - Adenomatous Polyposis Coli

ASIR - Age-standardized Incidence rates

ASMR - Age-standardized Mortality rates

BMI — Body mass index

Biallelic - A mutation that occurs on both alleles of a single gene

CRC - Colorectal cancer

CCHS - Canadian Community Health Survey

CTFPHC - Canadian Task Force on Preventive Health Care

FAP - Familial adenomatous polyposis

FIT - Fecal Immunochemical Test

FOBT - Fecal occult Blood Test

HCAs - Heterocyclic amines

HNPCC - Hereditary Non-Polyposis colorectal cancer

IL-6 - interleukin-6

NL - Newfoundland & Labrador

MAP - MUTYH-associated polyposis

MMR - DNA Mismatch Repair gene

RCT - Randomised Controlled Trial

TNF-ɑ - tumor necrosis factor-alpha

TME - Tumor Microenvironment

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1. **Chapter One:** Overview and Introductions

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1.1. Overview

Colorectal cancer (CRC) remains a significant public health concern in Canada, representing the third most commonly diagnosed cancer and a leading cause of cancer-related morbidity and mortality (Tung et al., 2018; Canadian Cancer Society, 2022). Despite being one of the few cancers that can be effectively prevented and diagnosed early through consistent participation in screening programs, the burden of CRC in Canada continues to be a growing public health issue (Araghi et al., 2019; Arnold et al., 2017; Brenner et al., 2022).

However, there is inadequate national-level data to evaluate CRC screening patterns, trends, and gaps across the country. Furthermore, there is a paucity of studies investigating the facilitators and barriers to CRC screening participation at the national level (Lee et al., 2023). This study, leveraging data from the Canadian Community Health Surveys, aims to address these gaps by shedding light on the uptake and disparities in CRC screening across the country, evaluating the various factors influencing participation, and assessing the effect of organised provincial screening programs in improving CRC screening participation, particularly in the Atlantic provinces.

1.2. Colorectal Cancer in Canada: A Public Health Concern

The burden of CRC in Canada is substantial and concerning, with an estimated 24,300 new cases and 9,400 deaths in 2022 (Canadian Cancer Society, 2022). While the incidence and mortality rates have declined in recent decades, likely due to reduced risk factors, improved screening, and advancements in treatment, there are concerning trends that warrant attention (Brenner et al., 2022).

One such trend is the increasing incidence of CRC among adults aged under 50 years old in both Canada and the United States. In 2019, 20% of CRC cases in the U.S. were in people under 55, nearly double the 11% rate in 1995 (Siegel et al., 2023). A similar pattern is emerging in Canada (Canadian Cancer Society, 2023). The increasing rates among people in their under 50 are thought to be driven by factors such as unhealthy diet, physical inactivity, smoking, alcohol consumption, and family history (Araghi et al., 2019; Canadian Cancer Society, 2023). Additionally, CRC is being diagnosed at more advanced stages in younger adults (Blair et al., 2022), further exacerbating the burden.

Looking ahead, CRC incidence and mortality rates in Canada are projected to increase from 2030 onward, driven primarily by rising rates in the 40-59 age group, despite expected decreases among people aged over 70 over the next decade (Cancer Care Ontario, 2020; Poirier et al., 2019). Population growth and aging are contributory factors to this projected increase (Poirier et al., 2019).

Organised CRC screening programs in Canada recommend testing for average-risk adults aged 50-74. This has contributed to better early detection and survival rates (Canadian Partnership Against Cancer, 2019), still more targeted interventions may be needed to address the increasing burden, especially among lower-income groups and adults aged 50-59 (Poirier et al., 2019).

In summary, despite overall declining CRC rates, the rising incidence among younger adults and particularly among lower socioeconomic groups, represent concerning trends that necessitate further research. Such evidence can inform public health action to improve screening participation across the country and possibly mitigate the growing concerns around CRC.

1.3. Disparities in CRC Screening Participation

One of the critical aspects of CRC screening in Canada is the evident disparities in participation across various sociodemographic lines, including income, education, and race (Singh et al., 2015; Blair et al., 2022). Current understanding suggests that lower-income groups and individuals with less education are often less likely to participate in CRC screening (Amina et al., 2019; Baccolini et al., 2022). Similarly, racial, and ethnic minorities in different parts of the country report lower screening rates compared to people who identify as white or have higher socioeconomic status (Amina et al., 2019; Baccolini et al., 2022).

These disparities are often rooted in systemic issues beyond individual choices. Factors such as access to healthcare, cultural barriers, language proficiency, and lack of trust in the healthcare system can and often play significant roles in influencing participation rates (Blair et al., 2019). Addressing such disparities require a clear understanding of the complex, interconnected factors that shape health care behaviour and decisions, and a concerted effort involving healthcare providers, policymakers, community leaders, and organisations that work directly with various population groups.

1.4. Organised Screening Programs in Canada

Organised CRC screening programs have been established in several Canadian provinces with the goal of increasing screening rates and reducing the incidence and mortality of CRC (Canadian Partnership Against Cancer, 2020). These programs typically involve sending screening invitations and test kits to eligible individuals aged 50-74 years old, providing easy access to screening tests, and ensuring follow-up care for those with abnormal results (Canadian Partnership Against Cancer, 2020).

While these programs have reportedly contributed to increasing screening participation rates, their effectiveness is likely to vary across regional and provincial lines. Factors such as program design, implementation strategies, and resource allocation play critical roles in determining their success and effects of the screening programs (Brouwers et al., 2011). Moreover, these programs are not immune to the disparities and inequalities mentioned above. There is, therefore, a need to tailor these programs to better reach and serve underserved populations. Such interventions will require a thorough understanding of the barriers these groups face and the development of targeted strategies to overcome them.

1.5. Comparative Analysis with Other Cancer Screening Programs

In addition to focusing on CRC screening, this study also undertakes a comparative analysis with participation in other cancer screening programs, namely breast and cervical cancer. This assessment is crucial in understanding the broader context of cancer screening in Canada and identifying shared challenges and opportunities. Similar to CRC, breast and cervical cancer screenings also face issues related to disparities in participation and the effectiveness of organised screening programs (Adu et al., 2017; Alam et al., 2022).

By comparing CRC screening with breast and cervical cancer screening participation, this study aims to draw insights that could inform more effective screening strategies across different types of cancer. Also, CRC screening participation might benefit from better understanding of the various factors associated with participation in other cancer screening programs.

1.6. Thesis Goal and Objectives

The overall aim of this thesis is to provide a comprehensive evaluation of CRC screening participation in Canada, with a focus on identifying disparities, barriers, and determinants of screening uptake. The specific objectives include:

1. To assess the effect of organised provincial CRC screening programs in Atlantic Canada on screening participation rates, and to compare the factors associated with screening participation before and after the establishment of these programs. (Paper 1)
2. To examine the current state of CRC screening participation across Canada by assessing sociodemographic and racial disparities in screening uptake and identifying associated factors affecting participation. (Paper 2)
3. To investigate the patterns of concurrent participation in breast, cervical, and CRC screening among Canadian women, and to identify factors associated with concurrent participation in some or all three screening programs. (Paper 3)
4. To provide a comprehensive understanding of the facilitators and barriers to CRC screening participation in Canada, with a particular focus on disparities among different population groups.

5. To inform the development of targeted strategies and interventions aimed at improving CRC screening participation rates, reducing disparities, and addressing the barriers faced by underserved populations.

1.7. Theoretical Framework: Andersen's Behavioral Model of Health Services Use

To provide a comprehensive understanding of the factors influencing CRC screening participation and to interpret the findings from this research, the Andersen's Behavioral Model of Health Services Use will be employed as the overarching theoretical framework.

The Andersen Behavioral Model, initially developed in the 1960s and subsequently revised, offers a conceptual framework for examining the determinants of health services utilisation (Alkhawaldeh et al., 2023; Andersen, 1995; Jin et al., 2019). The model posits that an individual's use of health services is influenced by three main groups or categories of factors: predisposing characteristics, enabling resources, and need (Alkhawaldeh et al., 2023; Andersen, 1995).

Predisposing characteristics include demographic factors (e.g., age, sex, marital status), social structure (e.g., education, ethnicity, occupation), and health beliefs (e.g., attitudes, values, knowledge about health and illness).

Enabling resources refer to the means and resources available to individuals that facilitate or impede the use of health services. These include personal and family resources (e.g., income, health insurance), as well as community resources (e.g., availability and accessibility of healthcare facilities).

The need factor encompasses both perceived and evaluated need for healthcare services. Perceived need refers to an individual's subjective assessment of their health and functional status, while evaluated need is based on professional assessments of an individual's health status and the necessity for medical care (Alkhawaldeh et al., 2023; Lee et al., 2019; Jin et al., 2019).

In the context of CRC screening, the Andersen's Behavioral Model provides a comprehensive framework for understanding the complex interplay of predisposing, enabling, and need factors that influence an individual's decision to participate in screening programs (Lee et al., 2019; Jin et al., 2019). By examining these factors, this research aims to identify the barriers and facilitators to screening participation, as well as the disparities that exist among different sociodemographic and racial groups.

The application of this theoretical framework will guide the interpretation of the key findings from the three studies in this thesis, allowing for a deeper understanding of the determinants of CRC screening participation in Canada. Additionally, we hope that the insights gained from this research can inform the development of targeted interventions and strategies aimed at addressing the identified barriers and disparities, ultimately improving screening participation rates and reducing the burden of CRC in the country.

2. **Chapter Two:** Background

Chapter Two: Background

2.1. Colorectal Cancer: An overview

CRC remains a significant challenge in the global battle against cancer. Globally, CRC ranks third in terms of incidence and second in mortality, accounting for approximately 1.8 million new cases and 881,000 deaths in 2018 (Bray et al., 2018). The rates of both incidence and mortality are substantially higher in males than in females (Sung et al., 2021). In North America, CRC remains a significant public health concern, with the United States and Canada collectively reporting over 170,000 new cases annually (Siegel et al., 2020). Specifically, in Canada, CRC is the second most commonly diagnosed cancer in women and the third in men, with an estimated 24,300 Canadians diagnosed with CRC – accounting for 10% of all new cancer cases in 2022 and 9,400 deaths, representing 11% of all cancer-related deaths in 2022 alone (Canadian Cancer Statistics Advisory Committee, 2022). As a complex malignancy that originates from the inner lining of the colon or rectum, both parts of the large intestine, the impact of CRC extends beyond these statistics as it affects individuals, families, and healthcare systems in complex, multifaceted ways (American Cancer Society, 2020).

As one of the most prevalent cancers globally, understanding its biology and natural history is paramount for effective prevention, early detection, and treatment. Moreover, the burden of CRC in Atlantic Canada is particularly noteworthy, with the region exhibiting a higher prevalence of risk factors and incidence of CRC compared to other parts of the country (Brenner et al., 2020; Canadian Cancer Statistics Advisory Committee, 2020b; Marrett et al., 2008). Consequently, this chapter provides a broad look at CRC, from the structure of the large intestine and risk factors of CRC to natural history of the disease. It also reviews the implementation of CRC screening programs in Atlantic Canada and across the country aimed at reducing the personal, health system and economic burden of this important cancer.

2.2. The Large Intestine

The large intestine is essentially a tubular structure that forms the terminal part of the gastrointestinal track. The large intestine commences at the terminal ileum, which is the last part of the small intestine, as the cecum (Loda et al., 2017). Macroscopically, the large intestine is divided into the right/proximal colon and the left/distal colon. The right colon consists of the cecum, ascending colon, hepatic flexure, and transverse colon. The left colon consists of the descending colon, the splenic flexure and the sigmoid colon. Measured endoscopically, the rectum is about 15cm long and is often misclassified as the colon (Loda et al., 2017).

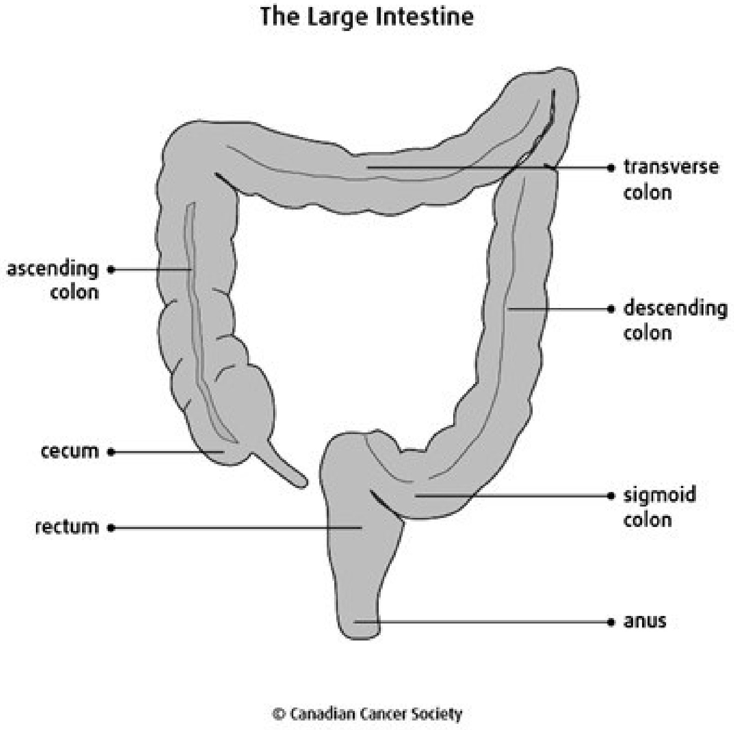


Figure 2.1: Overview of the Large Intestine and Rectum *(From: Canadian Cancer Society n.d. - in the public domain)*

Microscopically, the tube-like structure of the colon has four layers. From the inside out these layers include, the single lining of columnar epithelia cells called the mucosa, where most colorectal tumour (adenomas) arise, the sub-mucosa, the muscularis layer and lastly, the serosa, which is the outer connective tissue. (Loda et al., 2017).

The mucosa layer of the colon is of particular interest in CRC as this is where adenomas form (Loda et al., 2017). Microscopically, the colorectal mucosa layer consists of a single, flat layer of columnal epithelia cells, including goblet cells that secrete mucus. The flat layer is punctuated at intervals by blindly ending tubular structures called *the crypts of Lieberkuhn* (or just crypts) (Loda et al., 2017). Current evidence suggest that proliferative activities occur at the bottom of these crypts, from where new cells travel upwards towards the surface. Abnormal proliferative activities most likely beginning in these crypts, likely due to genetic changes, form the basis and beginning of CRC tumours (Boffetta & Hainaut, 2019; Loda et al., 2017).

The contents of the colon range from mostly fluid in the cecum and proximal colon, then progressively semi-solid and solid towards the end of the distal colon as water and electrolyte absorption occur throughout the colon (Loda et al., 2017; Song et al., 2015). The key contents of the colon that impact CRC risk include dietary fibre, undigested residue, bacteria, faecal bile salts and fat. Excess of bile salts, undigested dietary fat, and proliferation of certain types of bacteria have been suggested as among dietary exposures that play key roles in development of colorectal tumours (Coussens & Werb, 2002; Loda et al., 2017; Song et al., 2015; Yamagishi et al., 2016).

2.3. Risk Factors of Colorectal Cancer

CRC is a complex malignancy. Like most cancers, its etiology is multifactorial, with genetic determinants, environmental exposures, and lifestyle choices and behaviors all contributing to its development (Rustgi, 2007; Yamagishi et al., 2016). Epidemiologically, CRC cases can be broadly categorized into two main types based on their origin: sporadic or genetic (Rustgi, 2007; Yamagishi et al., 2016). Sporadic CRC, the most common type, accounts for over 80% of new cases and occurs without a clear hereditary link or identifiable high-risk genetic mutations (American Cancer Society, 2020).

While genetic CRC accounts for a smaller proportion of cases (estimated at 5-15%), up to 25% of those diagnosed with CRC have a family history of the disease (Rustgi, 2007; Yamagishi et al., 2016). This suggests that there are still unknown genetic factors that contribute to CRC risk, beyond currently identifiable high-penetrance mutations (Loda et al., 2017; Rustgi, 2007; Yamagishi et al., 2016). The complex interplay of factors contributing to CRC susceptibility can be broadly categorised as modifiable risk factors (significant in sporadic CRC) and genetic risks (inherited mutations).

2.3.1. Modifiable Risk Factors of CRC

Modifiable risk factors encompass lifestyle choices, behaviors, and exposures that significantly influence the risk of developing CRC (Hay et al., 2016; Rawla et al., 2019). These include a diet high in red and processed meats, physical inactivity, obesity, excessive alcohol consumption, and long-term smoking.

Diets high in red and processed meats have been consistently linked to increased CRC risk. When cooked at high temperatures, these meats produce carcinogenic compounds like heterocyclic amines (HCAs) and polycyclic aromatic hydrocarbons (PAHs), which can damage colonic cell DNA (Song et al., 2015; World Cancer Research Fund, 2018). Additionally, the typical "Western diet," characterized by high fat, high phosphate, low calcium, and low vitamin content, has been shown to trigger early-onset intraepithelial neoplasia in animal models and may contribute to the higher CRC incidence in Western countries (Greten & Grivennikov, 2019; Song et al., 2015). Conversely, diets rich in fruits, vegetables, and whole grains offer protective benefits, likely due to their high fiber content and antioxidants, which counteract carcinogenic effects (Coussens & Werb, 2002; Greten & Grivennikov, 2019).

Physical inactivity and obesity, which often lead to chronic inflammation, also increase CRC risk. Chronic inflammation, marked by the release of pro-inflammatory cytokines like tumor necrosis factor-alpha (TNF-ɑ) and interleukin-6 (IL-6), can cause DNA damage and promote tumor growth in the colon and rectum in humans (Coussens & Werb, 2002; Greten & Grivennikov, 2019; Loda et al., 2017). Excessive alcohol consumption and prolonged smoking further compromise immune responses and increase CRC susceptibility (Clinton et al., 2020; World Cancer Research Fund, 2018).

While the precise pathways through which these dietary and lifestyle factors contribute to carcinogenesis are not fully understood, research suggests processed meats produce HCAs, PAHs, and N-nitroso compounds during digestion, all of which are carcinogenic and can induce DNA mutations in colon cells (Coussens & Werb, 2002; Greten & Grivennikov, 2019). In essence, CRC develops due to the progressive accumulation of genetic mutations and damage. Its etiology can be conceptualised as occurring across multiple levels as illustrated in Figure 2.2 below. The figure illustrates how the interplay between the various risk factors, the mechanisms of action of these factors on the colon epithelium, genetic changes, and finally, the morphological transformation of normal colorectal mucosa cells all progressively lead to carcinogenesis in the colon and rectum (Yamagishi et al., 2016).

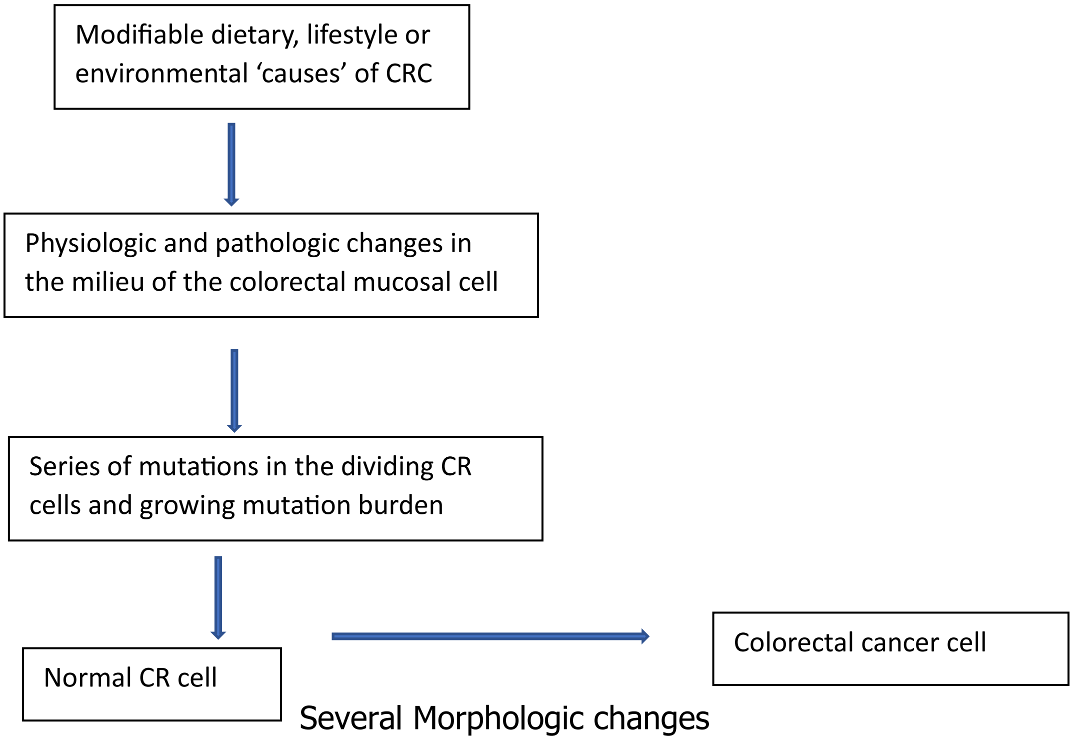


Figure 2.2: Overview of changes from normal colorectal cell to CRC

2.3.2. Genetic Risk factors

While most CRC cases are sporadic, a notable proportion can be attributed to inherited gene mutations (known as hereditary or familial CRC). Several specific genetic disorders, most of which are inherited in an autosomal dominant fashion, are associated with a very high risk of developing colon cancer (Rustgi, 2007). Familial adenomatous polyposis (FAP) and Lynch syndrome (hereditary nonpolyposis colorectal cancer [HNPCC]) are the most common of the hereditary colon cancer syndromes. Together, these two conditions account for about 5-15% of CRC cases, with Lynch syndrome being the more prevalent of the two (Arnold et al., 2020; Rustgi, 2007). However, as mentioned previously, a large proportion of sporadic CRC cases also carry one or more mutations in cancer-predisposing genes; the majority of these are not Lynch syndrome or FAP (Arnold et al., 2020). In fact, there is a growing consensus that genetic factors play a critical role in the development and progression of almost all colorectal tumors (Boffetta & Hainaut, 2019). Similar molecular genetic lesions have been found in both sporadic and familial colorectal neoplasms (Boffetta & Hainaut, 2019; Greten & Grivennikov, 2019).

2.3.2.1. Familial Adenomatous Polyposis (FAP)

FAP was the first recognized polyposis syndrome and remains the best characterised (Greten & Grivennikov, 2019). It is an autosomal dominantly inherited syndrome marked by the emergence of hundreds to thousands of colorectal adenomatous polyps during the second or third decade of life (Rustgi, 2007). Patients with this disorder have a strong predisposition for early-onset colorectal cancer, as well as other malignancies (Greten & Grivennikov, 2019). Synonyms for FAP include familial polyposis coli and adenomatous polyposis coli. Additionally, several variants of the syndrome exist, namely Gardner syndrome, Turcot syndrome, and attenuated adenomatous polyposis coli (AAPC or AFAP) (Curia et al., 2020). Men and women are equally affected. Only a small fraction (about 1%) of all CRC cases are due to FAP, and this fraction appears to be decreasing with improved diagnostic and preventive measures (Curia et al., 2020).

Mutations in the adenomatous polyposis coli (APC) gene, a tumor suppressor gene, are responsible for FAP syndrome (Coussens & Werb, 2002). One allele with the mutated gene is inherited from an affected parent. An acquired (somatic) mutation in the other APC allele results in developing adenomas, as the loss of both functioning copies of the APC gene allows uncontrolled cell growth (Coussens & Werb, 2002). It is worth noting that mutations of the APC gene also play a role in the development of sporadic colorectal cancers, with as many as 80% of sporadic CRC cases exhibiting somatic mutations of the APC gene (Greten & Grivennikov, 2019). However, the specific types and combinations of mutations differ between FAP and sporadic CRC (Coussens & Werb, 2002; Greten & Grivennikov, 2019).

The distinguishing presentation of FAP is the growth of profuse adenomatous colon polyps at a young age (Rustgi, 2007; Yamagishi et al., 2016). The average age of polyp development is 16 years, but polyps can emerge in patients as young as eight (Rustgi, 2007; Yamagishi et al., 2016). The number and size of these polyps increase over time, ultimately reaching anywhere from hundreds to thousands. The polyps have a slight predisposition for the distal (left-sided) colon (Greten & Grivennikov, 2019; Rustgi, 2007; Yamagishi et al., 2016).

Individual colon adenomas in patients with FAP are endoscopically and histologically identical to sporadic adenomatous polyps and do not have an intrinsically higher malignant potential (Greten & Grivennikov, 2019; Rustgi, 2007). However, nearly all patients with FAP will develop CRC due to the vast number and early onset of polyps (Curia et al., 2020; Greten & Grivennikov, 2019). Polyp number and age are key determinants of cancer risk: the more polyps and the younger the age of onset, the higher the risk. Without treatment, the average age of cancer onset is 39 years, and life expectancy is significantly reduced (Curia et al., 2020; Greten & Grivennikov, 2019; Rustgi, 2007).

2.3.2.2. MUTYH-associated Polyposis (MAP)

MUTYH-associated polyposis (MAP) is a similar but rarer form of hereditary CRC (Curia et al., 2020). MAP is an autosomal recessive syndrome caused by biallelic germline mutations in the base excision repair gene MUTYH (Curia et al., 2020). It can also present with multiple adenomas, typically fewer than the hundreds seen in FAP, and its manifestation can vary from individual to individual (Curia et al., 2020). There is growing evidence that germline mutations in the MUTYH gene may contribute to a substantial fraction of hereditary CRC cases that occur without a dominantly inherited genetic syndrome (Curia et al., 2020).

2.3.2.3. Lynch Syndrome (HNPCC)

Lynch syndrome (or HNPCC) is an autosomal dominant syndrome that is more common than FAP, accounting for about 2-5% of all CRC cases (Rustgi, 2007). Lynch syndrome is often suspected based on a strong family history of CRC, endometrial cancer, and other related cancers. The syndrome is named in honor of Dr. Henry Lynch, who pioneered research in this area (Rustgi, 2007).

Lynch syndrome is confirmed through genetic testing for disease-causing mutations in one of the DNA mismatch repair (MMR) genes, most commonly MLH1, MSH2, MSH6, or PMS2 (Rustgi, 2007). Individuals with Lynch syndrome typically have a germline mutation in one allele of an MMR gene, with the second allele inactivated by a somatic mutation (Rustgi, 2007).

These MMR genes are essential for correcting spontaneous errors during DNA replication (Rustgi, 2007). When damaged, these errors accumulate, leading to microsatellite instability (MSI) and a significantly increased risk of malignant transformation (Greten & Grivennikov, 2019; Rustgi, 2007; Yamagishi et al., 2016). Unlike the numerous polyps seen in polyposis disorders, individuals with Lynch syndrome usually develop fewer than ten polyps, which are often indistinguishable from sporadic polyps on endoscopy (Tamura et al., 2019; Yamagishi et al., 2016). However, compared to polyps in the general population, Lynch syndrome polyps tend to appear earlier (in the third or fourth decade of life), grow larger and more frequently, and progress to cancer more rapidly (Rustgi, 2007). In the absence of screening, most patients remain asymptomatic until cancer develops, making early detection through screening crucial (Greten & Grivennikov, 2019; Loomans-Kropp & Umar, 2019; Winawer et al., 1993).

The hallmark of Lynch syndrome is the predisposition to early-onset and/or multiple malignancies (Arnold et al., 2020; Arnold et al., 2017). Without intervention, patients with Lynch syndrome face an 80% lifetime risk of developing CRC, with an average age of onset 20 years earlier than sporadic CRC (Loomans-Kropp & Umar, 2019; Sung et al., 2021). CRCs in Lynch syndrome tend to be multiple, located proximally, and poorly differentiated (Rustgi, 2007; Yamagishi et al., 2016). There is also an increased risk of other cancers, including endometrial, ovarian, ureteral, renal pelvic, gastric, small intestinal, and hepatobiliary cancers (Loomans-Kropp & Umar, 2019; Sung et al., 2021). Even with aggressive management, the risk of cancer-related mortality remains significant (Leddin et al., 2018). Early identification of individuals at risk for Lynch syndrome is essential but can be challenging, as the diagnostic criteria continue to evolve (Leddin et al., 2018; Leddin et al., 2010).

2.3.2.4. Regional Considerations: Atlantic Canada

The Atlantic provinces of Canada have been shown to experience a relatively higher prevalence of CRC risk factors compared to other regions in Canada (Brenner et al., 2022; Ruan et al., 2023; Tung et al., 2018). The underlying reasons for this are not fully understood, but factors such as dietary habits, genetic predispositions, and environmental factors might contribute to this elevated risk (Ruan et al., 2023; Tung et al., 2018).

Regarding genetic predispositions, a combination of founder effects, genetic isolation, specific genetic syndromes, and gene-environment interactions have been suggested to contribute to the apparent higher genetic predisposition to CRC in the region (Tung et al., 2018). The region's demographic composition, with a higher proportion of older adults, may also play a role (Darvishian et al., 2023; Decker et al., 2023). Research efforts such as genome-wide association studies and whole-genome sequencing could help to uncover the specific genetic and environmental factors contributing to higher CRC risks in the region.

2.4. Natural History of Colorectal Cancer

Adenomatous polyps, resulting from intraepithelial neoplasia of the colon and rectum, represent one of the earliest precursors to colorectal carcinoma (Loda et al., 2017). The adenoma-carcinoma sequence describes the stepwise progression from normal colorectal epithelial cells to benign adenomas and then to invasive carcinomas (Winawer & Zauber, 2002; Yamagishi et al., 2016). The term "dysplasia" refers to the morphological, molecular, and histological changes in cellular structure and tissue architecture that characterize intraepithelial neoplasia (Coussens & Werb, 2002).

Current evidence supports the single crypt model as the origin of tumor development (Greten & Grivennikov, 2019; Loda et al., 2017; Yamagishi et al., 2016). This model proposes that tumor development begins with abnormal cellular changes in a single crypt of Lieberkühn, the blind-ended glands of the colon mucosa (Greten & Grivennikov, 2019). These changes involve two phases: increased cellular growth ("hyperproliferative cells") at the crypt base, followed by a shift in the proliferative compartment to the upper crypt, where new cells accumulate (Greten & Grivennikov, 2019; Yamagishi et al., 2016). Continued cell division sustains this hyperproliferation and alters the crypt, forming aberrant crypt foci (ACF), considered precursors to colon adenomatous polyps (Greten & Grivennikov, 2019; Yamagishi et al., 2016).

While progression from ACF to adenoma and then to carcinoma depends on adenoma size and dysplasia severity, evidence suggests that adenomas can progress, stabilise, or even regress (Yamagishi et al., 2016). Adenoma size is the most critical determinant of villous growth and dysplasia, while the level of dysplasia is the most significant risk factor for carcinogenesis (Greten & Grivennikov, 2019; Yamagishi et al., 2016).

This progression from ACF to carcinoma is gradual, typically taking 5-30 years, with a median of 10 years (Yamagishi et al., 2016). Although every adenoma has malignant potential, only a few progress to cancer (Greten & Grivennikov, 2019; Yamagishi et al., 2016). Most stabilise, some regress, and a small proportion may develop directly invasive clones (Yamagishi et al., 2016). Studies estimate the annual growth and transformation rate of adenomas at 0.25%, increasing to 17% for villous adenomas and 37% for those with high-grade dysplasia (Greten & Grivennikov, 2019; Yamagishi et al., 2016). Consequently, individuals with high-grade dysplasia adenomas have a significantly higher risk of metachronous cancer. Adenoma size and dysplasia level (low, moderate, high grade) are crucial in determining this risk (Boffetta & Hainaut, 2019; Loda et al., 2017; Yamagishi et al., 2016).

CRC symptoms typically manifest in the fifth or sixth decade of life and include changes in bowel habits, hematochezia (fresh blood in stool), abdominal pain, rectal pain, tenesmus (feeling of incomplete bowel emptying), and/or narrowed stools (; Loda et al., 2017; Winawer & Zauber, 2002). Constitutional symptoms like nausea, vomiting, unexplained weight loss, loss of appetite, weakness, fatigue, and dizziness may also occur (Greten & Grivennikov, 2019; Loda et al., 2017; Winawer & Zauber, 2002).

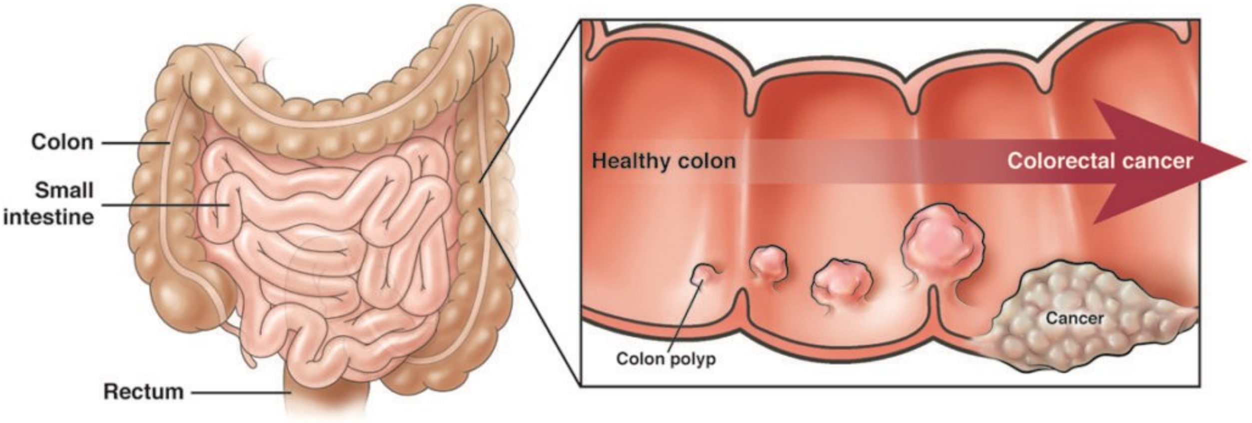


Figure 2.3: Sectional view of the Colon showing developing Polyp and Cancer *(From: American Gastroenterological Association, 2021 - in the public domain)*

2.5. Epidemiology of Colorectal Cancer

CRC is one of the most common neoplasms in humans and perhaps the most frequent form of hereditary neoplasia. CRC incidence and mortality rates vary markedly around the world and have changed significantly over the past couple of decades (Araghi et al., 2019; Arnold et al., 2017). According to the World Health Organization GLOBOCAN database, rates of both incidence and mortality are substantially higher in males than in females, and regional incidence and mortality of CRC varies over 10-fold (ASR incidence: 23.4 vs 16.2 per 100 000 worldwide; ASR mortality: 11.1 vs 7.2 per 100 000 worldwide, respectively) (Bray et al., 2018; Morgan et al., 2023), as seen in Figures 2.4 and 2.5 below. The highest incidence rates are in Australia and New Zealand, Europe, and North America, and the lowest rates are found in Africa and South-Central Asia (Morgan et al., 2023). These geographic differences appear to be attributable to differences in dietary, lifestyle, and environmental exposures that interact with a background of genetic susceptibility (American Cancer Society, 2020; Decker et al., 2023; Ferlay et al., 2015).

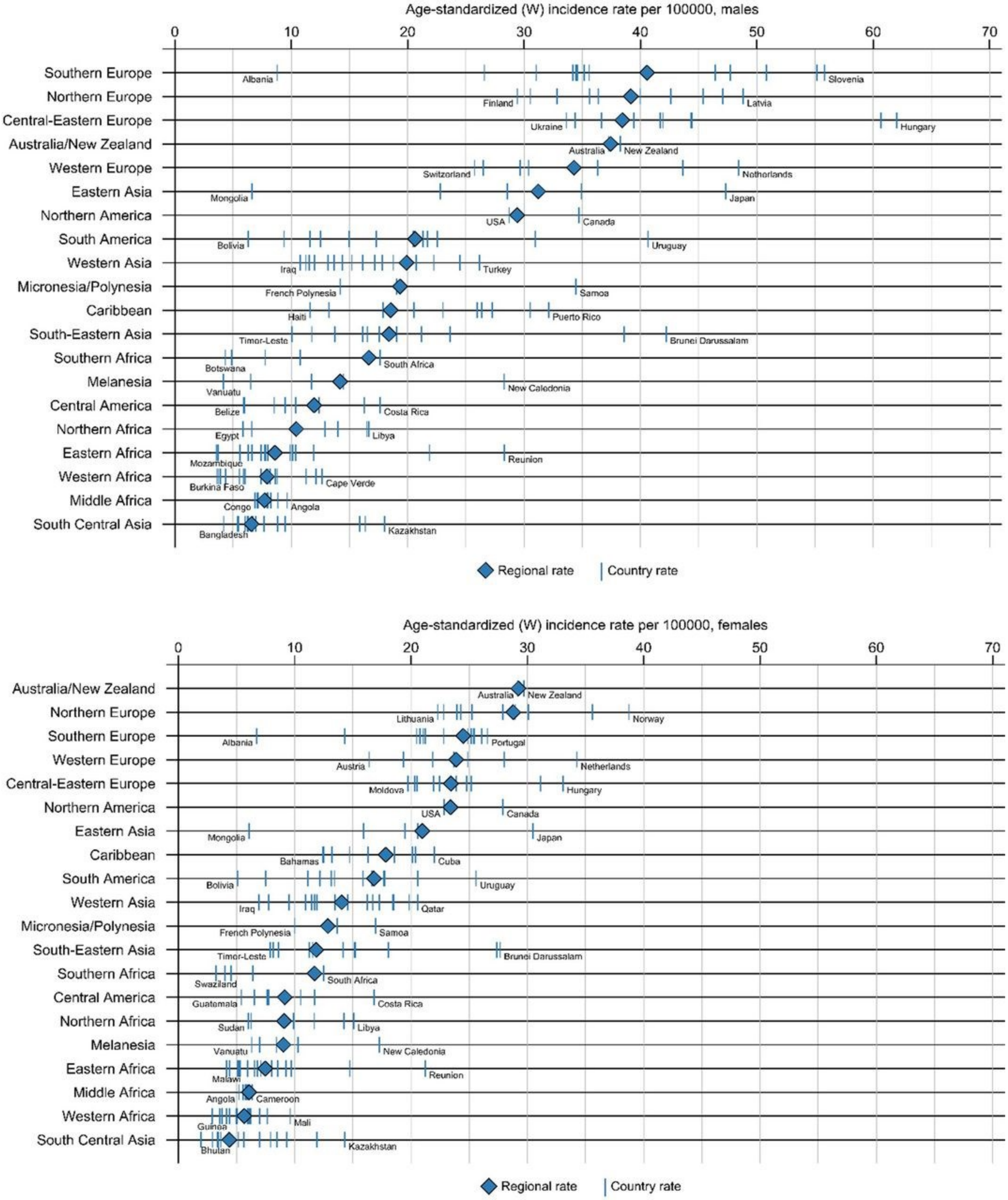
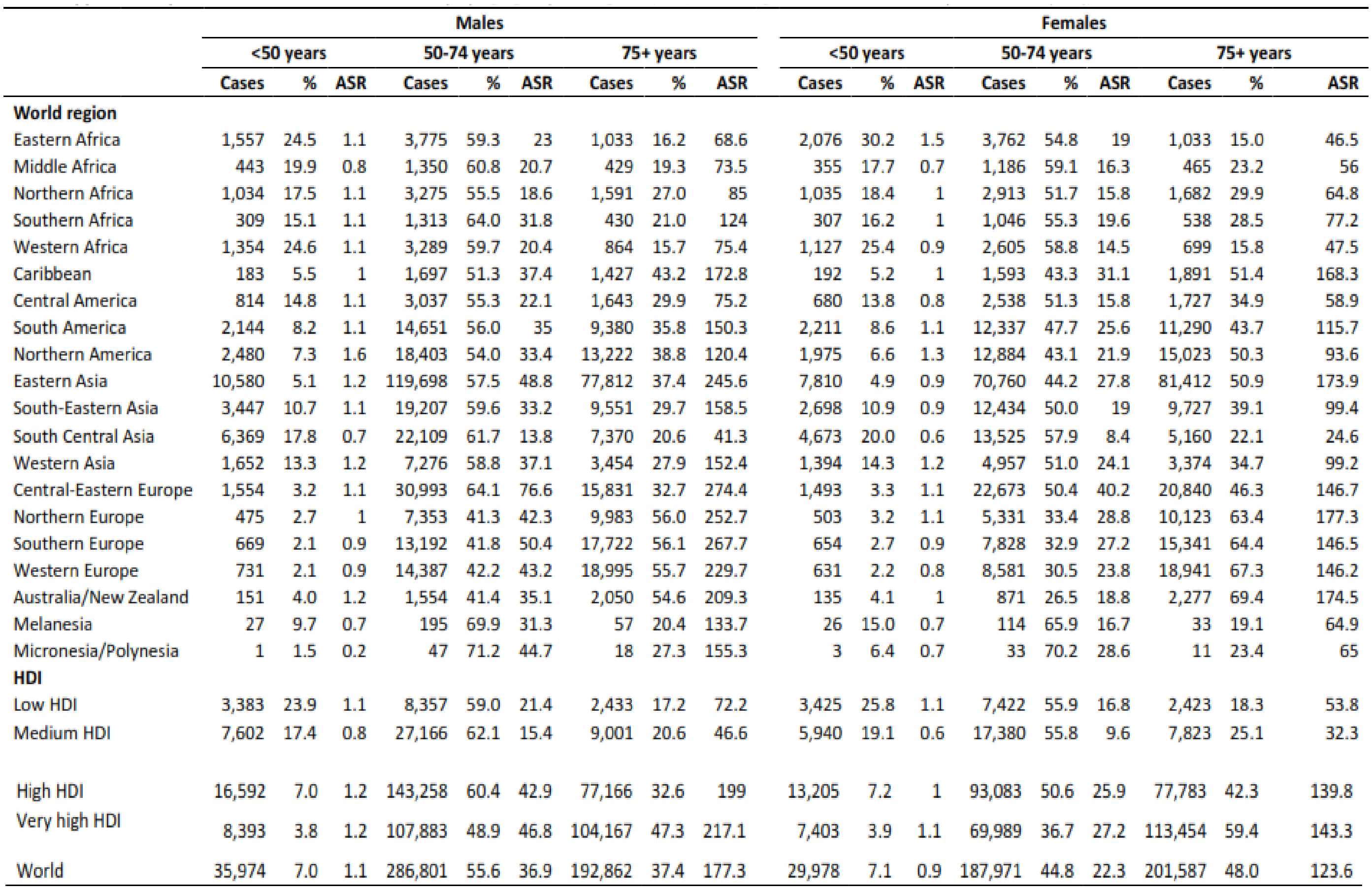


Figure 2.4: Age-standardised Incidence Rates per 100 000 of CRC in Males and Females by Global regions, 2020 *(Adapted with permission from: Morgan, et al., 2023)*



	Males									Females								
	<50 years			50-74 years			75+ years			<50 years			50-74 years			75+ years		
	Cases	%	ASR	Cases	%	ASR	Cases	%	ASR	Cases	%	ASR	Cases	%	ASR	Cases	%	ASR
World region																		
Eastern Africa	1,557	24.5	1.1	3,775	59.3	23	1,033	16.2	68.6	2,076	30.2	1.5	3,762	54.8	19	1,033	15.0	46.5
Middle Africa	443	19.9	0.8	1,350	60.8	20.7	429	19.3	73.5	355	17.7	0.7	1,186	59.1	16.3	465	23.2	56
Northern Africa	1,034	17.5	1.1	3,275	55.5	18.6	1,591	27.0	85	1,035	18.4	1	2,913	51.7	15.8	1,682	29.9	64.8
Southern Africa	309	15.1	1.1	1,313	64.0	31.8	430	21.0	124	307	16.2	1	1,046	55.3	19.6	538	28.5	77.2
Western Africa	1,354	24.6	1.1	3,289	59.7	20.4	864	15.7	75.4	1,127	25.4	0.9	2,605	58.8	14.5	699	15.8	47.5
Caribbean	183	5.5	1	1,697	51.3	37.4	1,427	43.2	172.8	192	5.2	1	1,593	43.3	31.1	1,891	51.4	168.3
Central America	814	14.8	1.1	3,037	55.3	22.1	1,643	29.9	75.2	680	13.8	0.8	2,538	51.3	15.8	1,727	34.9	58.9
South America	2,144	8.2	1.1	14,651	56.0	35	9,380	35.8	150.3	2,211	8.6	1.1	12,337	47.7	25.6	11,290	43.7	115.7
Northern America	2,480	7.3	1.6	18,403	54.0	33.4	13,222	38.8	120.4	1,975	6.6	1.3	12,884	43.1	21.9	15,023	50.3	93.6
Eastern Asia	10,580	5.1	1.2	119,698	57.5	48.8	77,812	37.4	245.6	7,810	4.9	0.9	70,760	44.2	27.8	81,412	50.9	173.9
South-Eastern Asia	3,447	10.7	1.1	19,207	59.6	33.2	9,551	29.7	158.5	2,698	10.9	0.9	12,434	50.0	19	9,727	39.1	99.4
South Central Asia	6,369	17.8	0.7	22,109	61.7	13.8	7,370	20.6	41.3	4,673	20.0	0.6	13,525	57.9	8.4	5,160	22.1	24.6
Western Asia	1,652	13.3	1.2	7,276	58.8	37.1	3,454	27.9	152.4	1,394	14.3	1.2	4,957	51.0	24.1	3,374	34.7	99.2
Central-Eastern Europe	1,554	3.2	1.1	30,993	64.1	76.6	15,831	32.7	274.4	1,493	3.3	1.1	22,673	50.4	40.2	20,840	46.3	146.7
Northern Europe	475	2.7	1	7,353	41.3	42.3	9,983	56.0	252.7	503	3.2	1.1	5,331	33.4	28.8	10,123	63.4	177.3
Southern Europe	669	2.1	0.9	13,192	41.8	50.4	17,722	56.1	267.7	654	2.7	0.9	7,828	32.9	27.2	15,341	64.4	146.5
Western Europe	731	2.1	0.9	14,387	42.2	43.2	18,995	55.7	229.7	631	2.2	0.8	8,581	30.5	23.8	18,941	67.3	146.2
Australia/New Zealand	151	4.0	1.2	1,554	41.4	35.1	2,050	54.6	209.3	135	4.1	1	871	26.5	18.8	2,277	69.4	174.5
Melanesia	27	9.7	0.7	195	69.9	31.3	57	20.4	133.7	26	15.0	0.7	114	65.9	16.7	33	19.1	64.9
Micronesia/Polynesia	1	1.5	0.2	47	71.2	44.7	18	27.3	155.3	3	6.4	0.7	33	70.2	28.6	11	23.4	65
HDI																		
Low HDI	3,383	23.9	1.1	8,357	59.0	21.4	2,433	17.2	72.2	3,425	25.8	1.1	7,422	55.9	16.8	2,423	18.3	53.8
Medium HDI	7,602	17.4	0.8	27,166	62.1	15.4	9,001	20.6	46.6	5,940	19.1	0.6	17,380	55.8	9.6	7,823	25.1	32.3
High HDI	16,592	7.0	1.2	143,258	60.4	42.9	77,166	32.6	199	13,205	7.2	1	93,083	50.6	25.9	77,783	42.3	139.8
Very high HDI	8,393	3.8	1.2	107,883	48.9	46.8	104,167	47.3	217.1	7,403	3.9	1.1	69,989	36.7	27.2	113,454	59.4	143.3
World	35,974	7.0	1.1	286,801	55.6	36.9	192,862	37.4	177.3	29,978	7.1	0.9	187,971	44.8	22.3	201,587	48.0	123.6

Figure 2.5: CRC Mortality by age group at diagnosis, sex, world region and Human Development Index (HDI), 2000 *(with permission from: Morgan, et al., 2023)*

In the United States, the lifetime incidence of CRC in patients at average risk is approximately 4% (American Cancer Society, 2020), while in Canada, the lifetime incidence and mortality of CRC in males are 7.1% and 3.1%, respectively. This translates to estimates that about 1 in 14 men will develop CRC during their lifetime, and 1 in 32 will die from the disease. This estimate is slightly lower for females, for whom about 1 in 18 Canadian women will develop CRC during their lifetime, and 1 in 37 will die from it, meaning a lifetime incidence and mortality of 5.5% and 2.7%, respectively (Canadian Cancer Statistics Advisory Committee, 2020a, 2020b). The Canadian national incidence of CRC has been trending downward over the last decade; however, there are notable variations across provinces and territories. For example, provinces such as Newfoundland and Labrador have historically reported higher rates, potentially attributed to a combination of genetic predispositions and lifestyle factors. In contrast, provinces like British Columbia have observed relatively lower incidence rates (Araghi et al., 2019; Brenner et al., 2019; Tung et al., 2018).

Low socioeconomic status (SES) is a significant modifier of CRC risk, likely associated with at least part of the variation in CRC incidence across regions (Blair et al., 2019). Some studies estimate the CRC risk to be approximately 30 percent higher in the lowest SES quintile compared with the highest SES (Mansouri et al., 2013; Wardle et al., 2016; Warren Andersen et al., 2019). Potentially modifiable behaviours such as physical inactivity, unhealthy diet, smoking, and obesity are thought to account for a substantial proportion (estimates of one-third to one-half) of this socioeconomic disparity in the risk of CRC (Araghi et al., 2019; Arnold et al., 2017; Bauer et al., 2022). This particularly relates to the intersection of barriers that people in the lowest SES quintile experience (Araghi et al., 2019; Arnold et al., 2017). Lower rates of CRC screening in lower SES groups also contribute to this disparity, as early detection and intervention are crucial for improving CRC outcomes (Araghi et al., 2019; Arnold et al., 2017; Bauer et al., 2022; Clinton et al., 2020; Rawla et al., 2019).

Age is another modifier of CRC risk, with CRC particularly uncommon before age forty (Arnold et al., 2017). The majority of CRC cases are diagnosed in individuals aged 50 and above; however, incidence rates begin to increase between the ages of 40 and 50, and age-specific incidence rates increase in each succeeding decade thereafter (Araghi et al., 2019; Arnold et al., 2017). There are growing concerns and increasing evidence showing a demographic shift in CRC incidence, with increasing incidence in the under-50 age group and reducing cases among older adults (Li et al., 2021; Morgan et al., 2023). These increases have been argued to be predominantly left-sided (distal colon) cancers in general, and rectal cancer in particular (Li et al., 2021). The reason(s) underlying this trend may be multifactorial (Li et al., 2021; Morgan et al., 2023).

A meta-analysis of 20 studies concluded that significant risk factors for early-onset CRC included CRC history in a first-degree relative (relative risk [RR] 4.21, 95% CI 2.61-6.79), hyperlipidemia (RR 1.62, 95% CI 1.22-2.13), obesity (RR 1.54, 95% CI 1.01-2.35), and alcohol consumption (RR for high versus non-drinkers 1.71, 95% CI 1.62-1.80) (O'Sullivan et al., 2022). Other risk factors for this demographic shift (e.g., hypertension, metabolic syndrome, ulcerative colitis, chronic kidney disease, diet, sedentary behavior, and occupational exposure to organic dusts) have also been highlighted in other studies (Arnold et al., 2017; Darren et al., 2022; Loomans-Kropp & Umar, 2019). CRC incidence has also been increasing in several transitional countries, such as Brazil and Costa Rica (Arnold et al., 2017). Again, the underlying reason for this rise is yet unclear but believed to be reflective of the global shift towards a more "Western" diet and reduced physical activity levels (Ferlay et al., 2015; Li et al., 2021; Morgan et al., 2023).

Additionally, gradual shift toward right-sided or proximal colon cancers among older adults (that is, aged 50+) has been observed both in the United States and internationally (Stoop et al., 2012; Tomaszewski et al., 2021). This change in the anatomic distribution of CRCs may be, in part, related to improvements in diagnosis and treatment, and increased screening with removal of adenomatous polyps in the distal colon (Arnold et al., 2017). Colonoscopy is believed to be more effective in preventing left-sided than right-sided CRCs, which could also contribute to a shift in the distribution of cancers in the colon (Graser et al., 2009; Stoop et al., 2012; Tomaszewski et al., 2021). It is likely that part of the difference is due to aspects of quality relating to the colonoscopy (poor right-sided preps, incomplete colonoscopy, anatomic configurations compromising visibility), but the biology may also differ between CRCs of the right and left colon (Graser et al., 2009; You et al., 2015). For example, serrated adenomas, which are flatter, more difficult to visualize endoscopically, often carry a different type of mutations, and more likely to cause microsatellite unstable CRCs, are more common in the right colon (Loda et al., 2017; You et al., 2015). Although all these issues may contribute to a shift toward right- rather than left-sided cancers, there also appears to be a true increase in the incidence of CRC, especially in the ascending colon and cecum (Arnold et al., 2017).

In fact, current modeling estimates predict a global CRC incidence of 3.2 million cases by the year 2040, which would be a 63% increase from the 1.8 million cases observed in 2020 if current incidence trends remain (Morgan et al., 2023). While the largest relative increase in CRC incidence is expected to occur in low- to middle-income and transitional countries, the most cases, in absolute terms, are still expected to be recorded in North America and western European countries (Morgan et al., 2023).

Additionally, CRC-related mortality is projected to increase by about 74%, from 0.9 million annual deaths in 2020 to over 1.6 million deaths by 2040, in absolute terms (Morgan et al., 2023). Again, while the mortality rate is expected to double in lower- to middle-income countries, most of these deaths are projected to occur in the developed countries of North America and western Europe. These regions could see CRC-related mortality increase from 832, 376 deaths in 2020 to 1.4 million deaths in 2040 (Morgan et al., 2023). For Canada, specifically, Ruan et al. (2023) project a 45% increase in annual CRC cases from 26,053 in 2020 to 37,697 in 2040 and a 44% increase in annual CRC related deaths from 9,361 to 14,175 within the same time frame. This projected increase in incidence and mortality from CRC further emphasises the pressing need to understand, design, and implement interventions to reduce the anticipated increase in health, financial, and quality-of-life burdens of CRC in the future (Ferlay et al., 2015; Li et al., 2021; Morgan et al., 2023). So far, screening remains the most important tool in this regard (Ferlay et al., 2015; Li et al., 2021).

2.6. Colorectal Cancer Screening

Despite advancements in screening and treatment, CRC remains a leading cause of cancer-related deaths globally and in Canada. With these advances in screening modalities and treatments options, CRC mortality rates have decreased in recent decades (Ellison & Saint-Jacques, 2023). The five-year net survival rate currently stands at 65%—early-stage diagnoses (stages I and II) have survival rates exceeding 90%, while five-year survival for late-stage diagnoses can be as low as 15% (Canadian Cancer Society, 2023; Ellison & Saint-Jacques, 2023). However, the absolute mortality numbers, especially in North America, remain a significant concern for healthcare professionals and policymakers (Ellison & Saint-Jacques, 2023).

The previous discussion on the epidemiology and natural history of CRC highlighted the silent and subtle, yet deadly, nature of the disease. CRC often progresses without noticeable symptoms in its initial stages (Rawla et al., 2019). Without preventive measures like screening, many individuals remain unaware of their condition until it reaches advanced stages (Ramos et al., 2023). This asymptomatic progression is a compelling argument for organised, accessible screening programs.

Early detection offers numerous benefits, including improved prognosis, less aggressive treatment options, and a higher chance of successful treatment (Levin et al., 2018; Mendivil et al., 2019). Early diagnosis can also significantly decrease potential complications and the costs associated with treatment (Levin et al., 2018; Mendivil et al., 2019; Ramos et al., 2023). As illustrated in Figure 2.6, screening can interrupt the adenoma-carcinoma pathway, either by removing precancerous polyps (adenomas) or by aiding the diagnosis of preclinical cancer. This often leads to more effective treatment with fewer complications and potentially lower costs (Knudsen et al., 2016). Therefore, screening benefits individuals, the healthcare system, and the economy.

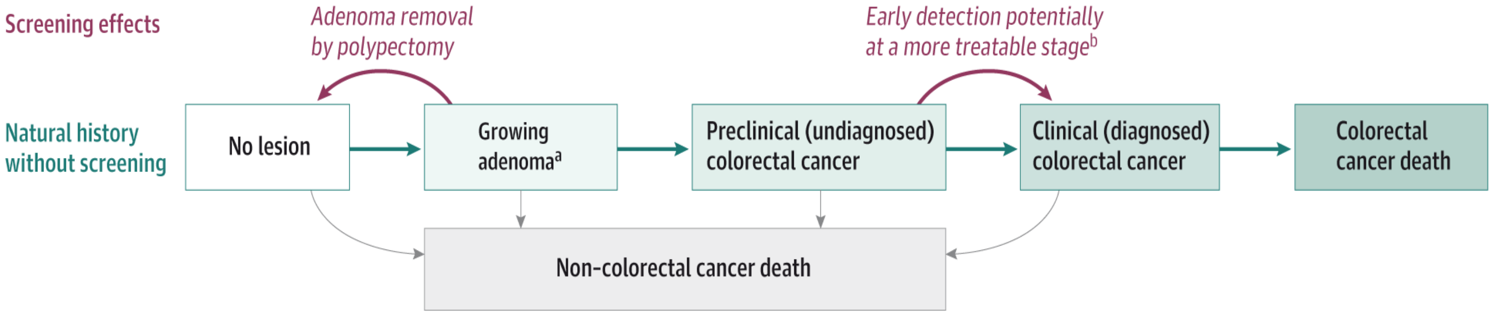


Figure 2.6: Significance of Screening in the Natural History of CRC

(with permission from: Knudsen et al. 2016)

2.6.1. Benefits of Colorectal Cancer Screening

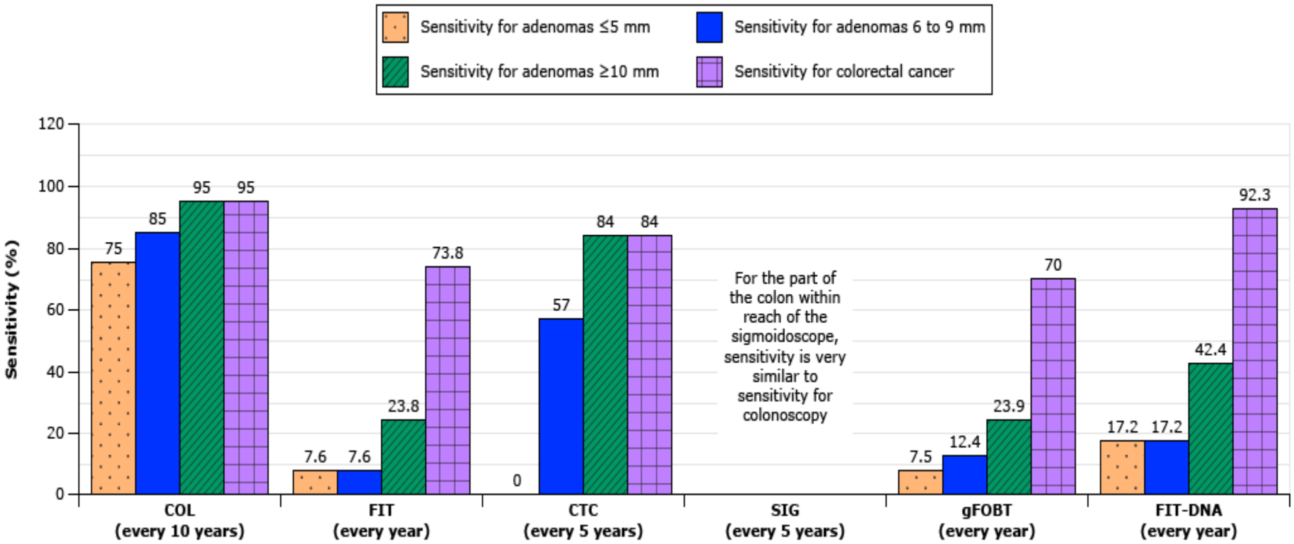
Early detection of CRC offers numerous health benefits to individuals. Primarily, early-stage CRC is more likely to be localised, meaning it has not spread to other parts of the body. This contributes to the relatively higher 5-year survival rate of about 90% (Canadian Cancer Society, 2023; Ellison & Saint-Jacques, 2023) underscoring the importance of early detection. Additionally, early diagnosis often necessitates less invasive treatment options, such as localised surgery, leading to improved post-treatment quality of life (Arnold et al., 2020; Ellison & Saint-Jacques, 2023; Ramos et al., 2023).

Early detection also improves healthcare system efficiency. Treating early-stage cancers typically requires fewer resources than treating advanced-stage cancers, resulting in shorter hospital stays and less need for intensive interventions (Levin et al., 2008; Mendivil et al., 2019). This frees up resources for other patients and reduces the strain on healthcare professionals (Mendivil et al., 2019). Additionally, early detection and treatment can lessen the demand for palliative care services often required for advanced cancer (Mendivil et al., 2019). By focusing on prevention and primary care, the health system can achieve better overall public health outcomes (Levin et al., 2008; Mendivil et al., 2019).

The economic implications of early CRC detection are substantial. Treating early-stage CRC is considerably less expensive than treating advanced disease. In Canada, the average, historical cost of treating a stage I CRC patient is estimated at $27,000, while treating a stage IV patient can exceed $50,000 (Maroun et al., 2003). Early detection thus leads to significant cost savings. Moreover, it reduces indirect costs like lost productivity due to illness or premature death (Gheorghe et al., 2021; Maroun et al., 2003). Early diagnosis also allows patients to return to work sooner, contributing to the economy (Gheorghe et al., 2021; Ramos et al., 2023).

2.6.2. Colorectal Cancer Screening Modalities

CRC screening is one of the most recent additions to organised, public health cancer screening programs, and it has seen considerable changes over the past two decades (Inadomi et al., 2021). In the late 20th century, as the burden of CRC became more pronounced, there was a growing recognition of the need for systematic screening (Eisinger et al., 2008). Initial efforts were fragmented and opportunistic, often based on individual physician recommendations. However, as evidence mounted regarding the efficacy of organised screening, countries and states began to implement more structured programs, with a focus on evidence-based practices and standardised protocols (Bénard et al., 2018; Buskermolen et al., 2019; Eisinger et al., 2008). Today, there are several screening modalities available, broadly categorised into stool-based tests, radiology tests, and endoscopy tests, each with varying levels of sensitivity and specificity for colon polyps and cancer (Eisinger et al., 2008). Screening protocols, guidelines, and recommendations also differ for individuals with a family history or genetic risk of CRC (high-risk population) compared to the general population with 'average risk' of CRC. These screening modalities are evaluated based on efficacy, invasiveness, and the risk of potential complications (Bénard et al., 2018; Buskermolen et al., 2019; Butterly, 2020).



	COL (every 10 years)	FIT (every year)	CTC (every 5 years)	SIG (every 5 years)	gFOBT (every year)	FIT-DNA (every year)
Test specificity	86	96.4	88	87	92.5	89.8
Colorectal cancer deaths averted per 1000 40-year-olds (n)*	22 to 24	20 to 23	16 to 24	16 to 21	20 to 23	21 to 24

Figure 2.7: Sensitivity, Specificity and CRC-Specific Death Averted for CRC Different Screening Modules *(From: Doubeni, 2023 - in the public domain)*

2.6.2.1. Stool-based Tests.

Stool-based tests have been a cornerstone of non-invasive CRC screening for decades. They detect blood or DNA markers in the stool that may indicate the presence of cancer or precancerous polyps, especially larger ones (Crouse et al., 2015). There are two main types: fecal immunochemical tests (FIT) and stool DNA tests (Crouse et al., 2015; Forbes et al., 2006).

FIT is considered more sensitive and has less dietary and medication restrictions during stool sample collection compared to the older guaiac fecal occult blood test (gFOBT) (Grobbee et al., 2017; Liles et al., 2012). FIT is now the preferred stool-based test for CRC (Grobbee et al., 2017; Hol et al., 2010), especially since 2008 when it was endorsed by multiple professional societies across North America (Levin et al., 2008; U.S. Preventive Services Task Force, 2008). The convenience of at-home sample collection and mailing for analysis, along with cost-effectiveness, make FIT particularly suitable for population-wide screening (Grobbee et al., 2017; Hol et al., 2010). FIT has a reported sensitivity of 79% and specificity of 94% for detecting CRC, but lower sensitivity (24%) for advanced adenomas (Winawer & Zauber, 2002). FIT is recommended annually or biennially by most jurisdictions including CTFPH, with positive results prompting a follow-up colonoscopy for confirmation and potential polyp removal (Bénard et al., 2018; Canadian Task Force on Preventive Health Care, 2016; Smith et al., 2019).

Stool DNA tests, a newer option, detect DNA mutations associated with CRC or precancerous polyps (Sabatino et al., 2015). The multitarget stool DNA test (FIT-DNA) is the only test currently approved by the US Food and Drug Administration (FDA) for CRC screening (Smith et al., 2019). Its efficacy is similar to FIT, with 92% sensitivity and 87% specificity for CRC, but 40% sensitivity for advanced adenomas (Smith et al., 2019). Recommended every three years by the U.S. Preventive Services Task Force, a positive FIT-DNA result also necessitates a follow-up colonoscopy (Sabatino et al., 2015; Tinmouth et al., 2016).

2.6.2.2. Endoscopy Tests

Endoscopy, considered the gold standard for CRC screening, involves inserting a flexible tube with a camera (endoscope) into the rectum and colon to visualise the lining and detect polyps or cancer (Tomaszewski et al., 2021). Colonoscopy examines the entire colon and rectum, while flexible sigmoidoscopy examines the rectum and lower third of the colon (Graser et al., 2009). Colonoscopy is recommended every ten years, while sigmoidoscopy is recommended every five to ten years by most national screening guidelines, including by CTFPH in Canada (Buskermolen et al., 2019; Graser et al., 2009). Colonoscopy has a 95% sensitivity for detecting CRC, compared to 60-70% for sigmoidoscopy (Buskermolen et al., 2019; Graser et al., 2009). Positive results typically lead to biopsy or polypectomy. While endoscopy, especially, colonoscopy has the highest sensitivity and specificity for pre-cancerous adenomas and CRC diagnosis (Buskermolen et al., 2019), as seen in Table 2.1 below, it is also the most invasive and resource-intensive. Endoscopy tests require extensive bowel preparations, which can be a barrier to participation (Rabeneck et al., 2008; Tomaszewski et al., 2021).

2.6.2.3. Radiology Tests

The radiology tests are not as popular as the stool-based and endoscopy tests and are also relatively newer. Conseqently, they are not included in the screening modalities or options of most juridictions (You et al., 2015). These tests involve the use of imaging tests to detect polyps or cancer in the colon. There are two types of radiology tests: computed tomography colonography (CTC) and double-contrast barium enema (DCBE) (Sofic et al., 2010; You et al., 2015). CTC uses a CT scanner to create images of the colon, instead of inserting an endoscope. CTC has a sensitivity of 90% for detecting CRC (Heresbach et al., 2011; Senore et al., 2018; Sofic et al., 2010). However, a positive result also requires follow-up with a colonoscopy for confirmation and polypectomy. In contrast, the DCBE uses X-rays and a contrast dye to create images of the colon. It has a sensitivity of 60-70% for detecting CRC, but often reserved for patients who cannot have a colonoscopy, for personal or medical reasons (Heresbach et al., 2011). Similar to CT colonography, a positive result requires follow-up with a colonoscopy. The

U.S. Preventive Services Task Force, American College of Gastroenterology and American Society of Clinical Oncology recommendations for both radiology tests are every five years (Lew et al., 2018; Sabatino et al., 2015).

Radiology tests have been reported to have higher sensitivity and more effective at detecting CRC and advanced adenoma compared to stool-based tests (Lew et al., 2018). They are also less expensive and less invasive compared to endoscopy tests (Lew et al., 2018; Sabatino et al., 2015). However, they require significant bowel preparation and expose patients to radiation. Additionally, positive results still require a follow-up colonoscopy (Forbes et al., 2006; Graser et al., 2009; Heresbach et al., 2011). Radiology tests are often not recommended for people with a high risk of CRC, such as people with a family history of CRC or a personal history of polyps or inflammatory bowel disease as colonoscopy offers more effective poly identification and removal (Lew et al., 2018; Nagata et al., 2017; Sabatino et al., 2015). They are also not the primary screening tests in Canada, the United States or much of the developed world (Knudsen et al., 2021).

Table 2.1: Comparison of the various CRC Screening Modalities

Screening Procedure	**Level of recommendation**	**Recommended Frequency**	**Sensitivity and Specificity**	**Pros**	**Cons**
Colonoscopy	Tier 1	Every 10 years	Adenomas ≥6mm: Sensitivity 75-93%, Specificity 94%. Adenomas ≥1cm: sensitivity 89-98%, Specificity 89%	Prevention by treating pre-malignant lesions. High sensitivity for CRC and pre-cancerous lesions. Long screen intervals if negative	Tedious bowel preparations. High quality standards needed, so operator dependent. Low but possible risk of serious adverse events
FIT	Tier 1	Every 1-2years	CRC: 74% sensitivity, 96% specificity. Advanced Adenomas: 24% sensitivity, 94% specificity	Non-invasive. Relative low cost Reasonably high sensitivity for CRC	Frequency of testing. Colonoscopy needed if positive. Low sensitivity for pre-cancerous lesions
Multi-target stool DNA test	Tier 2	Every 3 years	CRC: 1-time sensitivity of 92%. Advanced Adenomas: 40% sensitivity, 86% specificity	Non-invasive High 1-time sensitivity for CRC Fairly high sensitivity for Advanced Adenomas	More expensive than FIT Lower specificity than FIT
CT Colonography	Tier 2	Every 5 years	CRC: sensitivity 96% Adenomas ≥6mm: sensitivity 73-98%, Specificity 89-91%	High sensitivity for CRC and advanced adenomas	Tedious bowel preparations. Radiation exposure High cost
Flexible sigmoidoscopy	Tier 2	Every 5-10 years	Same as Colonoscopy	Prevention by treating pre-malignant lesions. High sensitivity for CRC and pre-	Tedious bowel preparations. High quality standards needed, so operator dependent.

				cancerous lesions. Long screen intervals if negative	Low but possible risk of serious adverse events Unable to detect proximal CRC.

*FIT: Fecal Immunochemical Test. *CT: Computed Tomography

2.6.2.4. Screening Modalities Comparison

While efficacy (capacity to detect cancer or adenomas) and accessibility (general uptake) are key indicators for comparing CRC screening modalities, these do not always tell the full story (Knudsen et al., 2021). The US Preventive Services Task Force conducted a modelling study to evaluate the potential benefits and costs of the different screening modalities, alone and in combination (Knudsen et al., 2021). The study included the five major screening modalities available and recommended in Canada and across North America, that is, the FOBT, FIT, FIT-DNA, CTC, flexible sigmoidoscopy, and colonoscopy. The study compared the potential benefits of screening, measured in Life Years Gained (LYG) per 1000 persons screened, with the burden of screening and harm - adverse effects or complication of screening. The burden of screening was measured in number of colonoscopies required - either as follow-up or surveillance test, and cathartic bowel preparations required as part of screening or surveillance per 1000 persons screened. Potential harm or adverse effects of screening, included serious gastrointestinal events (e.g., perforations or gastrointestinal bleeding), gastrointestinal events (e.g., diarrhoea, nausea or vomiting etc.), cardiac events (arrythmias, cardiac or respiratory arrest) respiratory events etc. per 1000 persons screened (Knudsen et al., 2021)

The study found that found that four screening modalities resulted in similar LYG with clinically significant benefits vs burden and harm ratio. Annual FIT results in 244 LYG per 1000 persons screened, CTC every 5years in 248 LYG, flexible sigmoidoscopy every 10 years with annual FIT in 256 LYG and colonoscopy every 10 years in 270 LYG per 1000 persons screened. The screening burden, measured as the number of colonoscopies required post screening, ranged from 900 colonoscopies, with annual FIT, to 1,750 colonoscopies per 1000 persons screened, for colonoscopy every 10 years, while harm from screening was around 23 complications per 1000 person screened. Similarly, the reduction in lifetime risk of death from CRC in the population was reportedly 81%, 82%, 85% and 87% for annual FIT, CTC every 5 years, flexible sigmoidoscopy every 10 years with annual FIT and Colonoscopy every 10 years, respectively (Knudsen et al., 2021).

As with other areas of clinical and population health, CRC screening is constantly evolving. Understanding new technologies, changing demographics, and ongoing research will continue to shape screening efficacy, uptake, and impact on the

CRC burden. The challenge lies in integrating these changes into a cohesive, effective, and equitable screening strategy for the general population.

2.6.3. Screening Guidelines and Recommendations

Screening guidelines and strategy vary, generally, by location but always include screening strategy for people at high risk of CRC, and organised screening programs for the 'average' risk general population (Eisinger et al., 2008). Screening can be opportunistic, in which screening is identified and referred through engagement with a health care practitioner. However, there is increasing preference for CRC screening as an organised public health program that offers equal access for all individuals in the population who meet the screening criteria (Blair et al., 2020; Eisinger et al., 2008).

The choice of screening modality for opportunistic screening depends on provider and patient preferences. But for organised screening programs, this generally includes one of FIT every year or two or FIT-DNA every 3 years with sigmoidoscopy or colonoscopy every 10 years (Bénard et al., 2018). CRC screening programs generally target people aged 50-74 years (the USPSTF is considering widening this age range to 45-75 due to increasing early-onset CRC) (US Preventive Services Task Force, 2021) and the CTFPH guideline recommends FIT/gFOBT tests every two years or flexible sigmoidoscopy/colonoscopy every 10 years for Canadians aged 50-74 years (CTFPH, 2016). Based on currently available evidence on risk versus benefits of screening, the CTFPH discourages CRC screening for people aged above 75 years and colonoscopy as a first-level screening test for CRC in people of all ages (Canadian Partnership Against Cancer, 2017b; CTFPH, 2016). Figure 2.8 below shows the screening guideline and the ‘screening pathway’ for the average risk general population.

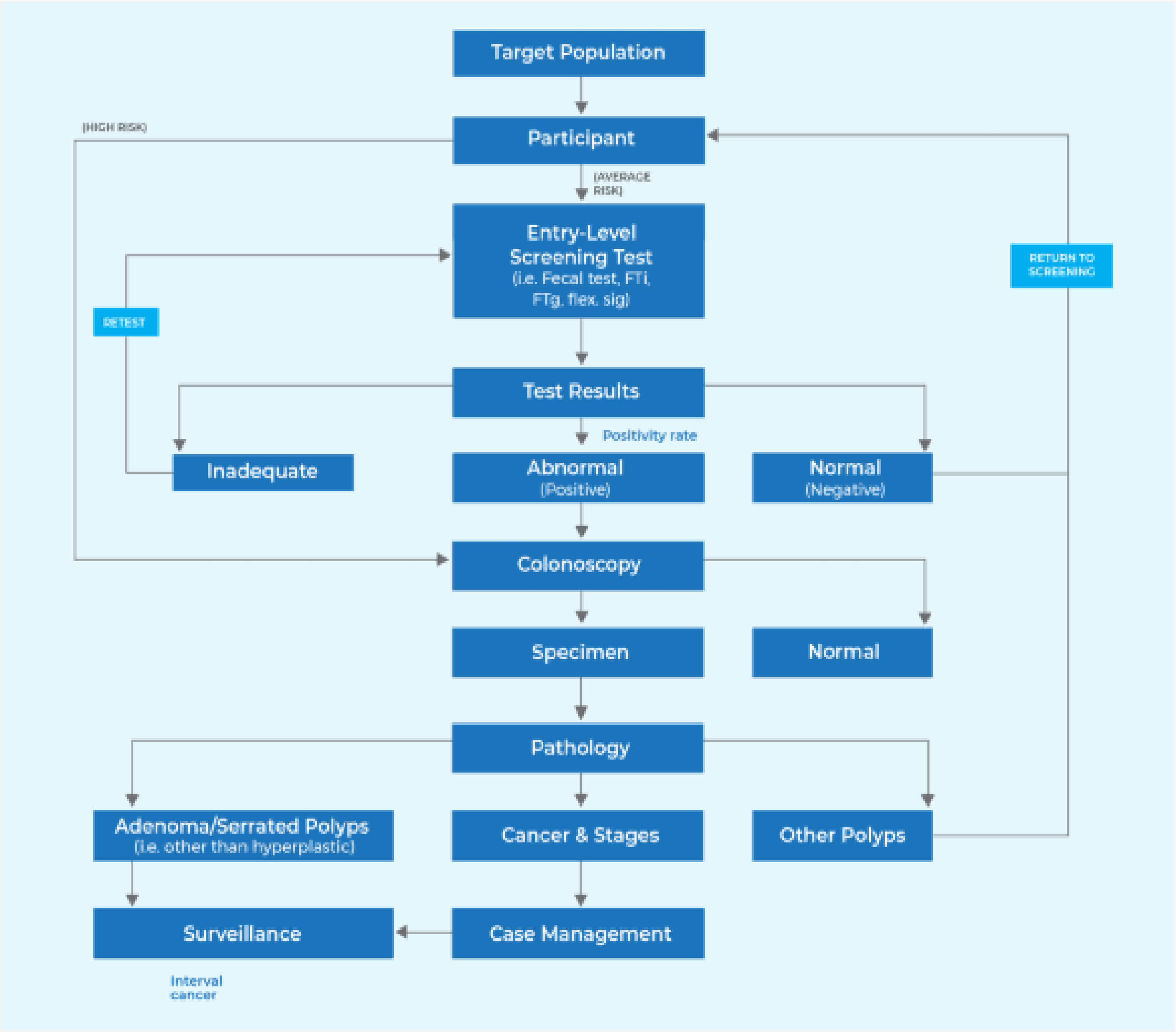


Figure 2.8: Screening Pathway for 'Average Risk' Population in Canada
(From: Canadian Partnership Against Cancer, 2020 – in the public domain)

Screening strategy for people at higher risk of CRC can be more complicated depending on whether they have a family history of CRC or not, and the type of genetic condition/predisposition to CRC suspected or confirmed (Leddin et al., 2018; Leddin et al., 2010). For people with HNPCC, for instance, the Canadian Association of Gastroenterology recommends full colonoscopy beginning between ages 20-25 and continued at intervals of 1-2 years (Leddin et al., 2018). Also, because the progression from colon adenoma to cancer is much faster in people with HNPCC relative to the general populations, polypectomy is recommended for all adenomas observed during colonoscopy, regardless of their size (Leddin et al., 2018). For FAP, however, flexible sigmoidoscopy annually or semi-annually beginning at puberty and continued until age 35 is also recommended by the Canadian Association of Gastroenterology. After 35 years, the interval can be reduced to every three years if no polyps have been detected. Once polyps emerge, however, annual colonoscopy becomes necessary (Leddin et al., 2018).

The Canadian Association of Gastroenterology and Canadian Cancer Society recommend that people with one or more second degree relatives (SDRs) with CRC or at least, one first degree relative (FDR) with non-advanced adenoma can be categorised as average risk and can follow the FIT every 1-2 years recommended screening strategy (Leddin et al., 2018; Leddin et al., 2010). However, the recommendation is different for people with at least one FDRs with 'advanced adenoma' or CRC.

Advanced adenoma is defined as adenoma 1cm or greater in size, villous histology or with moderate to high grade dysplasia. The Canadian Association of Gastroenterology classifies as ‘high risk’, people who have one FDR with CRC or two or more FDRs with CRC or advanced adenoma (Leddin et al., 2018). For the former category, recommended screening strategy is colonoscopy starting between age 40-50 years or 10 years earlier than the age of CRC diagnosis in the FDR and every 5-10 years plus FIT every 1-2 years, subsequently. For the latter category (2+ FDR with CRC or advanced adenoma), recommended screening strategy is colonoscopy every 5 years starting at age 40 or 10 years before the earliest age of CRC diagnosis in the FDR (Leddin et al., 2018).

2.6.4. Barriers and Facilitators to CRC screening

Despite growing evidence supporting CRC screening for prevention (or early diagnosis) and efforts by governments and policymakers to ensure accessible CRC screening programs, CRC screening uptake remains sub-optimal and faces a wide range of barriers and challenges (Adhikari et al., 2022; Ahmed et al., 2023; Almadi et al., 2015; Atkinson et al., 2015; Blair et al., 2020; Brouwers et al., 2011b; Sabatino et al., 2015). These barriers can be categorised as personal, organisational, and screen-related.

One personal barrier is sex, with females reportedly demonstrating lower CRC screening uptake (Daskalakis et al., 2020; Unanue-Arza et al., 2021). This disparity has clinical implications for CRC incidence and mortality. However, it's worth noting that while the overall trend shows lower uptake among females, some studies report relatively higher uptake of fecal tests - gFOBT and FIT, among females in several jurisdictions. Females also seem to be more likely to participate in fecal tests compared to other screening modalities (Crouse et al., 2015; Portillo et al., 2018).

Educational attainment also plays a role, with lower screening uptake among individuals with less than high school education (Crouse et al., 2015; Klabunde et al., 2005). This suggests a lack of awareness or understanding of early detection benefits, highlighting the importance of educational interventions and health literacy in promoting screening (Crouse et al., 2015; Inadomi et al., 2021; Janz et al., 2003; Kobayashi et al., 2014).

Socioeconomic status (SES) further complicates the issue (Crouse et al., 2015; Farr et al., 2022). While lower SES is often associated with reduced screening uptake (Mansouri et al., 2013; Wardle et al., 2016), some studies show a nuanced effect depending on interaction with other factors (Blair et al., 2019; Warren Andersen et al., 2019). This suggests that while SES is influential, other factors contribute to the multifaceted nature of screening uptake.

Rural residence is another barrier (Arcury et al., 2005; Davis et al., 2018; Honein-AbouHaidar et al., 2013). Rural inhabitants, potentially due to challenges in accessing healthcare, are less likely to undergo screening compared to urban/suburban counterparts, emphasising the need for improved rural healthcare access and infrastructure.

Co-morbidities also affect screening behaviour (Kiviniemi et al., 2011; Lo et al., 2015; Mansouri et al., 2013; Park et al., 2022). Certain conditions like diabetes and prior cardiovascular events are associated with poorer uptake, while others like breast and lung cancers have been associated with increased uptake (Mansouri et al., 2013; Schoenborn et al., 2019). This multidimensional effect suggests that the nature of co-morbidity, its management, and perceived impact on health influence screening decisions.

Knowledge and attitudes towards CRC and screening are also influential (Almadi et al., 2015; Shi et al., 2020). Even individuals with higher education may hold negative attitudes towards CRC and screening, suggesting that attitudes affect screening behaviour independently of education level (Crawford et al., 2016; Kruse-Diehr et al., 2023; Shi et al., 2020). This highlights the importance of targeted awareness campaigns and interventions to improve health literacy and emphasise preventive health benefits (Brouwers et al., 2011b; Inadomi et al., 2021).

From a healthcare organisation perspective, the absence of a regular healthcare provider or family physician is a significant barrier to CRC screening uptake (Lofters et al., 2015; Triantafillidis et al., 2017; Zarychanski et al., 2007). This is particularly problematic as physicians often act as gatekeepers to screening, initiating discussions about its importance and providing referrals for appropriate tests. Additionally, several provinces in Canada, notably Alberta, still require a GP referral for CRC screening, further emphasising the pivotal role of healthcare providers in facilitating access (Adhikari et al., 2022). The lack of a screening recommendation from a trusted healthcare professional can significantly reduce the likelihood of individuals pursuing screening, especially among older adults who may be more reliant on their physician's guidance (Triantafillidis et al., 2017; Zarychanski et al., 2007). Therefore, addressing this barrier requires strategies to improve access to primary care providers and encourage proactive communication about CRC screening within the healthcare system. Similarly, removing the requirement for a GP referral has also been suggested (Adhikari et al., 2022).

Screen-related barriers also play a role in deterring individuals from undergoing CRC screening. Concerns about potential risks or adverse events associated with screening procedures can create anxiety and hesitancy among individuals (Rabeneck et al., 2008; Shen et al., 2018; Tomaszewski et al., 2021). Additionally, the perceived unpleasant nature of certain tests, such as the embarrassment associated with handling feces for fecal tests (van Rossum et al., 2008; Young & Cole, 2009) or the physical discomfort of bowel preparations for endoscopy, can contribute to negative perceptions and avoidance (Rabeneck et al., 2008; Tomaszewski et al., 2021). Addressing these screen-related barriers requires clear communication about the safety and potential benefits of screening, as well as efforts to minimise discomfort and inconvenience associated with certain tests (Inadomi et al., 2021; Issaka et al., 2019).

On the positive side, several facilitators have been identified to promote CRC screening uptake (Adhikari et al., 2022; Kruse-Diehr et al., 2023; Singh et al., 2015). Regular encounters with healthcare services or providers, for instance, have been shown to significantly increase the likelihood of individuals undergoing CRC screening (Triantafillidis et al., 2017). This suggests that consistent interaction with the healthcare system not only increases awareness but also provides opportunities for screening discussions and recommendations. Similarly, having supplemental health insurance, potentially indicative of higher socioeconomic status or educational level, has been associated with significantly higher CRC screening uptake (Issaka et al., 2019; Triantafillidis et al., 2017). This may be due to increased financial resources and access to a broader range of healthcare options (Triantafillidis et al., 2017). Moreover, individuals with co-morbidities requiring regular healthcare utilisation also demonstrate increased screening uptake (Schoenborn et al., 2019). This could be attributed to opportunistic screening during medical consultations for other health conditions, although the underlying dynamics warrant further exploration (Schoenborn et al., 2019). Understanding these facilitators is crucial for developing effective interventions to improve CRC screening rates and reduce the burden of this preventable disease.

2.7. CRC Screening in Canada

While the overarching goal of CRC screening across all jurisdictions in Canada is the early detection and prevention of cancer, CRC screening in the country is characterised by individual provincial and territorial screening programs, each with its varying methods and strategies (Canadian Partnership Against Cancer, 2021). Following the publication of the first CRC screening guidelines in 2001 by the CTFPH (2016) recommending CRC screening for the general population, individual jurisdictions began establishing screening programs based generally on the guidelines. Currently, organised CRC screening programs are available to individuals who are asymptomatic and at average risk of CRC in one territory and nine provinces – see Figure 2.9 below. The Northwest Territories and Nunavut do not currently have screening programs, while Quebec just established theirs in early 2024 (Gouvernement du Québec, 2024). In these jurisdictions without organised screening programs, CRC screening services are often available to individually opportunistically through engagement or encounter with their health care provider (Canadian Partnership Against Cancer, 2021).

* The colorectal screening program in BC is offered province-wide with the exception of the Northern Health Authority, which does not participate in the program.

Figure 2.9: Status of Provincial Colon Screening Programs in Canada
(Canadian Partnership Against Cancer, 2021 - in the public domain)

As per the national guidelines, all jurisdictions with organised CRC screening programs target people who are average risk of CRC between the ages of 50 and 74 (some jurisdictions screen people up to 75 years – *see Table 2.2 below*) and employ stool-based CRC tests as the first level test (see patient flow in Figure 2.8 above). Currently, one Province (Manitoba) still offers gFOBT tests, while the other provinces and territories offer FIT tests for the colon screening programs.

Table 2.2 below summarises details of the provincial/territorial CRC screening programs. The primary advantage of organised CRC screening programs over opportunistic screening is that it makes screening available and accessible for the general population through several mechanisms (Eisinger et al., 2008; Wilkinson et al., 2022).

Organised programs proactively invite eligible individuals to participate in screening at regular intervals, increasing awareness and reducing the reliance on individual initiatives or provider recommendations. They also often employ reminder systems to prompt individuals who have not responded to initial invitations, further enhancing participation rates. These programs also adhere to standardised protocols for screening tests, ensuring consistent quality, and reducing variability in test performance and interpretation. This helps minimise errors and ensures that all participants receive a similar level of care (Wilkinson et al., 2022).

Similarly, the programs often have centralised systems for managing screening data, facilitating tracking of participation, test results, and follow-up procedures (Wilkinson et al., 2022). This ensures that individuals with abnormal results are promptly referred for further evaluation and treatment and receive support navigating the process. Lastly, organised screening programs aim to reach a broader segment of the population, including those who may not regularly seek healthcare or have access to a primary care provider. This helps reduce disparities in screening uptake across different socioeconomic groups and geographic regions (Eisinger et al., 2008; Wilkinson et al., 2022). Collectively, these factors contribute to higher screening rates and improved outcomes in organised programs compared to opportunistic screening, where individuals rely on their own initiative or sporadic provider recommendations, often leading to missed opportunities and lower overall participation (Denis et al., 2007; Eisinger et al., 2008). Additionally, the awareness and promotion that accompany establishment of organised screening programs often contribute to improve the overall awareness, understanding and perception of CRC and CRC prevention in the general population (Eisinger et al., 2008; Levin et al., 2018).

Provincial CRC screening programs are responsible for promoting CRC screening, recruiting/inviting eligible individuals to participate in the screening and ensuring reminders, notification of results and follow-up when necessary (see figure 2.8 above). As seen in *Table 2.3* below, the promotional and recruitment strategies deployed by the different provincial programs vary remarkably (Canadian Partnership Against Cancer, 2021).

Some jurisdictions design and implement elaborate promotional strategies, such as Colorectal Cancer Awareness Month, distribution of promotional materials or social media campaigns, while others rely on general public awareness campaigns. Invitation letters mailed to the target population, with or without the test kit included, is perhaps the most common recruitment strategy. Other programs require or encourage physician referral, others allow self-referral to the screening program for eligible individuals. A few jurisdictions also send out reminder notifications, usually in the form of a second invitation letter, to individuals with tests still outstanding. There is no denying that these varying strategies affect awareness level, and perhaps attitudes towards CRC screening. However, their effect on screening uptake requires further and ongoing assessment (Wilkinson et al., 2022). Lastly, results of the screening are often mailed out to the individuals and/or their healthcare provider (Canadian Partnership Against Cancer, 2020, 2021).

Table 2.2: Summary of Provincial Colon Screening Programs in Canada

Jurisdiction	**Program name**	**Program Start date & Status**	**Recruitment/Invitation Method**	**Screening Test Details**	**Normal Result Communication & Recall**
Yukon (YT)	ColonCheck Yukon	2017; Full program, territory wide	Physician referral; Self-referral in person; FIT kits are distributed at public events	*FIT every 2years, from 50-74 years	Care Provider contacts participants to provide results. Recall reminder and kit mailed together every 2 years
Northwest Territories (NT)	In planning stages		Opportunistic physician/NP/community health nurse referral		No formal recalls, up to participant or care provider to initiate screening again
Nunavut (NU)	Under development		Physician referral. Referral through other screening programs		
British Columbia (BC)	Colon Screening Program	2013; Full program, in 4 out of the 5 Health Authorities	Physician referral	FIT every 2years, from 50-74 years	Results mailed to participant; Requisitions for FIT mailed to participants when next due for FIT
Alberta (AB)	Alberta Colorectal Cancer Screening Program (ACRCSP)	2007; Full program, province wide	Physician or nurse practitioner referral	FIT every 1-2years, from 50-74 years	Results mailed to participant; No recall reminder, Care providers refer eligible participants

Saskatchewan (SK)	Screening Program for Colorectal Cancer	2009; Full program, province wide	Mailed invitation letter; Physician referral; Self-referral by phone	FIT every 2years, from 50-75 years	Results mailed to participant; Recall reminder and kit mailed together every 2 years
Manitoba (MB)	ColonCheck	2007; Full program, province wide	Letter campaigns; Physician referral; Self-request made online, phone, or in person; Referrals through other screening programs	FOBT every 2years, from 50-75 years	Care Provider contacts participants to provide results. Recall reminder and kit mailed after 2 years
Québec (QC)	Programme québécois de dépistage du cancer colorectal (PQDCCR) (Québec Colorectal Cancer Screening Program)		Program announced in February 2024 Previously, opportunistic screening through physician referral		
Ontario (ON)	ColonCancerCheck	2008; Full program, province wide	Mailed invitation, recall and reminder letters; Physician referral. self-referral by calling Telehealth Ontario; Self-referral through mobile screening coaches	**FIT every 2years, from 50-74 years	Results mailed to participant and Care Provider; Recall reminder sent in 2 years
New Brunswick (NB)	NB Colon Cancer Screening Program	2014; Full program, province wide	Mailed invitation letter	FIT every 2 years, from 50-74 years	Result mailed to participant; re-invitation and eligibility questionnaire sent after 2 years

Nova Scotia (NS)	Colon Cancer Prevention Program	2009; Full program, province wide	Mailed invitation letter and FIT kit sent after 2 weeks	FIT every 2 years, from 50-74 years	Result mailed to participant; Recall reminder & Kit mailed every 2 years
Prince Edward Island (PEI)	Colorectal Cancer Screening Program	2011; Full program, province wide	Mailed invitation letter; Physician referral; Self-referral by phone, email, online or in person	FIT every 2 years, from 50-75 years	Result mailed to participant; Recall reminder & Kit mailed every 2 years. In-person KIT pick-up available
Newfoundland and Labrador (NL)	NL Colon Cancer Screening Program	2012; Full program, province wide	Physician referral; Self-referral by phone, email or in person; Referral through other screening program; Website	FIT every 2 years, from 50-74 years	Result mailed to participant; Recall reminder & Kit mailed every 2 years

***FIT, Fecal immunochemical test; ** gFOBT kit was distributed until June 2019*

In cases of abnormal fecal test results, most provincial screening programs have system navigational support personnel or support in place to notify people and/or their health care provider of an abnormal result, invite the individuals for follow-up diagnostic colonoscopy and support them through this process (Canadian Partnership Against Cancer, 2019, 2021).

Furthermore, most provinces and territories have a different screening requirement or guideline for people at higher risk of CRC, especially due to personal or family history of CRC and presence of specific genetic mutations. Generally, these population begin screening, on average, at age 40 or ten years earlier than their family member with CRC or advanced adenoma diagnosis, usually with colonoscopy every five or ten years (Leddin et al., 2018; Leddin et al., 2010).

These programmatic differences reflect the diverse healthcare landscapes and population needs across the various jurisdictions of Canada, with government and policy makers adapting the national guidelines to their specific demographic and population needs. However, these differences also create a wide range of challenges with improving screening uptake uniformly across the country. It means that the effect and outcomes of CRC screening differs across jurisdictions. These factors make underscores the importance of assessing the effect of CRC screening programs and highlighting best practices.

Table 2.3: Summary of Recruitment and Reminder Notification Systems in Provincial Colon Screening Programs across Canada

Jurisdiction	Promotional Strategies	Reminder Notification
Yukon	Awareness campaign for Colorectal Cancer Awareness Month (March) (web, social media, posters, radio, community outreach)	Nil
Alberta	Social media campaign (Facebook, Instagram, Twitter), program website, program brochures, community events, booths at conferences	Nil
Saskatchewan (SK)	Program website Promotional and educational resources for health care providers and public Radio and print advertisement	Reminder letter sent 9 weeks after initial invitation
Manitoba	Education events for healthcare providers • Public awareness activities • Social media • Program website	Reminder letter sent 56 days after initial invitation
Ontario	Physician-linked correspondence program Screening Activity Report (SAR) is an online interactive report for physicians in a Patient Enrollment Model practice and provides screening data to help improve cancer screening rates and appropriate follow-up. The Sioux Lookout and Zone SAR was developed to support primary care physicians and nurses supporting screening in 27 First Nation communities. Public awareness campaigns (social media)	Reminder letter sent 4 months after initial invitation
QC	Promotion to PCP of the current guidelines which indicate that average risk individuals should be screened by FIT test	Nil

NB	Promotional and educational campaigns for health care providers and professionals (printed materials, program updates) Public awareness campaigns (social media, digital strategy, radio ads, presentations at community events	Reminder letter sent 12 weeks after initial invitation
PEI	Awareness campaign for Colorectal Cancer Awareness Month (March) with public advertising (web, print ads, TV, radio)	Nil
NL	Education and posters for health care providers Social media campaign (Facebook, Twitter) Presentations at health symposiums and community events	Nil

Abbreviations: AB, Alberta; BC, British Columbia; MB, Manitoba; NB, New Brunswick; NL, Newfoundland & Labrador; NS, Nova Scotia; ON, Ontario; PEI, Prince Edward Island; QC, Quebec; SK, Saskatchewan

2.7.1. Effect and Challenges of CRC Screening in Canada

Evidence from provincial program evaluations suggests that CRC screening programs have contributed to CRC detection and outcomes in Canada (Kobayashi et al., 2014; Logan et al., 2012; Pilonis et al., 2020; Portero de la Cruz & Cebrino, 2023), despite a scarcity of national-level studies. Increased uptake and participation across demographics are a key indicators of program effectiveness. While national data are scarce, Major et al. (2013) reported a 16.1% average participation rate in the first round of provincial programs between 2009 and 2011. Singh et al. (2015) later reported a 55.2% national participation rate, with significant variation across jurisdictions (ranging from 41.3% in the Territories to

67.2% in Manitoba). Participation was higher in regions with organised programs (62.8%) than in those without or in development (48.4%).

Current data suggest further progress towards the 60% national screening target (Canadian Partnership Against Cancer, 2021). This increased participation translates into earlier CRC detection, fewer late-stage diagnoses, and improved outcomes (Tinmouth et al., 2016).

However, challenges persist, particularly among disadvantaged groups. A Canadian Partnership Against Cancer review identified barriers to accessing CRC screening, highlighting disparities (Canadian Partnership Against Cancer, 2017b). A significant challenge across populations is the disparity in colonoscopy quality, a crucial screening component. Collaborative efforts are underway to standardise care, emphasising adequate polyp detection, appropriate follow-up, and minimising complications (Canadian Partnership Against Cancer, 2017b).

Low-income/SES populations face provider, support, and education-related barriers (Canadian Partnership Against Cancer, 2017b). Lack of provider recommendations or referrals often lead to poor awareness and de-prioritisation of screening (Durand et al., 2021; Lofters et al., 2015). Fear, misconceptions, and negative attitudes also affect decision-making (Kobayashi et al., 2014). Practical challenges like scheduling conflicts and low health literacy compound these issues (Horshauge et al., 2020; Kobayashi et al., 2014; Lin et al., 2020; Unanue-Arza et al., 2021).

Visible minorities face multifaceted barriers (Adu et al., 2017; Amina et al., 2019; Canadian Partnership Against Cancer, 2017b; Cobb et al., 2022; Honein-AbouHaidar et al., 2013). Health system navigation difficulties, exacerbated by language barriers, hinder communication and understanding (Crawford et al., 2016). Lack of culturally appropriate materials and low health literacy contribute to misunderstandings and low perceived importance of screening (Canadian Partnership Against Cancer, 2017b). Fear, embarrassment, family responsibilities, and reliance on family for guidance pose additional challenges.

As mentioned previously, individuals in rural/remote areas face additional/unique barriers (Canadian Partnership Against Cancer, 2017b; Darvishian et al., 2023). Lack of regular healthcare providers hinders screening promotion and referral. Geographical distances, limited facilities, and transportation issues lead to delayed or missed invitations/screening kits (Canadian Partnership Against Cancer, 2017b).

2.7.2. CRC Screening in Atlantic Canada

The Atlantic Canadian provinces—NL, NB, NS, and PEI—share unique sociodemographic and healthcare dynamics. While they have lagged behind other provinces in CRC screening organisation and participation, the period between 2010 and 2014 saw a noticeable shift (Canadian Partnership Against Cancer, 2021). Initially, screening uptake was lower than the national average, reflecting the early stages of organised programs (Darvishian et al., 2023). However, uptake seem to have increased over time. Following the inception of its Colon Cancer Prevention Program in 2009, Nova Scotia saw a steady rise in screening participation. New Brunswick and Prince Edward Island are also reporting increased screening, attributable, at least, in part, to the enhanced public awareness and streamlined processes heralded by the screening program. Newfoundland and Labrador experienced a more modest increase (Canadian Partnership Against Cancer, 2021). Nevertheless, peculiar challenges remain, notably the region's unique geographical and socioeconomic dynamics.

Atlantic Canada's mix of urban centers, rural towns, and remote areas impacts healthcare accessibility. Reaching screening centers can be challenging, particularly for those in remote communities. However, some provincial health authorities have addressed this through decentralized services, satellite centers, and mobile units (Nova Scotia Health Authority, 2017).

The region's sociocultural fabric, while rich in community ties that can be leveraged for awareness, also presents barriers due to traditional beliefs that may hinder screening uptake (Shi et al., 2020). Studies have highlighted how specific attitudes and cultural values, such as fatalism (the belief that health outcomes are predetermined and unchangeable), distrust of the medical system, concerns about privacy and modesty, and stigma associated with cancer, can negatively impact preventive health behaviors like cancer screening in various communities (Kobayashi et al., 2014; Shi et al., 2020).

The region's demographic composition, with an increasingly aging population and a substantial portion residing in rural or remote areas, poses a complex challenge to screening efforts (Decker et al., 2023; Tung et al., 2018). While older individuals are generally more likely to undergo CRC screening due to increased awareness and more engagement with health care services (Decker et al., 2023), the combination of an aging population and a large proportion of individuals living in rural or remote areas, as is common in the Atlantic provinces, can create significant barriers to screening uptake (Rat et al., 2018). Older adults in these areas often face challenges with transportation, limited access to healthcare facilities, and fewer healthcare providers. These factors can result in delayed or missed screening opportunities, ultimately hindering overall screening rates in the region (Shi et al., 2020). Tailored public health campaigns, mobile units, telehealth, and collaborations with local leaders can improve both awareness and reach (Inadomi et al., 2021; Rat et al., 2018).

Additionally, most Atlantic provinces have a considerable low-income/SES population (Darvishian et al., 2023; Tung et al., 2018). Economic disparities influence screening decisions, as individuals may deprioritise preventive care due to financial constraints, lack of awareness, or competing priorities (Canadian Partnership Against Cancer, 2017b). Consequently, improving economic conditions through government welfare services, could indirectly enhance screening uptake.

Compared to other provinces, the evolution of CRC screening uptake in Atlantic Canada offers some insights. Ontario and British Columbia, with established programs, consistently report higher participation rates (BC Cancer, 2020; Canadian Partnership Against Cancer, 2021; Darvishian et al., 2023; Rabeneck et al., 2014). However, the gap with Atlantic Canada seems to be narrowing (Canadian Partnership Against Cancer, 2021). By understanding the successful strategies employed in these provinces and the specific barriers to screening in each Atlantic province, governments, policymakers, and program administrators can design tailored policy changes and screening interventions. These interventions can adapt best practices, reach underserved populations, and ultimately improve CRC screening uptake across the board.

2.8. Concurrent Screening Participation

CRC, breast (BrCa), and cervical (CC) cancers are significant contributors to the Canadian cancer burden, accounting for an estimated 54,650 (24%) of overall cancer incidences and 15,280 (18%) of cancer-related deaths in 2022 (Darren et al., 2022). Concurrent participation, meaning participation in multiple (2 or 3) cancer screenings around the same time, is rooted in the understanding that if eligible individuals, especially women, participate in all relevant screenings, the combined impact could be pivotal in early detection and prevention of multiple cancers. This approach is important due to shared risk factors and potential co-occurrence of these cancers (Njor et al., 2023; Sabatino et al., 2012).

In Canada, organised screening programs for CRC, BrCa, and CC have been established, targeting specific age groups as recommended by CTFPHC (Canadian Partnership Against Cancer, 2019). The CTFPHC recommends mammography for BrCa screening every 2-3 years for women aged 50-74, CC screening with a Pap test every 3 years for women aged 25-69, and CRC screening with fecal tests every 2 years or flexible sigmoidoscopy/colonoscopy every 10 years for individuals aged 50-74 (Canadian Partnership Against Cancer, 2019; Major et al., 2015), though provincial variations in the implementation of these guidelines exist.

The rationale for concurrent cancer screenings is multifaceted. Epidemiologically, different cancers share risk factors like diet, physical activity, tobacco use, genetics, and environmental factors (Boffetta & Hainaut, 2019). This overlap suggests that individuals at risk for one type of cancer may also be at risk for others (Boffetta & Hainaut, 2019). making concurrent screening a potentially efficient way to assess multiple risks simultaneously.

Practically, consolidating screenings could improve efficiency and reduce healthcare costs (Brouwers et al., 2011a). By combining screening appointments or tests, healthcare systems can streamline procedures, optimise resource allocation, and minimise the burden on both patients and providers. Early detection of multiple cancers through concurrent screenings can lead to better prognoses and treatment options (Brouwers et al., 2011a), potentially reducing the need for more invasive and costly interventions later on.

Additionally, concurrent screenings provide valuable opportunities for education and engagement (Baccolini et al., 2022; Brouwers et al., 2011a). Each interaction with the healthcare system allows providers to reinforce the importance of preventive care, update personal health records, and tailor health messages to the individual's specific risk profile. This can lead to increased health literacy, empowered decision-making, and improved overall health behaviours (Baccolini et al., 2022; Brouwers et al., 2011a).

Despite these benefits and efforts to increase screening rates, many populations remain below national targets (Alam et al., 2022; Blair et al., 2019; Major et al., 2015; Sabatino et al., 2015; Schoenborn et al., 2019). Suboptimal uptake is evident in the fact that many cancers are diagnosed at late stages: 49% of CRC, 17.3% of BrCa, and 28.3% of CC are diagnosed at stage III or IV (Canadian Cancer Statistics Advisory Committee, 2018). While the 17.3% late-stage diagnosis rate for BrCa is relatively low, it still represents a significant number of cases that could potentially benefit from earlier detection and intervention. Understanding the successes and challenges of different screening programs is crucial to promoting better adherence to guidelines and improving early detection rates across all cancer types.

2.8.1. Breast Cancer Screening

BrCa remains the most common cancer among Canadian women (Canadian Cancer Society, 2023), making screening programs a key public health objective. Screening is widely recognised as essential for early detection, associated with improved survival rates and treatment options (Bauer et al., 2022). The CTFPH recommends mammograms every two to three years for women aged 50 to 74 at average risk, though provincial programs vary (Canadian Partnership Against Cancer, 2017a; Lu et al., 2012; Major et al., 2015). Mammography is the primary modality, with supplemental screening like MRI or ultrasound sometimes recommended for high-risk women or those with dense breast tissue (Canadian Partnership Against Cancer, 2017a).

Historically, breast cancer screening has been a focus of campaigns globally, with movements like "Pink Ribbon" raising awareness and increasing uptake (Wilkinson et al., 2022). With an 88% 5-year survival rate for stages I-III, breast cancer patients have some of the highest survival rates, partly attributable to screening advances (Canadian Partnership Against Cancer, 2019). A systematic review by Tonelli et al. (2011) estimated that increased mammography uptake, especially among women aged 50-69, led to a 21% reduction in breast cancer mortality in Canada. A Canadian Partnership Against Cancer report (2017a) also suggests that stable breast cancer incidence and mortality since the early 1990s is linked to mammography screening.

Despite this progress, breast cancer screening remains sub-optimal among certain groups (Adu et al., 2017; Bonafede et al., 2019). Socioeconomic status is a barrier, with women in lower economic groups facing challenges due to transportation costs, lower health literacy, and inability to take time off work (Adu et al., 2017; Bonafede et al., 2019; Lofters et al., 2019; Lu et al., 2012; Siu, 2016). Cultural and linguistic barriers, fear and anxiety, and health system factors like access to providers and facilities also contribute (Adu et al., 2017; Bonafede et al., 2019; Lofters et al., 2019; Lu et al., 2012; Siu, 2016). Additionally, individual decision-making regarding the perceived benefits and harms of breast cancer screening, including the potential or concern for overdiagnosis and overtreatment, can influence participation (Jin et al., 2019; Lee et al., 2020).

It's important to acknowledge the potential harms associated with breast cancer screening. Overdiagnosis, the detection of cancers that may not have caused harm in a woman's lifetime, can lead to unnecessary treatment and associated side effects (Jin et al., 2019; Lee et al., 2020). Mammograms can also produce false-positive results, leading to anxiety and additional testing, or false-negative results, delaying diagnosis and treatment (Adu et al., 2017). Radiation exposure from mammograms, although low, is a cumulative risk (Adu et al., 2017; Lee et al., 2020). Balancing the benefits of early detection with these potential harms is crucial for informed decision-making about screening participation (Jin et al., 2019).

Addressing these barriers requires tailored interventions to improve access, awareness, and address concerns specific to each population group. Open communication between healthcare providers and patients about the potential benefits and harms of screening is essential to ensure informed decision-making (Jin et al., 2019; Lee et al., 2020).

2.8.2. Cervical Cancer Screening

CC remains the third most common cancer among women, especially those aged 35-44 (Caird et al., 2022). The CTFPHC recommends screening from age 25 to at least 69, with three consecutive negative tests in the last 10 years (Canadian Partnership Against Cancer, 2019). Pap tests every three years are typical, but HPV testing, due to its higher sensitivity for detecting high-risk HPV strains, is increasingly used, often in conjunction with Pap tests (co-testing) for improved accuracy (Caird et al., 2022; Canadian Partnership Against Cancer, 2019). The shift towards HPV testing reflects the continuous evidence-based improvement in screening practices.

CC screening is a public health success in Canada, with routine Pap tests contributing to earlier diagnoses and significant reductions in CC incidence and mortality (Caird et al., 2022). Current statistics show a higher likelihood of early-stage CC diagnosis in Canada (Canadian Cancer Statistics Advisory Committee, 2019). Between 1984 and 2020, the age-standardised incidence rate (ASIR) dropped from 13 to 7.1 per 100,000, with an average annual percentage change (AAPC) of -1.8%. The age-standardised mortality rate (ASMR) also decreased by an average of 2.1% within the same period (Caird et al., 2022; Canadian Cancer Statistics Advisory Committee, 2019). However, this decline has slowed recently (Brenner et al., 2019), and further progress requires improved access, availability, and uptake of screening (Caird et al., 2022).

Challenges to CC screening uptake mirror those for BrCa and CRC, including personal factors (e.g., socioeconomic status, health literacy), health system factors (e.g., accessibility, provider availability), and screening-related factors (e.g., perceptions, beliefs, attitudes) (Alam et al., 2022; Bacal et al., 2019; Baccolini et al., 2022; Decker et al., 2009). "Screening complacency" is a notable factor, where the perceived lower risk and severity of CC, perhaps due to screening program success, may lead to lower prioritisation compared to other cancers (Atkinson et al., 2015). Similar to BrCa, rural/remote women, those in minority ethnic/migrant groups, and women with lower SES may have less access or inclination to participate (Kurani et al., 2020; Lo et al., 2013; Lofters et al., 2011; McCowan et al., 2019).

The introduction of widespread HPV vaccination programs has the potential to significantly reduce CC incidence in the long term by preventing HPV infections, the primary cause of CC (Caird et al., 2022). However, in the short to medium term, it's crucial to maintain and potentially increase screening uptake. This is because the vaccine's full impact will take time to manifest, and there are still individuals who may not have been vaccinated or may be infected with HPV strains not covered by the vaccine (Canadian Partnership Against Cancer, 2023). Continued screening efforts are essential to ensure early detection and treatment of CC in these populations, bridging the gap until the vaccine's full preventive potential is realised (Caird et al., 2022).

Widespread HPV vaccination, reminders, and educational interventions can help improve uptake (Caird et al., 2022) and address the remaining challenges. These efforts should focus on increasing awareness of the importance of screening even in the era of vaccination, dispelling misconceptions about CC risk, and addressing barriers to access for vulnerable populations (Canadian Partnership Against Cancer, 2023).

2.8.3. State of Concurrent Screening Participation

Numerous studies have examined participation rates and factors associated with breast, cervical, and CRC screening individually. These predictors fall under personal/demographic factors (socioeconomic status, language, knowledge, beliefs, attitudes), health system factors (accessibility, provider availability), and screening-related factors (convenience, perception, patient experience) (Farr et al., 2022; Lo et al., 2013; Sabatino et al., 2015; Tatari et al., 2020). However, with each program administered separately, information on concurrent participation in all three and its predictors in Canada is scarce (Vahabi et al., 2021).

Examining individual programs, CRC screening lags behind breast and cervical cancer screening in Canada (McCowan et al., 2019). Reviews show 64-70% of eligible women are up-to-date with mammography and Pap tests, while CRC screening struggles to reach the 60% national target (Crawford et al., 2016; Major et al., 2015; McCowan et al., 2019; Schoenborn et al., 2019). Barriers likely affect women differently. For some females, barriers may only exist for one of the screening programs, while such barriers might affect all three screening programs for others. This makes evaluating concurrent participation in multiple cancer screening program and understanding the various correlates of screening, particularly important.

Limited national data exist on concurrent screening rates in Canada. Vahabi et al. (2021) found that 48% of eligible Ontario women participated in all three screenings, 37% in one or two, and 15% in none. BrCa and CRC screening was the most common combination for those participating in two. This 48% rate aligns with international findings, ranging from 50% in the Netherlands, Denmark, and Scotland (53.7%, 55%, 52%) (Kregting et al., 2022; McCowan et al., 2019; Njor et al., 2023) to 30% in England (35%) and Japan (27%), and even 11.5% in France (Dawidowicz et al., 2020; Ishii et al., 2021; Rebolj et al., 2020).

This variation may stem from differences in eligible populations, program design/implementation (e.g., invitations, modalities), or screening culture (health-seeking behaviors, risk perception, attitudes) (Crawford et al., 2016; Horshauge et al., 2020; Kregting et al., 2022; Lin et al., 2020; Tatari et al., 2020). Concurrent participation rates in England and Scotland (35% and 52% respectively) offer insights, as these are jurisdictions that have screening culture and organisation comparable to Canada. In both studies, CRC screening had the lowest participation, with breast and cervical being the most common combination (McCowan et al., 2019; Rebolj et al., 2020). This suggests that screening organisation and cultural factors may significantly influence concurrent participation, perhaps even more so than individual program participation.

Understanding these influences is key to optimising screening program strategies and improving overall cancer prevention efforts.

2.8.4. Optimising Concurrent Screening Participation and Future Directions

Promoting concurrent screening participation offers significant benefits, primarily a holistic approach to cancer prevention. By facilitating early detection across multiple fronts, it increases the chances of timely interventions, improving prognosis and reducing mortality (Horshauge et al., 2020; Ishii et al., 2021; Jung, 2020; Lu et al., 2012). This is particularly important given the shared risk factors among BrCa, CC, and CRC.

From a health system perspective, concurrent screenings can lead to long-term cost savings. Early detection often translates to less aggressive and costly treatments, shorter hospital stays, and more efficient resource allocation (Caird et al., 2022). Additionally, integrated screening programs can improve the patient experience by streamlining scheduling and reducing the burden of multiple appointments (Tangka et al., 2022).

However, challenges exist in the current system. Fragmented communication between programs, lack of integrated records, and logistical hurdles like scheduling and time off work hinder concurrent participation (Tatari et al., 2020;

Tonelli et al., 2011; Vahabi et al., 2016). Personal and socio-cultural barriers, including low health literacy, fear, anxiety, and perceived inconvenience, also play a role (Tangka et al., 2022; Tatari et al., 2020; Tonelli et al., 2011; Vahabi et al., 2016). Belief systems, attitudes, language barriers, and limited access due to socioeconomic status or rural residence further complicate matters.

To overcome these challenges, public health policies should evolve to promote concurrent screenings. Integrating BrCa, CC, and CRC screening programs could create a "one-stop-shop" experience. This might involve co-locating services or coordinating schedules, as piloted in Alberta's 2021 integrated initiative (Canadian Partnership Against Cancer, 2023). Similar interventions evaluated by the CDC's Colorectal Cancer Control Program in the United States demonstrate the feasibility of integrated screening (Tangka et al., 2022).

In the interim, targeted education, awareness, and outreach programs, particularly for underserved populations, are essential. These interventions should address specific barriers and utilise culturally relevant materials and messengers. Investing in healthcare provider training to promote concurrent screening as routine care is also crucial (Zhu et al., 2022). Continued research is needed to clarify the requirements for effective integrated programs, ensuring that as medical advancements enhance screening tests, policies and strategies adapt to make concurrent participation a standard practice.

2.9. Use of Secondary Data in Health Research

Increasing digital technology and capacity to store and analyse large amount of data have significantly revolutionised epidemiological and health research (Benchimol et al., 2015). Large administrative and/or survey datasets, as secondary data sources, have become invaluable resources for understanding and informing health policies and practice (Benchimol et al., 2015; Schneeweiss & Avorn, 2005). Secondary data, which encompasses large administrative and survey datasets collected for purposes other than the research at hand, has emerged as a critical resource for understanding population health trends, evaluating health interventions, and informing evidence-based policies and practices (Schneeweiss & Avorn, 2005). These datasets, often collected on national or regional scales, offer considerable information on health behaviors, chronic conditions, healthcare utilisation, and the social determinants of health (Benchimol et al., 2015).

Secondary data offer several important advantages for health research. First, collecting primary data can be a resource-intensive endeavor, requiring substantial financial investments and time commitments for participant recruitment, data collection, and entry. Secondary data eliminate these costs to the researcher, allowing researchers to allocate resources more efficiently and accelerate the research process. Even when access fees are involved, they are typically lower than the expenses associated with primary data collection (Lofters et al., 2017; Roos & Nicol, 1999).

Second, large-scale surveys, such as the Canadian Community Health Survey (CCHS), often employ rigorous sampling methodologies to ensure that the data are representative of the target population. This representativeness enhances the generalizability of research findings, making them more applicable to broader populations. The large sample sizes also increase statistical power, enabling the detection of subtle associations or differences that might be missed in smaller studies (Béland, 2002; Lofters et al., 2017).

Third, frequent (for example, annual) surveys, like the CCHS, collect data over multiple years, allowing researchers to track changes in health indicators, behaviours, and outcomes over time. Even though different samples are often collected for the different iteration of the survey, this temporal analysis of multi-year data, is invaluable for understanding the evolution of health trends, evaluating the long-term impact of interventions, and identifying emerging public health issues (Béland, 2002; Lofters et al., 2017).

Lastly**,** many large secondary datasets are readily accessible to researchers through data sharing agreements or public repositories (Lofters et al., 2017). This accessibility facilitates timely analysis and knowledge generation, fostering collaboration and accelerating the pace of research (Lofters et al., 2017).

While secondary data offers numerous benefits, it also presents certain challenges (Benchimol et al., 2015; Sanmartin et al., 2016; Schneeweiss & Avorn, 2005). For one, secondary data may not always align with the specific research questions being investigated. Variables of interest may be absent, definitions may differ from those used in the research, or data quality issues like inconsistent or missing values may arise. Researchers often have to carefully assess the suitability of the data for their research questions and address any limitations through appropriate data cleaning and analysis techniques (Benchimol et al., 2015).

Additionally, the sheer volume and complexity of large datasets can be daunting. Managing and analysing such data often requires specialised software, robust computing tools, and expertise in data manipulation and statistical analysis. Researchers often need to invest time and resources in acquiring the necessary skills or collaborating with data scientists/analysts to effectively handle these datasets (Sanmartin et al., 2016; Schneeweiss & Avorn, 2005).

Similarly, secondary data, particularly those containing sensitive health information, raise ethical concerns regarding privacy and confidentiality. Researchers often have to adhere to stringent data protection protocols, ensuring that data are anonymised or de-identified and that access is restricted to authorised personnel. Moreover, researchers often have to submit their analyses outputs and findings to strict vetting rules to ensure no risk of disclosure exists.

These can and often contribute to tedious and slow research process (Sanmartin et al., 2016; Schneeweiss & Avorn, 2005).

2.9.1. Canadian Community Health Survey (CCHS)

The datasets used for the studies included in this thesis came from the CCHS. The CCHS has become a crucial resource for health research in Canada. Conducted annually by Statistics Canada, this cross-sectional survey provides a comprehensive and detailed snapshot of the health of Canadians at the sub-provincial (that is, health region) (Béland, 2002).

According to Statistics Canada, the CCHS is designed to fulfill several key objectives:

1. Health Surveillance**:** It supports health surveillance programs by providing reliable and timely data on health status, health behaviors, and healthcare utilisation at national, provincial, and health region levels. Such data are essential for monitoring population health trends, identifying emerging health issues, and evaluating the effectiveness of health interventions and policies.
2. Research on minority population groups and rare characteristics: The large sample size of the CCHS enables researchers to study small populations and rare health conditions that might be difficult to capture in smaller

studies. This is particularly valuable for understanding health disparities and the needs of specific sub-populations.

3. Timely and accessible information: The CCHS aims to release data in a timely manner and make it easily accessible to a wide range of users, including researchers, policymakers, healthcare providers, and the public. This promotes transparency, evidence-based decision-making, and public awareness of health issues.
4. Flexibility and responsiveness: The survey incorporates a rapid response option, allowing it to adapt to emerging health concerns and collect data on new or evolving health issues promptly. This flexibility ensures that the CCHS remains relevant and responsive to the changing health landscape in Canada.

2.9.1.1. History and Evolution of the CCHS

Since its inception in 2000, the CCHS has undergone several transformations to enhance its scope and relevance (Statistics Canada, 2015; 2017). In 2007, the survey transitioned from a biennial to an annual collection cycle, enabling more timely data collection and analysis. It also introduced a consistent core content, ensuring the tracking of key health indicators over time. Then in 2012/2013 the CCHS integrated content from the Canadian Health Measures Survey (CHMS), which collects direct physical measurements like blood pressure and cholesterol levels. This integration provided a more comprehensive view of health by combining self-reported data with objective health measures (Statistics Canada, 2017).

Another major redesign in 2015 involved changes to the sampling methodology, content, and target population. These changes aimed to improve the survey's efficiency, relevance, and ability to capture emerging health issues. Due to the significant methodological and content changes implemented in the 2015 redesign, researchers are asked to avoid or exercise caution when comparing CCHS data from before and after this period, as direct comparisons may not be appropriate given the methodological differences (Statistics Canada, 2017).

2.9.1.2. Sampling, Data Collection, and Processing

The CCHS employs a complex, multi-stage sampling design to ensure the representativeness of the Canadian population. Since 2015, a multi-stage sample allocation strategy has been used to give appropriate and representative sample distribution to the health regions and the provinces. For each age group (18 and over, 12 to 17), the sample is first allocated among the provinces using a power allocation of 0.75 according to the size of their respective population. Each province's sample is then allocated among its health regions using a power allocation of 0.35 according to the size of the population in each health region (Statistics Canada, 2015).

Also, from 2015 onwards, the CCHS has used two sampling frames: an area frame for adults (18 and older) and a list frame from the Canadian Child Tax Benefit (CCTB) records for youth (12-17). Using the area frame, a sample of dwellings is selected to target the population aged 18 and over (Statistics Canada, 2017). During collection, all members of the dwelling are listed, and persons aged 18 years or over are automatically selected using various selection probabilities based on age and household composition. One person aged 12 - 17 years is also pre-selected to complete the survey (Statistics Canada, 2017). Data collection is conducted through computer-assisted in-person and telephone interviews, ensuring standardised procedures and minimising data entry errors (Statistics Canada, 2017).

The CCHS questionnaire is modular, with a core component covering general health topics and optional modules, such as CRC screening participation, that can be selected by provinces and territories to address their specific health priorities. The survey covers a wide range of health-related topics, including chronic diseases, health behaviors, healthcare utilisation, and social determinants of health (Statistics Canada, 2017). However, as a consequence of this modular approach, optional modules are often missing for different provinces or territories across different years (Béland, 2002; Statistics Canada, 2017).

The collected data undergoes a rigorous processing phase at Statistics Canada, which includes:

- Checking for inconsistencies, out-of-range values, and logical errors in the data.
- Assigning numerical codes to categorical responses and standardising open-ended responses.
- Calculating new variables based on existing data (derived variables), such as body mass index (BMI), physical activity levels or socioeconomic status indicators.
- Assigning weights to each respondent to account for the complex sampling design and ensure that the results are representative of the Canadian population, even when analysis are done at the sub-population or regional level.
- Addressing missing data, particularly for household income, using statistical imputation methods to estimate missing values based on available information (Statistics Canada, 2015; 2017).

Additionally, to protect respondent confidentiality, the CCHS implements strict disclosure control measures. These measures include removing direct identifiers, suppressing, or aggregating data for small cell sizes, and applying statistical techniques to minimise the risk of re-identification.

Statistics Canada places a high priority on data quality and employs various measures to ensure the accuracy and reliability of CCHS data. These measures include:

- Tracking and reporting response rates to assess the representativeness of the sample and identify potential nonresponse bias.
- Conducting thorough checks to identify and correct inconsistencies or errors in the data.
- Providing comprehensive training to interviewers and implementing quality control procedures to ensure standardised data collection (Statistics Canada, 2015; 2017).

However, the CCHS, like any survey, is subject to potential errors and limitations. These include the inherent variability associated with sampling a subset of the population rather than conducting a complete census. Statistics Canada provides coefficients of variation (CVs) to quantify the sampling error associated with different estimates and survey weights for analyses. Also, errors can occur during data collection, processing, or analysis. This may include respondent recall bias, interviewer error, or data entry mistakes. Statistics Canada implements quality control measures to minimise these errors.

While the linkage to income tax records improves the accuracy of income data, it is not possible for all respondents due to factors like consent withdrawal or missing tax information. Lastly, substantial aspect of CCHS data rely on self-reported information. This may be subject to recall bias or social desirability bias (Statistics Canada, 2015; 2017).

Lastly, Statistics Canada adheres to strict ethical guidelines to protect the privacy and confidentiality of CCHS respondents. Key ethical considerations include:

- Informed Consent: Participants are informed about the purpose of the survey, the voluntary nature of participation, and the measures taken to protect their confidentiality.
- Data Anonymisation: Direct identifiers are removed from the data before it is released to researchers.
- Restricted Data Access: Access to the master data files is limited to authorised researchers who agree to comply with strict confidentiality protocols (Statistics Canada, 2017).

2.9.1.3. Relevance of CCHS for Cancer Screening Research

The CCHS is an important resource for health research in Canada, offering a wealth of data on various health topics, including cancer screening (Lofters et al., 2017). Its comprehensive nature allows researchers to investigate the prevalence of cancer screening behaviours, identify disparities in uptake across different population groups, and examine the factors that influence screening decisions (Lofters et al., 2017).

For cancer screening research specifically, the CCHS provides crucial information on:

- Cancer Screening Uptake: The survey collect data on participation in various cancer screening programs, including CRC, BrCa, and CC screening. These data can be useful for monitoring trends, evaluating the effect of screening programs on reported participation levels, and identifying populations with lower screening rates.
- Barriers to health service utilisation: The CCHS collects self-reported data on the barriers individuals face in accessing and participating in cancer screening. This includes lack of awareness, fear or anxiety, and accessibility barriers. Understanding these barriers is crucial for developing targeted interventions to improve screening uptake.
- Impact of public health programs: The CCHS allows researchers to assess the effect and/or contributions of organised cancer screening programs to population-level screening rates. By comparing data before and after program implementation, where available, researchers can estimate the effect of these programs and identify potential areas for improvement.

By leveraging CCHS data, researchers can generate evidence-based insights that inform the development of effective cancer prevention and control strategies. This includes tailoring interventions to specific populations, addressing barriers to screening, and promoting equitable access to services. The CCHS can play a vital role in advancing our understanding of cancer screening behaviours and ultimately contributes to reducing the burden of cancer in Canada (Lofters et al., 2017.

2.10. Andersen’s Behavioural model of health service use

The Andersen Behavioral Model (Andersen model) remains major theoretical framework in health services research, providing a robust framework for understanding the multifaceted factors that influence individuals' utilisation of health services (Andersen, 1995). Initially introduced in 1968 by Ronald M. Andersen, a medical sociologist and health services researcher, the model has since undergone several revisions and expansions, solidifying its position as a widely adopted theoretical framework in the field (Andersen, 1968; Andersen & Newman, 1973

2.10.1. Evolution of the Andersen model

At its core, the Andersen model holds that the use of health services, defined as any contact between individuals and the healthcare system (e.g., preventive services, diagnostic tests, treatment, rehabilitation), is a function of three primary categories of factors: predisposing characteristics, enabling resources, and need (Andersen, 1995). Predisposing characteristics include demographic attributes (age, sex, marital status), social structural elements (education, ethnicity, occupation), and health beliefs (attitudes, values, knowledge). These factors shape an individual's perceptions of health and illness and their inclination to seek healthcare. Enabling resources, including personal finances, health insurance, and community-level healthcare accessibility, determine an individual's capacity to utilise services. Lastly, the need component, said to encompass both perceived and evaluated health needs, represents an individual's perceived health status and the objective necessity for medical care (Alkhawaldeh et al., 2023; Andersen, 1995).

A significant milestone was reached in 1995 with Andersen's seminal paper, "Revisiting the Behavioral Model and Access to Medical Care: Does It Matter?" (Andersen, 1995). This version expanded the model to incorporate feedback loops, acknowledging that health outcomes and consumer satisfaction could, in turn, influence predisposing factors and perceived need. It also introduced the concept of the health care system as an enabling factor, highlighting the role of national health policy and resources in determining population health.

The most recent update to the model, published in 2001 by Andersen and Davidson, further expanded the framework by emphasising the role of contextual and community-level factors (Andersen et al., 2001). This version argues that both individual and community characteristics can predispose, enable, or suggest a need for health services use. For example, the socioeconomic status of a neighborhood may not only reflect individual income but also serve as a community-enabling factor, influencing access to care (Brown et al., 2004).

The model's evolution also includes adaptations for specific populations. For instance, the Behavioral Model for Vulnerable Populations (Gelberg et al., 2000) was developed to better understand health services use among homeless people, recognising their unique predisposing (e.g., childhood characteristics) and enabling (e.g., competing needs) factors. Additionally, the model has been adapted to explore the use of complementary and alternative medicine (Fouladbakhsh & Stommel, 2007), demonstrating its flexibility in addressing diverse healthcare contexts.

2.10.2. Andersen model and cancer screening research

The Andersen model's popular use in health services research stems from its comprehensive and adaptable nature (Alkhawaldeh et al., 2023). It has been employed to investigate a wide array of health behaviours, including preventive care utilisation, chronic disease management, mental health service use, and vaccination uptake (Alkhawaldeh et al., 2023; Babitsch et al., 2012). The model's ability to accommodate both individual and contextual factors, as well as health behaviours, makes it particularly valuable for understanding disparities in healthcare utilisation across diverse populations. For instance, it has been used to examine the impact of individual factors like self-efficacy and decisional balance on CRC screening adherence (Jin et al., 2019), as well as the influence of contextual factors like government subsidies and access to information on screening uptake (Chan et al., 2022).

With regards to cancer screening, specifically, the Andersen model has been applied to various contexts. For instance, Jin et al. (2019) utilised the Andersen model to investigate CRC screening adherence among Korean Americans, identifying enabling factors like income, regular check-ups, doctor recommendations, self-efficacy, and decisional balance as significant predictors. The study highlights the importance of both structural (e.g., access to healthcare) and psychosocial (e.g., self-efficacy) factors in facilitating screening behaviour.

Similarly, Chan et al. (2022) employed the Andersen model to examine CRC screening uptake in Hong Kong, finding that the availability of government subsidies and educational materials were key enabling factors. This study underscores the role of contextual factors, such as health policies and information dissemination, in promoting screening participation.

In the context of breast cancer screening, studies like the one by Jin et al. (2019) have used the Andersen model to identify factors associated with mammography adherence among Korean American women. Their findings emphasised the importance of knowledge, self-efficacy, and positive attitudes towards screening, highlighting the need for tailored interventions to address these factors.

These studies, among others, demonstrate the versatility and utility of the Andersen model in understanding cancer screening participation across diverse populations and settings. By identifying the specific predisposing, enabling, and need factors that influence screening behaviors, the Andersen model can inform the development of targeted interventions and policies to improve screening rates and ultimately reduce the burden of cancer (Chan et al., 2022; Jin et al., 2019).

2.10.3. Challenges and critiques of the Andersen model

While the Andersen model offers a valuable framework, its application presents certain challenges. One key issue is the variability in how variables can and have been operationalised across studies. For instance, socioeconomic status may be classified as a predisposing factor in some studies and an enabling factor in others (Babitsch et al., 2012). This inconsistency can hinder comparisons between studies and complicate the interpretation of findings.

The Andersen model has faced critiques for its potential neglect of cultural factors and its limited consideration of psychosocial factors like stress, social support, and coping mechanisms (Babitsch et al., 2012). These factors can significantly influence health beliefs, perceived need, and ultimately, health service utilisation (Babitsch et al., 2012). In response to these critiques, some researchers have expanded the Andersen model to incorporate cultural and psychosocial dimensions. For example, Bradley et al. (2002) expanded the model to include psychosocial factors in the context of long-term care use, while others have emphasised the need to consider cultural factors in understanding health service utilisation among diverse populations (Lederle et al., 2021).

Additionally, the model has been criticized for its linear structure, which may not fully capture the complex and often non-linear pathways to health service utilisation (Alkhawaldeh et al., 2023; Babitsch et al., 2012). Some studies have attempted to address this by proposing alternative models that incorporate more complex relationships between the Andersen model's components (Herrmann et al., 2017).

Despite these challenges and critiques, the Andersen model remains a valuable tool for health services research. Its adaptability and potential for expansion have allowed researchers to tailor the model to specific contexts and populations, enhancing its relevance and applicability. In chapter six, the Andersen model is used to synthesis and summarise the findings of the three studies in this thesis.

Using the model as a lens to interpret and make sense of the various factors affecting CRC screening participation in the Canadian context serves two functions. One, it highlights this thesis contribution to our understanding of the factors associated with CRC screening participation. And consequently, the avenues and potential targets for interventions for improving health service utilisation.

Chapter Three

Paper 1: **Colorectal Cancer Screening Uptake in Atlantic Canada, Before and After the Colon Screening Programs. What Has Changed?**

Adefemi, K., Knight, J. C., Zhu, Y. and Wang, P. P.

Adefemi, K., Knight, J. C., Zhu, Y., & Wang, P. P. (2024). Evaluation of population-based screening programs on colorectal cancer screening uptake and predictors in Atlantic Canada: insights from a repeated cross-sectional study. *BMC Global and Public Health*, *2*(1), 28. https://doi.org/10.1186/s44263-024-00061-6

Also, preliminary results from this chapter were presented at the *2022 Beatrice Hunter Cancer Research Institute/Terry Fox Research Institute (BHCRI/TFRI) Cancer Research Conference* on November 7-8, 2022. This chapter was presented at the *2023 Annual Meeting of the American College of Epidemiology* on September 11-14, 2023, and the *2023 Canadian Cancer Research Conference* on November 12 –14, 2023 (both poster presentations).

An earlier version of the chapter was published as an open-access pre-print article in the Research Square Preprint Platform as an open-access article distributed under the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium provided Research Square Preprint Platform is cited as the source.

3.1. Abstract

Background: Colorectal cancer (CRC) poses a significant public health challenge in Canada, with the Atlantic Provinces bearing a particularly high burden. The implementation of population-based colon screening programs is aimed to address this concern. However, limited research exists on the impact of these programs, including their uptake, barriers, and predictors of screening participation. This study aimed to examine the impact of the first few years of the CRC screening programs in the Atlantic provinces of Canada by assessing changes in screening uptake, barriers, and predictors of screening among eligible populations.

Methods: Employing a repeated cross-sectional design, this study analysed data from a representative sample of 7614 respondents in 2010 and 6850 in 2017 from the Atlantic provinces aged 50–74 years, extracted from the Canadian Community Health Survey (CCHS). The outcomes measured were CRC screening rates, changes in factors associated with screening uptake, and barriers to participation. Potential factors examined included age, sex, income, education, smoking, and health status.

Results: The proportion of adults aged 50–74 years who meet CRC screening requirements increased from 42% in 2010 to 54% in 2017 yet below the national target of 60%. New Brunswick reported the most significant increase in screening prevalence (18%, $p < 0.05$). Participation in fecal tests increased from 19.6 to 32.4%. Despite these improvements, disparities in screening participation remained, with lower uptake observed among individuals with lower income and education levels. Age (> 60 years, AOR 1.95 95% CI 1.39 - 2.73, 2010 and 2.09 95% CI 1.49 - 2.94, 2017), the presence of multiple chronic health conditions (2.69 95% CI 1.91 - 3.78, 2010 and 2.11 95% CI 1.50 - 2.96, 2017), having a regular healthcare provider (2.27 95% CI 1.32 - 3.89, 2010 and 1.91 95% CI 1.30 - 2.80, 2017), and nonsmoking status (AOR 1.68 95% CI 1.25 - 2.25, 2010 and 2.55 95% CI 1.95 - 3.33, 2017) were factors consistently associated with CRC screening participation.

Conclusion: This study shows that while CRC screening uptake increased across the Atlantic provinces between 2010 and 2017, barriers to and disparities in screening participation persist. This highlights the need for targeted interventions to improve awareness, access, and screening uptake, particularly among disadvantaged groups, to promote equitable healthcare outcomes. Continued

efforts should focus on reducing barriers to screening and leveraging available evidence to inform interventions aimed at mitigating the CRC burden in the region.

3.2. Co-authorship Statement

Kazeem Adefemi drafted this chapter and substantively revised it, made substantial contributions towards the study design, data acquisition, analysis, and interpretation of the study results. Dr. Peter Wang substantively revised the work, and made substantial contributions towards study design, data acquisition, and interpretation. Dr. John C. Knight substantively revised the work, and made substantial contributions to the study design, data acquisition and interpretation. Dr. Yun Zhu revised the work and made substantial contributions towards study design and analysis.

All authors read and approved the final version of this chapter.

3.3. Introduction

Despite being one of the few cancers that can be effectively prevented; the health, financial and health resources burden of CRC in Canada remain a growing and significant public health concern (Tung et al., 2018). CRC remains the third most diagnosed cancer in Canada and the second leading cause of cancer-related death (Canadian Partnership Against Cancer, 2020). Current estimates from Canadian Cancer Society (2022) project that 24,300 new cases of CRC were diagnosed in 2022, with 9,400 associated mortality. The burden of CRC is particularly concerning in the Atlantic Provinces of Canada (Decker et al., 2023). With age-standardized incidence rates and age-standardised mortality rates ranging from 102.9, and 42.4 in Newfoundland and Labrador to 62.1 and 26.7 in New Brunswick respectively, CRC incidence and mortality is highest among all age groups in the Atlantic provinces compared to the rest of Canada (Brenner et al., 2022; Canadian Cancer Society, 2022).

CRC screening is critical for reducing the incidence and mortality of this disease. CRC screening modalities, especially stool- tests, guaiac faecal occult blood testing (gFOBT) or Faecal immunochemical testing (FIT), Flexible Sigmoidoscopy and Colonoscopy, work by intervening in the cancer progression process; either by detection and subsequent removal of pre-cancerous adenomatous polyps or the early detection of CRCs in asymptomatic individuals (Adhikari et. al., 2022; Andersen et al., 2019). Multiple randomised, cohort and observational studies have demonstrated the importance and effectiveness of the various CRC screening modalities for reducing CRC incidence and mortality (Araghi et al., 2019, Buskermolen et al., 2019).

However, participation rate, that is, the proportion of eligible individuals who comply with the recommended screening guidelines, is a major factor in the effectiveness of CRC screening. Low participation rates undermine the impact of any screening strategy. Some modelling studies suggest participation rates of 65-70% will be required to optimise the impact of CRC screening (Adhikari et al., 2022). Current guidelines from the Canadian Task Force on Preventive Health Care (CTFPH), recommends CRC screening for Canadians aged 50-74 with stool-based tests – gFOBT or FIT every two years or flexible sigmoidoscopy every ten years for the general, average-risk, population through organised, population based screening programs, and sets a target of 60% participation rate for screening at the provincial and national level to ensure the effectiveness of screening programs (Decker et al., 2023).

Zarychanski et al. (2007) and Singh et al. (2015) evaluated CRC screening participation rates in Canada before the widespread implementation of provincial screening programs. Zarychanski et al. (2007) found that less than 24% of adults eligible for screening reported any history of CRC screening in 2003, with 18% up to date with screening. While screening participation rates increased to over 50% in 2012 (Singh et al., 2015), screening rates remain lower for under-served populations, especially low income, rural/remote residents, and minority groups who continue to face additional barriers to screening (Butterly, 2020). Singh et al. (2015) concluded that sociodemographic factors, especially income, education and access to a regular healthcare provider remained strong predictors of CRC screening even in Provinces that had well-established provincial colon screening programs.

Although Atlantic Provinces established population-based colon screening programs between 2009 and 2014 (see Table 3.1 below), CRC incidence and mortality continue to be higher in the region compared to other parts of Canada, and current estimates suggest screening rates are low and inequities in screening access remain (Singh et al., 2015) Evaluating the impact and effect of these provincial screening programs is crucial for understanding where progress is being made and where inequities remain or where more work must be done to achieve the goals of CRC prevention in the region.

While the primary aim of screening is to reduce the burden of CRC, this can also be achieved with opportunistic screening. The advantages of organised, public health screening program, over opportunistic screening are numerous. One, it increases knowledge and awareness of the importance of screening, and the role of screening in cancer prevention. Two, it reduces barriers to, and inequity in access to screening resources/opportunities. Essentially, organised screening programs have the potential to increase both the uptake and effectiveness of screening. With the Atlantic provinces experiencing significantly higher age-standardised incidence and mortality rates from CRC, achieving optimal returns from the CRC screening programs is crucial. Unfortunately, there is a dearth of research evaluating changes in screening uptakes due to the screening programs. This study therefore provides a first look at CRC screening uptake before and a few years after the onset of the screening programs. The study also evaluates changes in barriers and access to these screening by evaluating changes in associated with screening uptake among the general population.

Table 3.1: Details of Provincial CRC Screening Programs in Atlantic Canada

Province	**Program name**	**Program Start date & Status**	**Recruitment/Invitation Method**	**Screening Test Details****	**Normal Result Communication & Recall**
New Brunswick	NB Colon Cancer Screening Program	2014; Full program, province wide	Mailed invitation letter	FIT* every 2 years, from 50-74 years	Result mailed to participant; re-invitation and eligibility questionnaire sent after 2 years
Nova Scotia	Colon Cancer Prevention Program	2009; Full program, province wide	Mailed invitation letter and FIT kit sent after 2 weeks	FIT every 2 years, from 50-74 years	Result mailed to participant; Recall reminder & Kit mailed every 2 years
Prince Edward Island	Colorectal Cancer Screening Program	2011; Full program, province wide	Mailed invitation letter; Physician referral; Self-referral by phone, email, online or in person	FIT every 2 years, from 50-75 years	Result mailed to participant; Recall reminder & Kit mailed every 2 years. In-person KIT pick-up available

Newfoundland and Labrador	NL Colon Cancer Screening Program	2012; Full program, province wide	Physician referral; Self-referral by phone, email or in person; Referral through other screening program; Website	FIT every 2 years, from 50-74 years	Result mailed to participant; Recall reminder & Kit mailed every 2 years

*FIT = Fecal Immunochemical Test for 'asymptomatic, average risk individuals' aged 50-74.

** All Provincial Colon Cancer Screening programs are designed in line with guidelines from the CTFPH, that is, CRC screening for individuals at average risk between the ages of 50 and 74, with a fecal test every 2 years or flexible sigmoidoscopy/Colonoscopy test every 10 years.

Details from: *Canadian Partnership Against Cancer (2021).*

3.4. Methods

3.4.1. Study Design

In this study, we employed a repeated cross-sectional design, which involved secondary analysis of cross-sectional data from the 2010 and 2017 cycles of the CCHS (Statistics Canada, 2010; 2017). Unlike longitudinal studies that follow the same individuals over time, repeated cross-sectional studies analyse data from different samples at multiple time points. This approach allows for the examination of trends and changes in population-level outcomes (Rafferty et al., 2015), such as CRC screening uptake. For this study we focused on responses to the CRC screening questionnaire module administered to older adults across the Atlantic provinces.

3.4.2. Data Source

Data for this study were obtained from the master files of the 2010 and 2017 CCHS. The survey is a national, cross-sectional survey conducted by Statistics Canada to collect detailed health status, health care utilisation, sociodemographic details, and determinants of health from people aged 12 years and over living in all the health regions of the ten provinces and three territories of Canada. The CCHS interviews an approximate sample of 130,000 people every two years and produces annual microdata files that are available to researchers for analyses.

The survey uses a multi-stage, cluster sampling technique to ensure a representative sample of the country is sampled for data collection (Statistics Canada, 2017). Although sampling for the CCHS excludes full-time members of the armed forces, and people living on reserves/settlements and certain remote regions, especially remote regions of Quebec, this is collectively less than 3% of the Canadian population. Households are randomly selected as the final sampling unit for the CCHS with interviewers administering computer assisted personal interview (CAPI) in multiple languages (Statistics Canada, 2017). The sampling and data collection design of the CCHS allow researchers to access reliable demographic and health status estimates that are valid at the health region level (Statistics Canada, 2017).

For this study, data for respondents aged 50-74 years old resident in the Atlantic Provinces, namely, New Brunswick (NB), Newfoundland & Labrador (NL), Nova Scotia (NS) and Prince Edward Island (PEI) were analysed. There were 62,909 and 56,950 respondents sampled to be representative of 28,878,418 and 30,985,500 Canadians respectively in the 2010 and 2017 surveys. Sample from the Atlantic provinces were 7,614 (representative of: 1,449,028) and 6,850 (representative of: 1,472,700) respectively in both surveys (Statistics Canada, 2010; 2017). All analyses were performed with the use of survey weights provided with the microdata files by Statistics Canada to adjust for the complex sampling design and ensure that the estimates are representative of the general population. The 2010 and 2017 master files were accessed and analysed for this study through the Statistics Canada's Research Data Centers (RDC) program at Memorial University of Newfoundland.

It is noteworthy that the CRC Screening module is an optional component of the CCHS. The 2010 and 2017 master files were selected for analyses as questions on CRC screening were administered in all the provinces of interest in these two survey years. Additionally, the CCHS underwent a major redesign starting in 2013 'to review the sampling methodology, adopt a new sample frame, modernise the content and review the target population' (Statistics Canada, 2017). Consequently, Statistics Canada advises against merging pre- and post- 2015 files for analyses. Nonetheless, comparing estimates from 2010 and 2017, analysed separately, still provides valuable insight into changes and trends in utilisation of health care resources such as cancer screening.

3.4.3. Outcome Variables

The two main outcome variables for this study were CRC screening history – 'ever-screen' and up to date with CRC screening – 'screen up-to-date.' The CRC screening guideline from the CTFPH recommends screening for individuals at average risk of CRC between the ages of 50 and 74, every 2 years with a fecal test, either the guaiac fecal occult blood test (gFOBT) or fecal immunochemical test (FIT), or sigmoidoscopy once every 10 years. In line with this guideline, ever-screen was defined as any history of exposure to any CRC screening test - fecal test or endoscopy (sigmoidoscopy/colonoscopy). Similarly, screen up-to-date was defined as participation in the fecal test in the 2 years or endoscopy tests in the 10 years prior, to the survey. Screening participation or screening uptake is used interchangeably, subsequently, to refer to being 'screen up-to-date.'

Participation in any fecal or endoscopy test was included in the definition of the outcome variables for two reasons. One, the CCHs question simply asks respondents if they 'ever had a fecal/sigmoidoscopy/colonoscopy test – lifetime' (Yes/No) and 'last time respondents had the test.' There were no data to distinguish if the test(s) were opportunistic, diagnostic or as part of the public health CRC screening program in the provinces. However, previous studies suggest that patients' self-report may not be reliable in distinguishing screening from diagnostic CRC tests (Singh et al., 2015). Additionally, participation in CRC tests for non-screening purposes also serve as screening for CRC as patients do not need to repeat the tests for screening purposes within the recommended timeline (Helsingen et al., 2019; Eisinger et al., 2008).

3.4.4. Independent Variables

The main predictor variables analysed in this study were comprised of sociodemographic and health behavior factors that have been shown in previous studies to be associated with CRC and/or CRC screening uptake. The key sociodemographic variables analysed included age (5 year age categories from 50-74 years), sex, marital status (categorised as married/common law, widowed/divorced/separated, and single/never married), highest education level (categorised as, less than high school education, high school graduation, and post-secondary education) and total household income (categorised as less than $40K, $40k-$60K, $60k - $80K, $80k-$100k and over $100k). This study also evaluated the effect of self-reported health status aggregated into three categories (Great, Good and Poor) from the five categories in the CCHS, access to a regular health care provider (Yes or No), body weight, using Body mass index (BMI), international standards (obese, over-weight, normal weight and under-weight) and number of chronic health conditions (comorbidity) (0, 1-2, 3-5 and 6+) on history, and up-to-date status for CRC screening. Regarding comorbidity, respondents were asked "do you have Asthma/high blood pressure/diabetes etc. (Yes/No/Don't know), the 'yes' responses were aggregated as number of chronic health conditions reported. The key health behavior variables evaluated for this study included smoking status (non-smoker, occasional smoker, and daily smoker), physical activity level (inactive, moderately active, and very active) and consumption of the recommended daily fruit and vegetables (Less than 5 serve daily, 5-10 serve daily and 10+ serve daily) - see Appendix C for relevant sections of the CCHS questionnaire. Also, 'Don't know', 'Refusal' and 'Not stated' responses were aggregated as missing data. Since the proportion of missing data were less than 5% on average, complete case analysis was conducted, excluding missing data.

3.4.5. Statistical Analyses

All analyses were weighted and bootstrapped using survey weights and 500 replicate bootstrap sampling weights provided with the master files by Statistical Canada. The use of survey weights for sub-group analyses ensures that estimates are representative of the target population of the selected Provinces and to adjust for the complex survey sampling design. Only weighted proportions are reported as per Statistics Canada's confidentiality and data protection requirements.

Descriptive analyses using survey procedures in SAS 9.4 (SAS Institute Inc. 2013) was performed to evaluate the distribution of the various sociodemographic and health behaviour characteristics. We estimated the proportions of respondents with a history of CRC screening and those that are up to date with CRC screening by year – 2010 and 2017, by modality – Fecal or Endoscopy and by province, then bivariate analyses was performed to determine differences in screening prevalence across different sociodemographic groups and province of residence. We first conducted multivariable logistic regression analyses with each of the potential predictor variables, adjusting for age and sex a priori. Then we developed full multivariable logistic regression models with all variables except for education level. Multicollinearity between independent variables, particularly age and income, was tested using an inflation factor of 5 as the cutoff. Given the apparent correlation between education level and income, only income was included in the full model to avoid multi-collinearity. Lastly, we stratified the analyses by sex to assess if the predictors of screening uptake significantly vary for males and females. Results are reported as weighted percent (%) and odds ratios (OR) with their associated 95% confidence intervals (CI) in compliance with Statistics Canada's confidentiality and data protection requirements. The threshold for significance is $p < 0.05$.

All analyses were performed for people aged 50-74, the recommended age group for CRC screening and people resident in the Atlantic Provinces during the survey. While the 2017 CCHS distinguished between sigmoidoscopy and colonoscopy in the questionnaire, this distinction was not present in 2010. To ensure consistency, responses were aggregated under the broader term ‘endoscopy test’ for both years. Similarly, while the 2010 CCHS asked respondents for reasons for undertaking the CRC screening, the 2017 CCHS collected data on reasons for not screening among respondents who reported no history of CRC screening. These variables were analysed to provide insights into the self-reported barriers affecting screening behaviours of respondents across the region.

3.4.6. Ethics Statement

Given the extensive checks and review required to access CCHS data at the secured RDC, review and approval of this study by the Human Research Ethics Board (HREB) of Memorial University of Newfoundland & Labrador was not required.

3.5. Results

3.5.1. Demographic Characteristics

The distribution of demographic characteristics among respondents in this study is shown in Table 3.2. Overall, there was a slightly higher proportion of females (51%) than males in both years, with a notable decrease in the proportion of females in NL from 52% to 50% between 2010 and 2017. The provinces experienced an overall aging trend, with the proportion of people in their fifties decreasing from an average of 48% to 42%, while the proportion of people in their 60s and 70s increased by an average of 5% and 2% respectively. However, these demographic changes varied across provinces. For example, NB had the highest decrease in the proportion of people in their 50s (11%), NL had the highest increase in the proportion of people in their 60s (5%), and NS had a 4% increase in the proportion of people in their seventies.

The proportion of people who were married or in a common-law relationship remained consistent across all provinces at about 75% of respondents. In terms of education, there was a reduction in the proportion of people with post-secondary education from 57% to 54% on average, while the proportion of people with less than a high school education decreased from 26% to 21%. However, there was a 9% increase in the proportion of people with high school education.

The income gap between the rich and the poor widened between 2010 and 2017. The proportion of people with a household income of at least $80,000 almost doubled from 21% to 41%, while those with a household income of $40,000 or less decreased slightly by 6%. Among the four provinces, respondents in NL reported the lowest average household income, while respondents in NS reported the highest.

The number of people with three or more chronic health conditions increased by 5%, with PEI experiencing the most pronounced increase in comorbidity (7%). This was associated with a 3% average reduction in the population reporting having access to a regular healthcare provider. However, there was an increase in the proportion of people reporting very active physical activity level (20% to 34%), and reduction in self-reported physical inactivity (54% to 27%). Also, the proportion of individuals reporting daily smoking decreased slightly from 17% to 16%.

Table 3.2: Demographic Characteristics of Respondents in CCHS 2010 and 2017, Atlantic Provinces

Characteristics	**Atlantic Provinces, % of Population**									
	New Brunswick		**Newfound & Labrador**		**Nova Scotia**		**Prince Edward Island**		**Atlantic Average**	
	2010 (%) Weighted n=237,836	2017 (%) Weighted n=260,620	2010 (%) Weighted n=167,397	2017 (%) Weighted n=194,962	2010 (%) Weighted n=291,758	2017 (%) Weighted n=332,344	2010 (%) Weighted n= 42,726	2017 (%) Weighted n= 51,684	2010 (%) Weighted n=739,718	2017 (%) Weighted n= 839,611
Sex										
Female	51.0	51.2	52.1	50.3	53.1	52.1	50.1	50.2	51.6	51.0
Male	49.0	48.8	47.9	49.7	46.9	47.9	49.9	49.8	48.4	49.0
Age										
50-54	24.8	17.5	23.1	21.0	25.0	18.4	22.0	21.1	23.7	19.5
55-59	26.4	23.1	23.6	19.6	23.9	23.0	22.9	21.6	24.2	21.8
60-64	21.0	26.6	23.9	23.7	21.2	24.0	24.4	22.0	22.6	24.1
65-69	16.0	18.2	17.4	23.0	17.7	18.5	16.1	18.8	16.8	19.6
70-74	11.9	14.5	12.0	12.8	12.2	16.2	14.6	16.5	12.7	15.0
Marital Status										
Married, Common-Law	76.3	74.2	80.2	73.7	76.1	73.5	79.2	74.9	77.9	74.1
Widow, Separated, Divorced	16.4	18.1	14.7	19.0	18.3	17.1	14.8	15.8	16.0	17.5
Single, Never Married	7.3	7.6	5.2	7.2	5.5	9.4	5.8	9.2	6.0	8.4
Missing	0.0	0.0	0.0	0.1	0.1	0.0	0.2	0.1	0.1	0.0
Education										
Post Sec. Sch	54.0	50.5	51.4	53.0	62.8	59.0	60.8	54.7	57.2	54.3
Sec. Sch	19.7	28.7	14.2	21.6	11.8	22.0	10.7	19.5	14.1	22.9

Less Sec. Sch	21.3	19.0	32.7	24.5	23.7	15.8	28.3	23.7	26.5	20.8
Missing	5.0	1.7	1.7	0.9	1.7	3.2	0.3	2.2	2.2	2.0
Household Income										
LESS $39,999	33.3	26.4	37.1	28.6	30.4	23.5	28.8	25.3	32.4	25.9
$40,000 - $59,999	17.8	17.2	19.9	18.5	17.3	16.6	19.4	20.2	18.6	18.1
$60,000 - $79,999	14.5	13.9	10.1	14.4	13.5	14.6	14.5	15.0	13.1	14.5
$80,000 - $99,999	5.8	12.8	6.0	7.6	5.9	11.6	7.0	11.4	6.2	10.9
$100k+	14.5	29.7	12.8	30.8	17.4	33.7	14.8	28.1	14.9	30.6
Missing	14.2		14.1		15.5		15.5		14.8	
Self-reported Health Status										
Great	45.4	47.1	55.1	55.9	48.4	51.9	63.1	56.7	53.0	52.9
Good	47.8	47.8	39.2	39.6	44.8	41.9	29.5	37.3	40.3	41.6
Poor	6.8	4.8	5.4	4.5	6.9	5.7	7.3	5.9	6.6	5.2
Weight*										
Underweight	1.0	1.0	0.3	1.4	1.0	0.7	1.1	0.2	0.8	0.8
Normal weight	28.3	21.1	26.9	14.7	31.1	21.5	33.4	25.5	29.9	20.7
Overweight	34.4	31.8	37.9	38.6	37.7	36.5	36.6	36.5	36.7	35.9
Obese	30.6	41.9	30.3	39.4	26.6	36.6	26.1	32.4	28.4	37.6
Missing	5.7	4.2	4.8	5.9	3.7	4.7	2.8	5.4	4.2	5.0
Number of Comorbidities#										
0	23.2	16.4	19.8	14.7	21.2	17.8	27.3	25.2	22.9	18.5
1-2	44.7	45.6	45.8	48.3	46.0	46.2	44.8	40.5	45.3	45.1
3-5	25.1	31.1	29.6	31.6	28.0	30.7	23.5	30.2	26.6	30.9
6+	7.0	7.0	4.8	5.3	4.8	5.3	4.4	4.1	5.2	5.4
Regular Care Provider - Yes	93.8	96.2	93.8	90.5	95.7	91.5	92.3	87.1	93.9	91.3

Physical Activity level**										
Very active	20.3	32.9	16.5	36.4	24.2	33.7	18.1	32.9	19.8	34.0
Moderately active	24.2	31.9	23.6	32.5	23.0	36.4	25.0	37.0	24.0	34.4
Inactive	52.3	30.0	56.7	27.0	51.0	26.1	55.0	26.5	53.7	27.4
Smoking										
Daily smoker	17.3	9.7	18.1	21.1	18.9	15.4	14.9	16.9	17.3	15.8
Occasional smoker	2.3	2.7	2.2	2.9	2.6	3.6	6.5	3.2	3.4	3.1
Non-smoker	80.1	87.6	79.2	75.9	78.2	80.9	78.7	79.9	79.1	81.1

*Weight categories based on BMI international standards. **Physical activity levels according to the World Health Organization’s standards #Comorbidities include a wide range of chronic health conditions from migraine, diabetes, high blood pressure to fibromyalgia and cancer (non-specific)

Sec. Sch: Secondary School

3.5.2. Screening Participation

The prevalence of people who have a history of CRC screening participation in the Atlantic provinces increased from 53% in 2010 to 67% in 2017, indicating a 14% increase in screening participation rate during the study period (Table 3.3). NB saw the highest increase in screening participation rates, from 50% to 70%, and respondents in NB reported the highest screening participation rates in 2017. NL, which initially had one of the highest screening rates in 2010, reported the slowest increase and the lowest CRC screening uptake in 2017, increasing from 54.5% to 62.8%. This trend was similar for the population of people who were up to date with CRC screening guidelines. On average, the proportion of individuals up to date with fecal tests (<2 years) or sigmoidoscopy/colonoscopy (<10 years) increased by almost 13% from 42% to 54.5%, still falling short of the national target of 60%. NB recorded the highest increase in up-to-date CRC screening, from the lowest rate of 39% in 2010 to 57% in 2017, second only to NS with a screening rate of 59.6%. These two provinces saw statistically significant increases in the proportion of people up to date with CRC screening. In contrast, NL reported only a 5% increase in screening rates, from 44% in 2010 to 49% in 2017. When considering the breakdown of different screening tests, there was a slight drop in the proportion of people up to date with endoscopy tests, accompanied by a notable increase fecal test uptake (19.6% to

32.4%), which aligns with the emphasis on fecal test as the primary screening test for CRC with the onset of CRC screening programs in the Atlantic provinces.

Table 3.4 provides the demographic distribution of respondents who are up to date with CRC screening. In 2010, 53% of women were up-to-date with CRC screening, compared to 47% of men; by 2017, women's participation slightly decreased to 52%, while men's participation increased to 48%. This change shows a modest convergence in screening rates between the sexes over the study period, except for PEI, where men reported a higher screening participation rate of 54% in 2017. Further, on average, while screening participation increased among people in their 60s and 70s by 3% and 2% respectively, from 2010 to 2017, it decreased by 5% among people in their 50s.

In 2010, screening participation was highest among married individuals, people with income above $80,000, and those with post secondary school education. While this pattern remains consistent in 2017, there was decline in screening rates among married individuals (80% to 76%) and people with post secondary education (62% to 57%) but increase screening among people who earn $80,000+ (36% to 42%). Between 2010 and 2017, CRC screening participation almost doubled among people who report a high school education (12% to 23%).

Table 3.3: CRC Screening Participation by Province in 2010 and 2017

Screening Tests	**Atlantic Provinces; % of Population**									
	NB		**NL**		**NS**		**PEI**		**Atlantic Average**	
	2010	2017	2010	2017	2010	2017	2010	2017	2010	2017
Any exposure to CRC Screening test - **'Ever-Screen'**	**50.4**	**70.3**	**54.5**	**62.8**	**53.8**	**69.7**	**54.8**	**66.6**	**53.4**	**67.3**
Fecal test <2yrs	13.8	28.6	18.9	23.0	21.3	44.3	24.5	33.7	19.6	32.4
Endoscopy test <10yrs	25.2	28.3	25.0	25.8	21.2	15.3	17.8	18.8	22.3	22.1
Either/both – **Screen_up-to-Date**	**39.0**	**56.9**	**43.9**	**48.8**	**42.5**	**59.6**	**42.3**	**52.5**	**41.9**	**54.5**
Change, 2010 to 2017 (%)	**17.9***		**4.9**		**17.1***		**10.2**		**12.6**	

Abbreviations: NB, New Brunswick; NL, Newfoundland & Labrador; NS, Nova Scotia; PEI, Prince Edward Island.
* Significant at *p> 0.05 – z test of equal proportions*

3.5.3. Reasons for and Barriers to CRC Screening

The self-reported reasons for undertaking CRC tests (2010) are listed in Table 3.5, while barriers or reasons for not participating in CRC screening (2017) are listed in Table 3.6. Overall, 57.5% of respondents completed the fecal test for a "check-up," and approximately 29% did so to follow-up on a medical problem. Similarly, about 29% completed a sigmoidoscopy or colonoscopy for a check-up, while 46% did so for follow-up. Among people who had not undergone CRC screening, approximately 41% and 50% did not participate because they considered the fecal and endoscopy tests, respectively, to be unnecessary. Additionally, 24% and 37% did not participate because their healthcare provider reportedly deemed the CRC screening tests unnecessary.

Table 3.4: Distribution of (Up to Date) CRC Screening Participation by Demographic Characteristics, CCHS 2010 and 2017, Atlantic Provinces

Demographic Characteristics	**Atlantic Provinces; % of Population**									
	NB		**NL**		**NS**		**PEI**		**Atlantic Average**	
	2010	**2017**	2010	**2017**	2010	**2017**	2010	**2017**	2010	**2017**
Sex										
Female	51.7	**51.0**	53.3	**57.0**	56.0	**54.9**	51.3	**46.0**	53.1	**52.2**
Male	48.3	**49.0**	46.7	**43.0**	44.0	**45.1**	48.7	**54.0**	46.9	**47.8**
Age										
50-54	17.3	**14.4**	23.5	**18.8**	15.9	**13.7**	15.1	**14.1**	18.0	**15.3**
55-59	24.7	**19.5**	20.6	**16.3**	25.9	**22.5**	18.4	**22.0**	22.4	**20.1**
60-64	23.4	**30.7**	25.0	**26.9**	23.6	**26.4**	30.8	**25.2**	25.7	**27.3**
65-69	20.5	**18.6**	17.6	**24.0**	20.3	**18.8**	17.7	**20.3**	19.0	**20.4**
70-74	14.1	**16.8**	13.3	**14.0**	14.3	**18.6**	18.1	**18.5**	14.9	**17.0**
Marital Status										
Married, Common-Law	79.4	**75.3**	79.2	**72.2**	79.5	**76.1**	83.7	**79.3**	80.4	**75.7**
Widow, Separated, Divorced	15.8	**19.1**	16.2	**20.3**	17.6	**16.0**	13.6	**13.9**	15.8	**17.3**

Single, Never Married	4.9	**5.7**	4.6	**7.5**	2.8	**7.9**	2.7	**6.8**	3.7	**7.0**
Education										
Post Sec. Sch	58.3	**50.1**	58.6	**57.0**	64.4	**61.9**	67.2	**57.7**	62.1	**56.7**
Sec. Sch	14.5	**28.1**	15.8	**20.7**	11.4	**20.1**	6.7	**21.8**	12.1	**22.7**
less Sec Sch	23.9	**20.2**	24.5	**21.3**	22.7	**15.0**	25.4	**19.8**	24.1	**19.1**
Missing data	3.2	**1.6**	1.1	**1.0**	1.5	**3.0**	0.7	**0.8**	1.6	**1.6**
Household income										
$80k+	34.7	**41.1**	32.1	**40.6**	38.8	**46.4**	39.6	**41.3**	36.3	**42.4**
$40k - $80k	30.4	**30.8**	32	**30.4**	32.3	**32.4**	33.9	**37.9**	32.1	**32.9**
< $40k	34.9	**28.1**	35.9	**29.1**	28.9	**21.2**	26.6	**20.7**	31.6	**24.8**
Number of Comorbidities										
0	15.3	**11.3**	14.0	**6.1**	15.4	**13.4**	26.6	**22.2**	17.8	**13.3**
1-2	45.0	**52.6**	44.8	**52.1**	41.8	**46.0**	43.1	**47.8**	43.7	**49.6**
3-5	30.0	**27.8**	36.9	**35.3**	36.2	**34.9**	25.5	**26.9**	32.1	**31.3**
6+	9.8	**8.3**	4.3	**6.5**	6.6	**5.7**	4.8	**3.0**	6.4	**5.9**

Abbreviations: NB, New Brunswick; NL, Newfoundland & Labrador; NS, Nova Scotia; PEI, Prince Edward Island.
Sec. Sch: Secondary School

Table 3.5: Self-reported reasons for CRC Screening participation – 2010, Atlantic Provinces

Variable	**% of Respondents who had Fecal test <2yrs**				
	NB	NL	NS	PEI	Atlantic Average
Age	1.7	0.4	3.6	0.8	1.6
Checkup	53.9	45	61.9	68.9	57.5
Family History	9.0	11.8	6.1	3.5	7.6
Follow-up	31.2	37.8	21.1	25.5	28.9
Other	3.8	4.4	6.6	1.2	4.0
Treatment	0.5	0.6	0.6	0.00	0.4
	% of Respondents who had Endoscopy <10yrs				
After Fecal test	0.7	0.0	0.0	0.0	0.7
Age	1.1	1.6	0.4	0.9	1.0
Checkup	33.4	20.6	36.2	24.9	28.8
Family history	19.4	24.6	17.4	21.2	20.6
Follow-up	43.4	49.3	41.6	49.4	45.9
Other	1.5	1.1	2.6	2.0	1.8
Treatment	0.6	2.8	1.7	1.6	1.7

Table 3.6: Self-reported barriers to CRC Screening – 2017, Atlantic Provinces

Variable	**% of Respondents with no Fecal in <2yrs**				
	NB	**NL**	**NS**	**PEI**	**Atlantic Average**
Didn't know about the test	5.0	2.3	0.6	0.6	2.1
Doctor deems test unnecessary	29.9	33.3	13.6	18.8	23.9
Fear/discomfort	1.1	0.4	4.6	0.3	1.6
Had Endoscopy test instead	10.9	11.6	14.1	14.6	12.8
Lack of time	1.9	0.6	9.3	7.3	4.8
No access to test	1.4	1.5	0.5	0.2	0.9
No doctor	0.3	0.1	2.2	0.3	0.7
Other	11.3	4.9	17.8	15.4	12.3
Didn't think test is necessary	38.1	45.4	37.2	42.4	40.8
Variable	**% of Respondents with no Endoscopy in <10yrs**				
Didn't know about the test	0.4	0.0	0.3	1.1	0.5
Doctor deems test unnecessary	43.1	37.0	33.2	35.5	37.2
Fear/discomfort	1.7	1.3	1.9	0.0	1.3
Had fecal test	1.3	1.0	4.2	2.6	2.3
Lack of time	0.3	0.4	2.1	0.1	0.7
No access to test	0.4	1.1	0.2	1.4	0.8
No Doctor	0.3	0.1	1.5	0.4	0.6
Other	9.5	3.8	7.3	4.7	6.3
Didn't think test is necessary	43.0	55.2	49.2	54.2	50.4

3.5.4. Factors associated with screening participation.

Building on the demographic distribution of CRC screening participation outlined in the preceding section, our multivariate logistic regression analysis adjusted for potential covariates for 2010 and 2017, revealed consistent factors associated with screening participation across both years. (Table 3.7). For instance, compared to people aged 50-54, people aged 60-64 (AOR 1.95 95% CI 1.39 - 2.73, 2010 and AOR 2.09 95% CI 1.49 - 2.94, 2017) or 70-74 (AOR 2.20 95% CI 1.51 - 3.20, 2010 and AOR 1.96 95% CI 1.32 - 2.92, 2017), married (AOR 1.51 95% CI 1.04 - 2.18, 2010 and AOR 1.21 95% CI 0.82 - 1.77, 2017), have multiple chronic health conditions (AOR 2.69 95% CI 1.91 - 3.78, 2010 and AOR 2.11 95% CI 1.50 - 2.96, 2017), and have a regular healthcare provider (AOR 2.27 95% CI 1.32 - 3.89, 2010 and AOR 1.91 95% CI 1.30 - 2.80, 2017) were consistently associated with increased likelihood of screening participation. Conversely, daily smokers, people who are single (never married), obese, and those reporting 'great' health (AOR 0.83 95% CI 0.50 - 1.37, 2010 and AOR 0.99 95% CI 0.57 - 1.73, 2017), had decreased screening odds. In 2010, low income, especially household income below $40,000, was linked to lower screening odds, but this association was no longer significant in 2017. In 2017, being male (AOR 0.79 95% CI 0.64 - 0.99) and residing in NL were associated with decreased odds of screening.

In the analyses stratified by sex, the factors associated with screening participation were similar to the non-stratified analyses, but some associations were more pronounced or more consistent for males compared to females. For example, while people in their 60s and 70s consistently had higher odds of screening in 2010 and 2017, this was no longer significant in 2017 for females aged 65-69 (AOR 1.37 95% CI 0.82 - 2.29). Similarly, marital status, weight, physical activity level and access to regular healthcare provider all show stronger associations in males compared to female. However, having multiple chronic conditions – 3-5 (AOR 3.25 95% CI 2.03 - 5.21, 2010 and AOR 2.30 95% CI 1.35 - 3.92, 2017), and having a household income of over $100k (AOR 1.89 95% CI 1.04 - 3.43, 2010 and AOR 1.18 95% CI 0.75 - 1.84, 2017) were more pronounced for females. Again, these associations remained consistent from 2010 to 2017.

Table 3.7: Factors associated with being up to date CRC screening in Atlantic Provinces 2010 and 2017, Stratified by Sex

Variable	**2010**			**2017**		
	Adjusted OR (95% CI)			**Adjusted OR (95% CI)**		
	Overall	**Men**	**Women**	**Overall**	**Men**	**Women**
Age						
50-54	1.0 (ref)**	1.0 (ref)	1.0 (ref)**	1.0 (ref)**	1.0 (ref)**	1.0 (ref)
55-59	1.46 (1.04 - 2.07)	1.25 (0.72 - 2.18)	1.68 (1.09 - 2.59)	1.29 (0.92 - 1.82)	1.40 (0.79 - 2.48)	1.21 (0.76 - 1.95)
60-64	1.95 (1.39 - 2.73)	1.56 (0.95 - 2.57)	2.47 (1.59 - 3.82)	2.09 (1.49 - 2.94)	3.31 (1.88 - 5.83)	1.50 (0.90 - 2.49)
65-69	1.93 (1.36 - 2.73)	1.46 (0.86 - 2.50)	2.56 (1.65 - 3.99)	1.56 (1.09 - 2.23)	1.83 (1.04 - 3.21)	1.37 (0.82 - 2.29)
70-74	2.20 (1.51 - 3.20)	2.21 (1.23 - 3.95)	2.26 (1.37 - 3.72)	1.96 (1.32 - 2.92)	1.88 (0.97 - 3.63)	2.23 (1.30 - 3.83)
Sex						
F	1.0 (ref)			1.0 (ref)*		
M	0.97 (0.76 - 1.22)			0.79 (0.64 - 0.99)		
Comorbidity						
0	1.0 (ref)**	1.0 (ref)**	1.0 (ref)**	1.0 (ref)**	1.0 (ref)**	1.0 (ref)**
1-2	1.50 (1.13 - 1.99)	1.64 (1.06 - 2.56)	1.49 (1.01 - 2.26)	2.30 (1.69 - 3.12)	1.99 (1.31 - 3.03)	2.56 (1.62 - 4.05)
3-5	2.69 (1.91 - 3.78)	2.39 (1.31 - 4.37)	3.25 (2.03 - 5.21)	2.11 (1.50 - 2.96)	1.94 (1.21 - 3.11)	2.30 (1.35 - 3.92)
6+	3.38 (1.91 - 5.98)	1.60 (0.48 - 5.30)	5.27 (2.46 - 11.27)	2.81 (1.62 - 4.87)	4.50 (1.94 -10.43)	2.00 (1.01 - 4.48)
Province						
NL	1.0 (ref)	1.0 (ref)	1.0 (ref)	1.0 (ref)**	1.0 (ref)**	1.0 (ref)
NB	0.83 (0.65 - 1.06)	0.93 (0.60 - 1.45)	0.76 (0.54 - 1.07)	1.36 (1.01 - 1.83)	1.47 (0.96 - 2.24)	1.15 (0.76 - 1.74)

NS	0.90 (0.70 - 1.16)	0.80 (0.53 - 1.22)	0.96 (0.67 - 1.39)	1.54 (1.21 - 1.96)	1.61 (1.07 - 2.42)	1.43 (1.00 - 2.07)
PEI	0.87 (0.58 - 1.32)	0.86 (0.41 - 1.82)	0.92 (0.57 - 1.49)	1.52 (1.09 - 2.14)	2.4 (1.4 - 4.12)	1.05 (0.63 - 1.71)
Marital status						
Single, Never Married	1.0 (ref)**	1.0 (ref)**	1.0 (ref)	1.0 (ref)**	1.0 (ref)	1.0 (ref)
Widow, Separated, Divorced	1.40 (0.94 - 2.11)	2.04 (1.09 - 3.84)	1.03 (0.56 - 1.88)	1.15 (0.77 - 1.72)	1.21 (0.70 - 2.11)	1.16 (0.63 - 2.14)
Married, Common Law	1.51 (1.04 - 2.18)	2.49 (1.35 - 4.62)	0.97 (0.57 - 1.66)	1.21 (0.82 - 1.77)	1.27 (0.77 - 2.11)	1.24 (0.66 - 2.33)
Household income						
< $39,999	1.0 (ref)	1.0 (ref)	1.0 (ref)	1.0 (ref)	1.0 (ref)	1.0 (ref)
$40,000 - 59,999	1.09 (0.74 - 1.58)	0.76 (0.46 - 1.30)	1.38 (0.90 - 2.12)	0.99 (0.73 - 1.35)	0.73 (0.44 - 1.19)	1.19 (0.75 - 1.88)
$60,000 - 79,999	1.40 (0.99 - 1.98)	1.10 (0.63 - 1.92)	1.83 (1.12 - 2.99)	1.00 (0.72 - 1.39)	0.99 (0.58 - 1.68)	0.93 (0.57 - 1.51)
$80,000 - 99,999	0.98 (0.61 - 1.59)	0.78 (0.40 - 1.52)	1.21 (0.56 - 2.62)	0.79 (0.54 - 1.17)	0.7 (0.37 - 1.32)	0.73 (0.43 - 1.23)
$100k+	1.42 (0.93 - 2.16)	0.99 (0.53 - 1.85)	1.89 (1.04 - 3.43)	1.14 (0.87 - 1.59)	1.01 (0.59 - 1.71)	1.18 (0.75 - 1.84)
Perceived Health Status						
Poor	1.0 (ref)**	1.0 (ref)**	1.0 (ref)	1.0 (ref)	1.0 (ref)	1.0 (ref)
Good	0.88 (0.56 -1.40)	0.66 (0.29 - 1.48)	1.30 (0.70 - 2.40)	1.11 (0.66 - 1.86)	1.02 (0.48 - 2.19)	1.36 (0.65 - 2.85)
Great	0.83 (0.50 - 1.37)	0.54 (0.23 - 1.29)	1.36 (0.72 - 2.60)	0.99 (0.57 - 1.73)	0.72 (0.33 - 1.59)	1.36 (0.57 - 3.2)
Weight$^{\#}$						
Obese	1.0 (ref)**	1.0 (ref)**	1.0 (ref)	1.0 (ref)**	1.0 (ref)**	1.0 (ref)
Overweight	1.43 (1.11 - 1.86)	1.81 (1.22 - 2.69)	1.19 (0.82 - 1.72)	1.10 (0.86 - 1.42)	1.25 (0.85 - 1.82)	0.97 (0.65 - 1.45)

Normal weight	1.27 (0.92 - 1.70)	1.19 (0.73 - 1.91)	1.38 (0.90 - 2.11)	1.07 (0.79 - 1.44)	1.13 (0.70 - 1.83)	1.05 (0.69 - 1.59)
Underweight	1.07 (0.44 - 2.57)	1.53 (0.18 - 3.03)	0.85 (0.29 - 2.53)	0.97 (0.17 - 5.68)	2.81 (0.03 - 7.48)	0.45 (0.03 - 6.20)
Regular Healthcare Provider						
No	1.0 (ref)**	1.0 (ref)**	1.0 (ref)	1.0 (ref)**	1.0 (ref)**	1.0 (ref)
Yes	2.27 (1.32 - 3.89)	3.04 (1.50 - 6.16)	1.61 (0.70 - 3.71)	1.91 (1.30 - 2.80)	2.33 (1.39 - 3.90)	1.58 (0.82 - 3.03)
Physical Activity Level						
Inactive	1.0 (ref)**	1.0 (ref)**	1.0 (ref)**	1.0 (ref)	1.0 (ref)	1.0 (ref)
Moderately active	1.25 (0.96 - 1.64)	1.52 (1.00 - 2.30)	1.05 (0.73 - 1.52)	1.09 (0.82 - 1.45)	1.14 (0.73 - 1.76)	1.18 (0.78 - 1.79)
Very active	1.18 (0.86 - 1.58)	1.29 (0.84 - 1.98)	1.11 (0.73 - 1.67)	1.20 (0.90 - 1.59)	1.05 (0.69 - 1.60)	1.60 (1.10 - 2.35)
Smoking Status						
Daily smoker	1.0 (ref)**	1.0 (ref)**	1.0 (ref)	1.0 (ref)**	1.0 (ref)**	1.0 (ref)**
Occasional smoker	1.68 (0.85 - 3.34)	2.01 (0.67 - 5.99)	1.41 (0.52 - 3.85)	1.23 (0.64 - 2.37)	0.75 (0.25 - 2.28)	1.76 (0.68 - 4.54)
Non-smoker	1.68 (1.25 - 2.25)	1.64 (1.04 - 2.57)	1.60 (1.09 - 2.36)	2.55 (1.95 - 3.33)	2.62 (1.71 - 3.99)	2.58 (1.75 - 3.82)
Fruits & Vegetable Consumption						
< 5 Serve daily	1.0 (ref)	1.0 (ref)	1.0 (ref)	1.0 (ref)**	1.0 (ref)	1.0 (ref)
5-10 Serve Daily	0.99 (0.79 - 1.26)	0.99 (0.65 - 1.52)	1.02 (0.74 - 1.41)	0.97 (0.73 - 1.29)	1.01 (0.64 - 1.60)	1.01 (0.70 - 1.45)
10+ Serve Daily	3.01 (1.14 - 7.94)	3.10 (0.31 -3.86)	3.06 (1.19 - 7.89)	5.19 (1.79 - 5.06)	0.74 (0.02 - 5.89)	3.05 (0.04 -9.91)

Note: ** p >.001; * p>.05. $^{\#}$Weight categories based on BMI international standards.

Abbreviations: NB, New Brunswick; NL, Newfoundland & Labrador; NS, Nova Scotia; PEI, Prince Edward Island

3.6. Discussion

Our study assessed CRC screening uptake in the Atlantic Provinces of Canada – NB, NL, NS, and PEI – comparing before and after the implementation of organized provincial CRC screening programs in line with national guidelines (CTFPH, 2016). Our findings indicate that while screening participation increased post-implementation of these programs, the magnitude and nature of this change varied across provinces. Persistent disparities in CRC screening participation, particularly among certain demographic groups, were evident.

Participation in CRC screening and being up to date with CRC screening requirement increased in all Provinces with the establishment of CRC screening programs. However, only NS and NB came close to meeting the national CRC screening target of 60% in 2017. The increase screening participation was more pronounced for Fecal test, which is the primary screening tests for CRC in all the Provincial programs. Fecal tests became the most popular screening tests in all the provinces, especially NS. Thus, establishment of provincial screening programs in line with national guidelines (CTFPH, 2016) possibly contributed to reduced variability in test modality in the individual provinces.

However, the increase in screening participation varied across the provinces. There was at least a 10-percentage points difference in the screening rates increase reported in NS and NB, for example, compared to NL, which saw the lowest increase in CRC screening uptake. Absolute increase in the uptake of fecal screening tests ranged from 23% in NS to 4.1% in NL (14.8% in NB and 9.2% in PEI). These changes in CRC screening participation did not seem to be dependent on how long the screening Programs had been in place, as NB with the most recent screening program reported a more significant increase in screening participation than NL and PEI. Table 7 below shows the promotional and recruitment strategies deployed by the screening programs in the four provinces. It could be argued that the community-based education and awareness campaigns and reminder notifications in NB possibly contributed towards better screening uptake in the province. Current evidence supports the importance of multifaceted interventions and community engagement strategies in improving CRC screening participation (Butterly, 2020; Inadomi et al., 2021).

Nonetheless, the average 60 percentage points increase in screening participation, in terms of proportion of people who were 'up to date' with their screening, is comparable to the effect of organised screening programs reported elsewhere in the literature (Honein-AbouHaida et al., 2013; Levin et al., 2018; Denis et al., 2007; Peris et al., 2007; Logan et al., 2012; Lo et al., 2015). Honein-AbouHaidar et al (2013) estimated CRC screening participation in Ontario, Canada between 2005 and 2011 to evaluate the effect of the 'Colon Cancer Check (CCC)' program on screening participation (a similar geographic, demographic and timeframe with our study). They found that uptake of the fecal test increased from 7.6% to 14.8%, while being ‘up to date’ with CRC screening increased from 27.2% to 41.3%. Logan et al. (2012) reports outcome of the first round of invitations to the UK Bowel Cancer Screening Program and found that about 55–60% of the 2.1 million people who received invitations participated in the screening program across the four provincial hubs where the program was administered. Similarly, Denis et al. (2007) reported a 76.5% participation rate in CRC fecal screening tests in France, after two rounds of invitation, while Peris et al. (2007) found that completion of CRC fecal screening tests increased from 17.2% in the first round of invitations to 22.3% after a second round of invitation to a pilot colorectal cancer screening program in Barcelona, Spain.

There are slight differences in the UK, French and Spanish programs compared to the Atlantic CRC screening programs worth mentioning, though. The programs in these other jurisdictions were largely pilot programs with considerable amount of public engagement and educational campaign. Consequently, the effects might not necessarily be sustainable over an extended period. Second, the demography and target population, especially for the UK program was average risk population aged 60–69 years. This age group has been shown to be consistently more compliant with CRC screening, especially compared to people in their fifties, which is a key finding of our study as well.

Moreover, follow-up study by Lo et al., (2015) found that average participation rate across the England increased from 57.4% in first round of screening to

66.2% in the third biennial invitation round, with only 44.4% of the target population still ‘up to date’ with CRC screening at the third round. Similarly, a national study by Portero de la Cruz and Cebrino (2023) found that average national CRC screening participation rate in Spain only increased from 32.35% in 2017 to 43.92% in 2020 and that only 38% of the target population were up to date with CRC screening requirement.

Our study found disparities in CRC screening uptake across the Atlantic provinces, especially related to age, income, education levels and health status. For example, screening participation was consistently lowest among the youngest age group (50-54) in 2010 (40.4%) and reduced even further in 2017 (35.4%). Similarly, screening participation remained lower among people with lower education levels – especially, less than high school qualification, lower income earners and people with fewer than two chronic health conditions.

These disparities in CRC screening uptake, especially among younger adults (50s) and those facing socio-economic disadvantages, are particularly concerning. The younger demographic stands to potentially benefit more from early cancer detection (Levin et al., 2018). So, any decline in screening uptake among this group demands attention. Furthermore, the disparities related to socio-economic factors reflect the broader global health challenge of ensuring equitable access to health resources and the multifaceted factors that influence (preventive) health decisions and behaviours (Bauer et al., 2018; Butterly et al., 2020). Such disparities are not just numbers; they represent lives, many of which could be saved with early detection.

We also found a slight decline in screening participation among people with no chronic health conditions and significant increase in screening uptake among people with 1-2 chronic health issues. This suggest that health care utilisation, and constant interaction with health care providers might facilitate positive screening behaviours (Butterly, 2020; Zarychanski et al., 2007).

With regards to factors associated with screening participation, our findings show that obesity, daily smoking, aged 50s, and a lack of access to regular health care provider remain were associated with lower odds of CRC screening participation in both 2010 and 2017. While physical inactivity, perceived 'great' health status and being single/never married were associated with lower odds of CRC screening in 2010, these were no longer significant predictors in 2017. This change in associated factors might indicate positive benefits of the educational and informational campaigns associated with the establishment of the screening programs.

However, being male and living in NL was associated with lower odds of screening participation in 2017. Considering that NL established its screening program ahead of PEI and NB, and the relatively higher per capital incidence and mortality of CRC in the province (Tung et al., 2018), it is imperative to investigate and understand factors associated with the comparatively lower effect the screening program on CRC screening uptake in the province. Stratified analyses indicate that age, BMI, marital status, province of residence and access to a regular health care provider were more pronounced and consistent factors associated with screening among males, compared to females. Conversely, household income and multiple chronic health conditions were more strongly and consistently associated with screening participation among females.

These sociodemographic disparities in CRC screening participation align with evidence from other jurisdictions. In reviews of the different factors associated with poor screening participation, Gimeno García (2012) and Unanue-Arza et al., (2021) highlight age, marital status, income, education levels and health behaviours like smoking and alcohol consumption as the different factors that persistently influence screening behaviours. Lo et al., (2015) found that 'socioeconomic deprivation' was consistently associated with lower CRC screening uptake in England, while Warren Andersen et al., (2019) and Bauer et al., (2022) reported similar socioeconomic disparities in CRC screening uptake across the United States.

However, one of the main advantages of population-wide, public health screening programs compared to opportunistic screening, is that they offer a standardised system of care that ensures wide and equitable access for everyone, irrespective of socioeconomic status. Findings from our study suggests that the provincial CRC screening programs have yet to achieve this objective. This suggest that interventions that target and address the different barriers among different age, sex and socio-economic groups are necessary to address these disparities and ensure higher CRC screening participation population wide.

The 2017 survey asked respondents who have no history of CRC to select from a list of potential reasons for not screening. This aspect of the 2017 survey allowed this study to gain some insight into people's awareness, beliefs, and attitudes towards CRC screening in the Atlantic provinces. A substantial proportion of people who had no screening history in 2017 report thinking the CRC test is not necessary for them or that their health care provider deemed the tests unnecessary. This is in line with findings reported by in Shi, et al (2020) regarding the awareness of, and attitudes towards CRC screening in NL. Given the higher prevalence of CRC risk factors, incidence, and mortality in the Atlantic provinces (Decker et al., 2023; Tung et al., 2018; Ruan et al, 2023) addressing these (mis)perceptions and attitudes is crucial. Frameworks like Health Belief Model offer structured strategies to address such challenges. By emphasising the severity of CRC and the crucial role of early detection, public health initiatives could potentially alter these perceptions (30, 31).

The Health Belief Model (HBM) suggests that people are more likely to engage in health behaviours, such as cancer screening, if they perceive themselves to be susceptible to the health problem, believe that the health problem can be serious, that the benefits of taking action outweighs any costs or discomfort, and feel comfortable in their capacity to act (Moattar et al., 2014; Lin et al., 2020).

When applied to CRC screening, HBM suggests that uptake of CRC screening might continue to remain sub-optimal if concerted efforts are not targeted towards educating the people about the potential severity of CRC, as well, as the significant benefits of regular screening, to shift perception and attitudes towards screening.

Additionally, the clinical significance, efficacy and effectiveness of screening tests in reducing CRC incidence and preventing mortality, especially through early diagnosis, have been demonstrated repeatedly in the literature (Warren Andersen 2019; Brenner et al., 2014; Lin et al., 2016), such that evidence in support of CRC screening has received an "A" grade from the US Preventive Services Task Force (Butterly, 2020). However, it appears that low poor screening participation rates continue to affect the contribution of screening to CRC mitigation here in Atlantic Canada, and across the developed world.

In light of our findings of persistent disparities in CRC screening participation along with the various factors associated with screening uptake, it's crucial to address these inequalities with targeted, multifaceted interventions that have shown promise in various jurisdictions and should be applicability in the Atlantic provinces (Butterly et al., 2020; Davis et al., 2018; Eisinger et al., 2008). These strategies should not only cater to the diverse needs of different demographic groups but also aim to address challenges specific to age, sex, and socioeconomic status. This study also underscores the importance of continuous evaluation and adaptation of screening programs to meet the evolving health landscape of the Atlantic provinces.

3.6.1. Implications of Findings and Recommendations

The establishment of Provincial CRC Screening programs appears to have contributed towards improved CRC awareness and better screening uptake among the general population in Atlantic Canada. But the findings of this study show that disparities in screening uptake persists and that work still need to be done to improve the level of awareness, attitude, and acceptance of CRC screening as a crucial tool for reducing the burden of CRC in the region. Below are some recommendations:

- Given the proportion of adults who thinks the CRC screening tests are not necessary, tackling misconceptions and barriers surrounding CRC screening through educational and mass media campaigns that use targeted, culturally relevant, clear, and specific messaging is crucial. Accurate information that dispels myths and resolve any potential concerns, especially from trusted sources, can help increase awareness, improve acceptance of the CRC tests, and encourage participation.

- While educational and mass media campaigns can help improve attitudes and awareness, evidence from the literature and our findings suggest that awareness alone will not suffice. Tailoring interventions to address the unique needs, barriers and demographic characteristics of specific populations could reduce disparities in screening participation among specific, underserved populations and improve overall screening rates. Inadomi et al., (2021) emphasises the importance of multi-level interventions that address patient level, provider level and system-level barriers, in successfully improving screening uptake.
- Improve healthcare provider-engagement and communication. The proportion of people who reported that their healthcare provider deemed CRC screening tests unnecessary suggests the need for better engagement between the screening program and healthcare providers. Evidence consistently shows that recommendations from their healthcare provider is a strong predictor of screening. Healthcare providers can be trained and enlisted to discuss/communicate the benefits of screening, address concerns and provide clear recommendations for screening.

3.6.2. Strength and Limitations

The primary limitation of this study, similar to all survey studies, is recall bias. Data collected for the CCHS surveys are self-reported and thus likely to be affected by recall bias, such over or under reporting of screening participation. Although Nova Scotia established its CRC Screening program in 2009, one year before the baseline, 2010, in our study, data on CRC screening for all provinces in the Atlantic region are only available for 2010 and 2017. The 2018 to 2022 CCHS did not collect CRC screening data from provinces in the region. Additionally, Statistics Canada warns that data from CCHS pre and post 2015 should not be merged for analyses due to significant changes in sampling methodology and design of survey instruments.

However, we believe that the use of data from 2010 and 2017 CCHS still served the purpose of evaluating the effect of the Provincial screening programs on screening uptake and associated factors. Lastly, the CCHS contains inadequate data to exclude people with hereditary CRC syndromes and those who are higher risk of CRC due to family history and hence require sigmoidoscopy/colonoscopy more frequently. However, current estimates indicate that this group constitutes less than 3% of the general population. Our study provides a comprehensive review of the effects and limitations of the first few years of Provincial CRC screening programs in Atlantic Canada.

3.7. Conclusion

This study highlights the positive contribution of provincial CRC screening programs to participation rates across the Atlantic provinces, though with notable inter-provincial variations. Persistent disparities in screening participation exist within provinces, particularly affecting people in their 50s and socio-economically disadvantaged groups. These findings emphasise the need for interventions to promote equitable access, address misconceptions through community-based initiatives and tailored messaging and facilitate cross-provincial collaboration for best practice sharing. Improving overall screening rates and achieving equity in access remain critical public health priorities for reducing the burden of CRC throughout the Atlantic provinces. More research is required to further our understanding of these barriers to CRC screening and to inform more effective interventions.

Chapter Four

Paper 2: Racial And Sociodemographic Distribution of Colorectal Cancer Screening in Canada – A Cross Sectional Study

Adefemi, K., Knight, J. C., Zhu, Y., & Wang, P. P. (2024). Racial and sociodemographic distribution of colorectal cancer screening in Canada: A cross-sectional study. *Canadian Journal of Public Health*. https://doi.org/10.17269/s41997-024-00859-9

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Also results from this chapter was accepted for presentation at the 2024 Canadian Centre for Applied Research in Cancer Control (ARCC) conference on May 16-17, 2024.

4.1. Abstract

Objectives

To assess the racial and sociodemographic distribution of colorectal cancer (CRC) screening uptake in Canada, identify disparities, and evaluate the potential predictors and barriers to CRC screening.

Methods

Data from the 2017 cycle of the Canadian Community Health Survey (CCHS) was analyzed, focusing on individuals aged 50-74 years. CRC screening participation rates were evaluated at both national and provincial levels and across various sociodemographic characteristics. Multivariable logistic regression models were employed to identify predictors and barriers to CRC screening.

Results

Of the 56,950 respondents to the 2017 CCHS, 41.7% (n= 23,727) were aged between 50-74 years. The overall CRC screening participation rate was 59.8%, with provinces like Alberta and Manitoba achieving rates of 65.7% and 66.5%, respectively. Significant disparities were observed across socioeconomic, geographical, and racial or ethnic groups. Notably, older adults [AOR 2.41 95%

CI-2.06 - 2.83], higher income earners [AOR 1.99 95% CI-1.77 - 2.24] and non-smokers [AOR 1.76, 95% CI-1.55 - 2.0] had higher odds of screening, while immigrants and minority ethnic groups, especially, South-East Asians [AOR 0.48, 95% CI-0.29 - 0.78] and South Asians [AOR 0.65, 95% CI-0.44 - 0.95] had lower odds of being up-to-date with CRC screening. A significant portion of unscreened individuals cited their healthcare provider's perception of the test as unnecessary as a barrier to screening uptake.

Conclusion

While CRC screening participation rates across Canada seem close to meeting the national target, significant disparities persist. Addressing these disparities is crucial for public health. Efforts should focus on enhancing public awareness, facilitating accessibility, and ensuring cultural appropriateness of CRC screening initiatives and messaging.

4.2. Co-authorship Statement

Kazeem Adefemi drafted this chapter and substantively revised it, made substantial contributions towards the study design, data acquisition, analysis, and interpretation of the study results. Dr. Peter Wang substantively revised the work, and made substantial contributions towards study design, data acquisition, analysis, and interpretation. Dr. John C. Knight substantively revised the work, and made substantial contributions to the study design, data acquisition and interpretation. Dr. Yun Zhu revised the work and made substantial contributions towards study design and analysis.

All authors read and approved the submitted version of this chapter.

4.3. Introduction

Organised, population-wide screening for CRC screening programs targeting people aged 50-74 years and at average risk of colorectal cancer have been established in nine of the ten Canadian Provinces, over the last decade (Canadian Partnership Against Cancer, 2020). Despite the body of evidence suggesting that organised CRC screening programs can reduce CRC mortality and incidence (Blair et al., 2020; Eisinger et al., 2008; Levin et al., 2018), CRC remains the third most diagnosed cancer and the second leading cause of cancer-related mortality. In 2022 alone, CRC accounted for 10% of all cancer incidence and 11% of cancer-related mortality in Canada (Darren et al., 2022). CRC therefore remains significant public health concern in Canada.

Understanding the patterns of CRC screening and identifying potential disparities among diverse population groups are imperative to inform targeted interventions and policy measures to alleviate this burden. In fact, the Canadian Strategy for Cancer Control, 2019-2029 identifies strengthening existing cancer screening programs to diagnose cancer faster, accurately and at an early stage (Priority 2, Action 2), and eliminating barriers and disparities to access for cancer screening programs (Priority 4, Actions 1 and 2), as key priorities for reducing the burden of CRC in Canada (Canadian Partnership Against Cancer, 2019).

After publication of the CRC screening guidelines by the Canadian Task Force on Preventive Health Care (CTFPH – first in 2001, updated guideline in 2016) recommending CRC screening for the general population, the first provincial screening programs were established in 2007/08 (Alberta, Manitoba, and Ontario). By 2014, all Canadian provinces, except Quebec, have implemented province-wide CRC screening programs. In one of the first studies on CRC screening prevalence, Major et al. (2013) reported an average participation rate of 16.1% from the first round of CRC screening programs between January 2009 and December 2011 across five provinces. Using data from the Canadian Community Health Survey (CCHS) for 2012 (when only five Provinces had CRC Screening programs), Singh et al. (2015) reported an average 55.2% participation rate (30.1% for fecal test, 37.2% for endoscopic tests) across Canada. These studies identified significant disparities in CRC screening participation across various sociodemographic groups that requires particular attention. However, few studies have assessed CRC screening participation rates, and the disparities in screening uptake at a national level, especially since the widespread implementation of provincial CRC screening programs.

Additionally, CRC screening participation among migrant and visible minority groups in Canada have received limited attention. Analysing data from Immigrants who had been in Ontario Canada, for at least 10 years, using multiple cycles of the CCHS, Shen et al. (2018) and Amina et al. (2019) found that CRC screening participation was significantly lower for recent and long-term immigrants than the general population. They also found that this disparity was especially pronounced for people from middle to low-income countries and refugees.

Crouse et al. (2015); Lo et al. (2015) also reported poorer screening participation among minority ethnic groups in Calgary (Canada) and England, while Crawford et al. (2016) found lower screening uptake among South Asian populations in United Kingdom, United States and Canada. These studies suggest that poorer CRC screening participation among migrant and minority groups might be mediated by a multitude of factors. These include perceived barriers, social norms, poor health care and/or screening knowledge, reduced access to health care, and attitude and beliefs about cancer and screening (Crawford et al., 2016; Crouse et al., 2015; Durand et al., 2021; Kobayashi et al., 2014; Tatari et al., 2020).

Given the comparatively higher rate of mortality and morbidity, overall, among people with low socio-economic status, and the poorer health care utilisation among migrant groups (Kobayashi et al., 2014; Shen et al., 2018), these disparities in healthcare access and utilisation could be a potential barrier to CRC screening uptake. However, without clear, evidenced-based understanding of the factors associated with CRC screening under-utilisation among specific population groups and the general population within the Canadian context, little can be done to improve screening rates and consequently reduce the burden of CRC in Canada.

To address this gap in knowledge, we hypothesis that while CRC screening participation rates have increased across Canada, significant inequalities and disparities in screening access and utilisation persists. Using data from the 2017 CCHS, which provides the most recent complete CRC screening data for all ten provinces, our study aims to achieve two main objectives. First, we aim to provide an updated assessment of CRC screening participation rates across Canada since the last review by Singh et al. (2015) based on data from the 2012 CCHS. We expect that our study will provide relevant information on how the implementation of provincial CRC screening programs across the country have affected screening uptake. Second, we aim to provide a broader, national assessment of the disparities in CRC screening rates among the various racial and sociodemographic groups. We believe that findings from our study could inform interventions aimed at reducing screening disparities and ensure the goals of the CRC screening programs are achieved.

4.4. Methods

4.4.1. Design

Data for this cross-sectional study were extracted from the 2017 cycle of the CCHS. The CCHS is population-based cross-sectional survey conducted by Statistics Canada. The survey collects information related to health status, determinants of health and health service utilisation from a representative sample of people aged 12 years and over, across the ten provinces and three territories of Canada. The survey uses a complex multi-stage sampling process, and the sampling frame covers an estimated 97% of the Canadian population. Excluded are full-time members of the Canadian Forces, people who live on Reserves and residents of some remote communities, collectively about 3% of the population. The 2017 cycle used computer assisted personal and telephone interviews to collect data from a total of 65,000 respondents with an overall response rate of 87.6%, and thus data were available for a total of 56,950 participants. Further details on CCHS design, methodology and interviewing process are provided by Statistics Canada (2017)

The current analysis aims to a) assess CRC screening participation rates at the national and provincial level, b) evaluate the racial and sociodemographic disparities in CRC screening participation rates at the national level and c). identify associated factors and barriers to CRC screening in the country. As such, the analysis was limited to individuals who fall within the CRC screening guidelines, that is, aged 50-74 years and with valid responses to the CRC screening module of the CCHS and other variables of interest, especially immigration status, race, educational attainment, sex, and household income. Of the 56,950 respondents to the 2017 CCHS, 41.7% (n= 23727) were aged between 50-74 years. Of these respondents, 74.3% (n= 19,889) were non-immigrants, 3.0% (n= 261) were recent immigrants (in Canada for 0-9 years) and 22.7% (n= 3,123) were old immigrants (in Canada for 10+ years).

4.4.2. Study variables.

The primary and secondary outcome variables in this study were history of CRC screening participation, coded as 'Ever-Screen', and screening participation within guideline requirements, coded as 'up-to-date Screen'. In the 2017 CCHS, the CRC module first asked respondents if they 'ever had a fecal, sigmoidoscopy/colonoscopy test – lifetime' (Yes/No), then ask about the 'last time respondents had the test.' The former was coded as 'ever screen' to capture any history of CRC screening participation. This is because history of any exposure to CRC screening test has been argued to provide insight into the general level of knowledge and awareness about CRC screening within the population (Issaka et al., 2019). Further, respondents who reported fecal CRC screening test within the previous 2 years or an endoscopy test in the 10 years before the survey were coded as 'up-to-date Screen' (Canadian Task Force on Preventive Health Care, 2016).

The primary independent variables in the current study were racial group and immigration status. Racial groups (eight categories) aggregated the CCHS categories, due to small numbers, into Arab/West Asian, Black, White, East Asian, Latin American, South-East Asian, South Asian and others/multi-racial, to capture the different racial groups collected in the CCHS. The second independent variable, immigration status (three categories) was categorised into 'recent immigrants', for people who arrived in Canada zero to nine years before the survey year, 'old immigrants' for participants who arrived in Canada ten or more years before the survey year, and 'Canada-born' to describe people who are non-immigrants. Other independent variables included in the analysis included age (5-year age categories), sex, marital status (married/common law, widowed/divorced/separated, and single/never married), educational attainment (less than secondary school education, secondary school education, and post-secondary education), and total household income (Less than $40K, $40k-$60K, $60k - $80K, $80k-$100k and over $100k). Other health behaviour and lifestyle factors included in the analyses include weight (using BMI data [International standards] and categorised as normal, overweight, and Obese), self-reported health status (Great, Good and Poor), physical activity level (Very active, Moderately active, and Inactive -based on WHO guidelines on weekly activity levels), current smoking status (Daily smoker, Occasional smoker and Non-smoker) access to a regular health care provider (Yes/No), and up to date participation in (women only) Breast (mammography) and Cervical (Pap smear) cancer screening. These are covariates that have been identified as potential predictors of CRC screening behaviour and uptake in previous studies (Darvishian et al., 2023; Farr et al., 2022; Honein-AbouHaidar et al., 2013; Singh et al., 2015), were also selected due to data availability in the 2017 CCHS. Most of the CCHS questions have ‘Don’t know’, ‘Refusal’ and ‘Not stated’ options to allow for non-response. These were all aggregated as missing data. The proportion of missing data were considerably low, less than 5% on average. Consequently, missing was excluded from all analyses.

4.4.3. Statistical Analysis

All analyses were performed using SAS Statistical Software version 9.4. The survey procedures in SAS were used and analyses were weighted using sampling weights provided by Statistics Canada to account for the uneven probabilities of selection due to the complex, multi-stage sampling process of CCHS. Analyses were bootstrapped using 500 replicate bootstrap sampling weights provided with the master files by Statistics Canada to ensure more accurate estimates of variance. Only weighted proportions are reported in line with Statistics Canada’s confidentiality and data protection requirements (Statistics Canada, 2017).

Descriptive statistics were calculated for the analytic sample to describe the distribution of the various sociodemographic and health behaviour characteristics, and to estimate the proportions of respondents who have a CRC screening history and those who are up-to-date with CRC screening across the ten provinces. Due to small sample size, immigration status and racial categories could not be analysed at the provincial level. Bivariate analysis was performed to compare the prevalence of CRC screening across the various immigrant and racial groups, at a national level, using chi square tests. Multivariable logistic regression was used to test the association between the potential predictor variables in the study with being up-to-date with CRC screening, adjusting for the two major cofounders, age, and sex a priori. Subsequently, a full multivariable logistic regression model with all the variables from the age and sex adjusted models, except educational attainment, was constructed to test the various predictors of CRC screening, and to investigate the relationship between CRC screening and racial and immigrant status while accounting for potential predictors such as province of residence, age, household income and self-perceived health status. Multicollinearity between independent variables, particularly age and income, was tested using an inflation factor of 5 as the cutoff. Educational attainment was not included in the regression analyses due to correlation with household income. Lastly, the multivariable logistic regression was stratified by sex to evaluate whether predictors of CRC screening uptake varied by sex. Weighted proportions (%) and odds ratio (crude and adjusted) with their associated 95% confidence intervals (CI) are reported.

4.4.4. Ethics Statement

Accessing CCHS data at the secured Research Data Centre (RDC) requires extensive checks, review and vetting by Statistics Canada, as a result, this study did not require approval from the Health Research Ethics Board (HREB) of NL. Memorial University.

4.5. Results

4.5.1. Demographic distribution

Table 4.1 provides details regarding the demographic characteristics of peopled aged 50-74 years across the ten Canadian provinces. In the total sample (n= 23,727; weighted n= 1,111,7302) there were slightly more women on average (50.7%). Also, there were slightly more people in their fifties (44.6%) than sixties (41.4%), more people had post secondary education (56.7%), with highest levels in Alberta (63%) and lowest in New Brunswick (50%). There were also more people with household income of $100, 000 and over (36%) and less than $40,000 (21%) than other categories. The highest proportion of high-income earners was in Alberta and highest proportion of low-income earners in Newfoundland & Labrador. Over 70% of the participants were overweight or obese, with the highest proportion of obese respondents in New Brunswick. More than half of the respondents self-reported ‘great’ health status (52.8%), while about 90% reported having a regular healthcare provider. With regards to smoking status and physical activity levels, an average of 82% of the respondents nationwide are reportedly non-smokers, and 72% engage are ‘moderately’ or ‘very’ active. With regard to racial and immigrant status, the population of peopled aged 50-74 years old was predominantly White (79.6%), with smaller proportions of East Asian (3.8%), South Asian (2.9%), and Black (1.8%) individuals. Most of the population was also non-immigrant (72.9%), with a smaller proportion of old immigrants (21.5%) and new immigrants (2.4%).

Table 4.1: Demographic Characteristics of Canadians Aged 50-74 from the Canadian Community Health Survey, 2017

Characteristics	PROVINCES; % of Population										
	Canada *(weighted n= 1,111,7302)*	**AB**	**BC**	**MB**	**NB**	**NL**	**NS**	**ON**	**PEI**	**QC**	**SK**
Sex											
Female	**50.7**	49.2	51.6	50.3	51.2	50.3	52.1	51.9	50.2	50.3	49.6
Male	**49.3**	50.8	48.4	49.7	48.8	49.7	47.9	48.1	49.8	49.7	50.4
Age											
50-54	**21.5**	21.5	23.6	23.2	17.5	21	18.4	24.6	21.1	21.7	22.1
55-59	**23.1**	28.2	22.1	24.0	23.1	19.6	23.0	22.3	21.6	22.0	25.5
60-64	**23.1**	22.8	21.8	22.4	26.6	23.7	24.0	21.4	22.0	22.1	23.7
65-69	**18.4**	15.0	19.0	16.7	18.2	23.0	18.5	18.2	18.8	18.8	17.5
70-74	**14.0**	12.5	13.4	13.7	14.5	12.8	16.2	13.4	16.5	15.4	11.2
Education											
Missing data	**2.2**	1.9	2.2	2.5	1.7	0.9	3.2	2.8	2.2	2.4	1.9
Post Sec. Sch	**56.7**	63.2	60.8	52.9	50.5	53	59.0	61.5	54.7	57.9	53.0
Sec. Sch	**24.7**	25.1	26.8	28.7	28.7	21.6	22.0	24.4	19.5	21.8	28.8
Less Sec. Sch	**16.5**	9.9	10.2	15.9	19	24.5	15.8	11.3	23.7	17.9	16.4
Household income, $											
$100k and over	**36.3**	51.1	40.2	34.3	29.7	30.8	33.7	43.7	28.1	32.6	38.8
$80,000 - $99,999	**11.0**	11.0	11.0	11.3	12.8	7.6	11.6	11.9	11.4	11.6	9.9
$60,000 - $79,999	**14.6**	10.6	14.0	18.7	13.9	14.4	14.6	12.2	15.0	15.0	17.5
$40,000 - $59,999	**17.0**	13.4	16.0	21.5	17.2	18.5	16.6	14.3	20.2	16.7	15.3

LESS $39,999	**21.1**	13.8	18.7	14.1	26.4	28.6	23.5	17.9	25.3	24.2	18.5
Marital Status											
Missing data	**0.2**	0.3	0.3	0.4	0	0.1	0	0.2	0.1	0	0
Married, Common-Law	**73.2**	75.6	73.2	73.4	74.2	73.7	73.5	73.1	74.9	67.8	72.2
Widow, Separated, Divorced	**17.3**	16.6	18.1	15.4	18.1	19	17.1	17.1	15.8	19.1	16.4
Single, Never Married	**9.4**	7.5	8.5	10.8	7.6	7.2	9.4	9.6	9.2	13.1	11.3
Weight* (BMI)											
Missing data	**5.3**	6.5	5.0	4.9	4.2	5.9	4.7	7.6	5.4	3.1	6.1
Obese	**33.4**	31.1	26.0	30.3	41.9	39.4	36.6	28.1	32.4	30.5	37.6
Overweight	**36.7**	36.8	35.4	38.4	31.8	38.6	36.5	36.8	36.5	38.4	37.6
Normal	**24.6**	25.6	33.6	26.4	22.1	16.1	22.2	27.4	25.7	28	18.7
Self-reported Health Status											
Missing data	**0.1**	0	0.2	0	0.2	0	0.5	0.1	0.1	0.1	0.1
Great	**52.8**	56.1	51.6	53.7	47.1	55.9	51.9	51.6	56.7	55.4	48
Good	**42.1**	39.2	43.4	42.1	47.8	39.6	41.9	42.3	37.3	41.6	45.6
Poor	**5.0**	4.7	4.7	4.2	4.8	4.5	5.7	6.0	5.9	2.9	6.4
Regular Healthcare Provider											
Yes	**90.8**	91.1	90.1	92.9	96.2	90.5	91.5	93.1	87.1	86.6	88.8
Smoking Status											
Daily Smoker	**14.6**	13.7	10.2	11.9	9.7	21.1	15.4	14.5	16.9	14.7	17.6
Occasional smoker	**3.2**	2.8	4.1	2.0	2.7	2.9	3.6	2.5	3.2	3.6	4.2
Non-smoker	**82.3**	83.5	85.7	86.1	87.6	76	80.9	82.9	79.9	81.7	78.2

Physical activity level										
Missing data	**3.5**	2.4	3.7	2.3	5.3	4.1	3.8	3.3	3.6	2.3	4.1
Very active	**36.2**	39.4	46.2	35.8	32.9	36.4	33.7	36	32.9	34.9	34.2
Moderately active	**35.9**	37.4	33.5	36.2	31.9	32.5	36.4	35.7	37	38.5	40.2
Inactive	**24.4**	20.8	16.6	25.8	30.0	27.0	26.1	25.0	26.5	24.4	21.4

*Weight categories based on BMI international standards; Sec. Sch: Secondary School
Abbreviations: AB, Alberta; BC, British Columbia; MB, Manitoba; NB, New Brunswick; NL, Newfoundland & Labrador; NS, Nova Scotia; ON, Ontario; PEI, Prince Edward Island; QC, Quebec; SK, Saskatchewan

4.5.2. CRC Screening Participation

‘Ever-Screen’, that is, the proportion of the population who have ever had a CRC screening test was 72% on average, and this ranged from 77% in Alberta and Manitoba to 62.8% in Newfoundland & Labrador. However, the proportion for people up-to-date with CRC screen was 59.8% overall, just shy of the 60% national target for CRC screening. Similarly, this ranged from over 60% in Alberta (65.7%) and Manitoba (66.5%) to just under 49% in Newfoundland & Labrador. For endoscopy test, the rate was 19.8% on average, and for fecal test, it was 39.9%. The highest participation rate for endoscopy test was in New Brunswick (28.3%) and Newfoundland and Labrador (25.8%) and the highest participation rate for fecal test was in Alberta (50.0%) and Manitoba (49.6%). Overall, the rates of up-to-date Screen and uptake of the fecal test seem to be higher in Provinces with the longer running CRC screening programs, such as Manitoba and Alberta (both programs established in 2007). Table 4.2 also shows that there was comparatively lower screening participation and more inter-provincial variation in screening rates within the Atlantic region than other regions of Canada. Similarly, there was generally higher uptake of Pap test and Mammogram compared to CRC screening (Table 4.2).

Table 4.2: Cancer Screening Participation Rates by Province, CCHS 2017

Outcome		PROVINCES; % of Population									
	Canada *(weighted n= 1,111,7302)*	AB	BC	MB	NB	NL	NS	ON	PEI	QC	SK
Ever-Screen											
Yes	**72.2**	77.7	74.3	77.3	70.3	62.8	69.7	75.6	66.6	70.8	77.3
Fecal test < 2 yr.											
Yes	**39.9**	50.0	45.4	49.6	28.6	23.0	44.3	34.3	33.7	36.3	54.2
Endoscopy test < 10 yr.											
Yes	**19.8**	15.7	14.7	16.9	28.3	25.8	15.3	30.7	18.8	22.2	9.7
Up-to-date Screen											
Yes	**59.8**	65.7	60.1	66.5	56.9	48.8	59.6	65.0	52.5	58.6	63.8
Mammogram < 3 yr											
Yes	**80.4**	84.8	77.0	79.4	85.8	78.8	78.5	80.2	73.6	85.0	81.0
Pap smear test < 3yr											
Yes	**59.4**	63.8	56.3	70.6	61.4	64.6	56.7	58.6	52.7	49.5	59.9

Abbreviations: AB, Alberta; BC, British Columbia; MB, Manitoba; NB, New Brunswick; NL, Newfoundland & Labrador; NS, Nova Scotia; ON, Ontario; PEI, Prince Edward Island; QC, Quebec; SK, Saskatchewan

Ever-screen: any history of CRC screening; Up-to-date screen: CRC fecal test <2yr or CRC endoscopy test <10yr

The demographic and racial distribution of CRC screening participation in Table 4.3 shows significant variation in CRC screening participation among the different population groups in the country. Generally, the proportion of the population up to date with CRC screening increased with age, suggesting that older individuals were more likely to have recent CRC screening. Similarly, CRC screening participation was higher among females (53%) those with post-secondary education (61.9%), and those with a household income of $100k and over (42.1%). CRC screening was highest among the White population (81.8%) compared to all the other racial groups, and higher among Canadian born population (74.8%) compared to recent or old immigrant groups.

4.5.3. Barriers and Predictors to Screening

Table 4.4 provides self-reported barriers to CRC screening among the population with no CRC screening history. Significantly, the most commonly reported barriers to participating in the CRC fecal or endoscopy screening tests were the beliefs that their healthcare provider 'deems' the CRC screening test 'unnecessary' (39.9% and 52.1% respectively). This was followed by report that the respondents themselves think the screening tests to be unnecessary (29.1% and 33.9% respectively).

Table 4.3: Racial and Socio-demographic Distribution of Population Up to Date with CRC Screening, CCHS 2017

Variable	**% of Overall Population aged 50-74 yrs. old**	**% of up-to-date Screen population**
Age		
50-54	22.9	17.9
55-59	22.9	23.1
60-64	22.1	23.7
65-69	18.2	19.9
70-74	13.9	15.3
Sex		
Female	51.1	53.0
Male	48.9	47.0
Education		
Post Sec. Sch	59.7	61.9
Sec. Sch	24.4	24.0
less Sec. Sch	13.5	12.1
Income		
$100K and over	39.9	42.1
$80,000 - $99,999	11.5	11.9
$60,000 - $79,999	13.5	14.2
$40,000 - $59,999	15.5	14.7
LESS $39,999	19.6	17.1
Race		
Arab/West Asian	0.8	0.6
Black	1.8	1.8
East Asian	3.8	3.4
Latin American	0.9	0.7
S/East Asian	3.0	2.3
South Asian	2.9	2.6
White	79.6	81.8
Others/Multi-racial	2.4	2.6
Immigration Status		
Canada Born	72.9	74.8
Old Immigrant	21.5	20.7
New Immigrant	2.4	2.1

Sec. Sch: Secondary School; New immigrant: in Canada for 0-9yrs; Old Immigrant: in Canada for 10+years

Table 4.4: Self-reported barriers to CRC Screening, CCHS 2017

	% of Population with no CRC Screening History	
Reported Barrier	**Fecal test**	**Endoscopy tests***
Did not know about CRC test	1.7	1.1
Doctor thinks test is unnecessary	39.9	52.1
Fear and/or Discomfort	1.4	2.1
Had a different CRC test	13.4	2.5
Lack of time	4.5	1.8
No access to test	0.6	0.5
No doctor	2.0	2.2
Respondent thinks test is unnecessary	29.1	33.9
Other	7.5	3.9

*Endoscopy test: flexible sigmoidoscopy or colonoscopy tests

In the multivariable analyses of the various factors associated with 'up-to-date Screen' (henceforth referred to as 'screening participation) among Canadians aged 50-74 years old, after adjusting for age and sex, several factors emerged as predictors of CRC screening participation. Factors positively associated with screening participation included having multiple chronic conditions [AOR 1.52, 95% CI -1.23 - 1.90], belonging to the highest income bracket [AOR 1.99, 95% CI 1.77 - 2.24], being 'very physically active' [AOR 1.33, 95% CI-1.18 - 1.50], and self-reporting 'great' health [AOR 1.51, 95% CI 1.20 - 1.89]. Factors negatively associated with screening participation included being single/never married, lack of a regular healthcare provider, being a current daily smoker, and belonging to an immigrant [OR 0.67, 95% CI 0.46 - 0.99] or minority ethnic group, especially, East-Asian [OR 0.74, 95% CI 0.56 - 0.96] and South-East Asian [OR 0.54, 95% CI 0.35 - 0.83].

In the full model, after adjusting for all covariates, age emerged as a significant factor, with older individuals, especially aged 70-74, more likely participate in CRC screening [AOR 2.50, 95% CI 2.11 - 2.96]. Other factors positively associated with screening participation included higher household income [AOR 1.40, 95% CI 1.21 - 1.62], being female, having a regular healthcare provider [AOR 4.16, 95% CI 3.57 - 4.84], 'very active' lifestyle [AOR 1.33, 95% CI 1.17 - 1.51], and being a non-smoker [AOR 1.76, 95% CI 1.55 - 2.0]. Geographically, residents of Alberta and Manitoba were more likely to participate in CRC screening, while those in Atlantic Canada, especially Newfoundland & Labrador, were less likely to be screened. Among racial groups, South-East Asians [AOR 0.48, 95% CI-0.29 - 0.78] and South Asians [AOR 0.48, 95% CI 0.29 - 0.78] were less likely to participate in CRC screening compared to people who identify as White. When stratified by sex, similar factors emerged, but they were more pronounced for males than females. For example, age, access to regular healthcare provider, household income (of $100k+), being married, having multiple chronic health conditions (3-5, 6+) and being over-weight showed stronger association for males, but self-reported 'great health' and smoking status showed stronger association with CRC screening participation for females.

Additionally, females who were not up-to-date with Pap tests [AOR 0.41, 95% CI 0.35 - 0.47] and mammogram [AOR 0.17, 95% CI 0.14 - 0.20] were less likely to participate in CRC screening.

Table 4.5: Factors associated with CRC Screening Overall and Stratified by Sex, CCHS 2017

	Overall		**Stratified**	
Variable	**Unadjusted OR** (95% CI)	**Adjusted OR** (95% CI)	**Male** Adjusted OR (95% CI)	**Female** Adjusted OR (95% CI)
Age				
50-54	1.0 (ref)			
55-59	1.74 (1.51 - 2.01)	1.83 (1.58 - 2.13)	1.99 (1.64 - 2.42)	1.69 (1.37 - 2.10)
60-64	2.03 (1.78 - 2.32)	2.30 (2.00 - 2.65)	2.74 (2.22 - 3.38)	1.95 (1.60 - 2.38)
65-69	2.12 (1.84 - 2.44)	2.41 (2.06 - 2.83)	2.51 (2.03 - 3.10)	2.29 (1.84 - 2.85)
70-74	2.16 (1.87 - 2.50)	2.50 (2.11 - 2.96)	2.66 (2.09 - 3.39)	2.38 (1.89 - 2.99)
Sex				
Female	1.0 (ref)			
Male	0.83 (0.76 - 0.91)	0.80 (0.72 - 0.88)		
Comorbidity				
0	1.0 (ref)			
1-2	1.33 (1.17 - 1.51)	1.28 (1.11 - 1.46)	1.29 (1.06 - 1.57)	1.29 (1.08 - 1.54)
3-5	1.49 (1.30 - 1.70)	1.54 (1.32 - 1.80)	1.71 (1.36 - 2.15)	1.47 (1.20 - 1.79)
6+	1.52 (1.23 - 1.90)	1.86 (1.43 - 2.41)	2.23 (1.44 - 3.47)	1.66 (1.21 - 2.28)
Province				
NL	1.0 (ref)			
AB	2.11 (1.66 - 2.67)	2.29 (1.79 - 2.94)	3.16 (2.21 - 4.52)	1.66 (1.17 - 2.34)
BC	1.65 (1.32 - 2.05)	1.82 (1.43 - 2.31)	2.08 (1.46 - 2.95)	1.61 (1.15 - 2.26)
MA	2.19 (1.65 - 2.90)	2.36 (1.77 - 3.16)	2.74 (1.80 - 4.16)	2.10 (1.38 - 3.20)

NB	1.37 (1.05 - 1.79)	1.28 (0.96 - 1.71)	1.55 (1.05 - 2.30)	1.05 (0.70 - 1.57)
NS	1.54 (1.21 - 1.95)	1.54 (1.20 - 1.98)	1.61 (1.11 - 2.34)	1.44 (1.01 - 2.04)
ON	2.05 (1.67 - 2.53)	2.36 (1.90 - 2.93)	2.83 (2.07 - 3.86)	2.02 (1.47 - 2.77)
PEI	1.17 (0.87 - 1.57)	1.26 (0.92 - 1.73)	2.08 (1.28 - 3.38)	0.79 (0.51 - 1.24)
QC	1.52 (1.23 - 1.87)	1.64 (1.32 - 2.03)	2.12 (1.54 - 2.91)	1.30 (0.96 - 1.77)
SK	1.94 (1.46 - 2.57)	2.10 (1.57 - 2.80)	2.24 (1.47 - 3.42)	1.94 (1.30 - 2.89)
Marital Status				
Single, Never Married	1.0 (ref)			
Widow, Separated, Divorced	1.26 (1.07 - 1.49)	1.14 (0.96 - 1.36)	1.12 (0.88 - 1.44)	1.16 (0.92 - 1.45)
Married, Common Law	1.67 (1.44 - 1.92)	1.31 (1.11 - 1.54)	1.35 (1.07 - 1.72)	1.31 (1.04 - 1.64)
Household Income				
LESS $39,999	1.0 (ref)			
$40,000 - $59,999	1.25 (1.10 - 1.43)	1.10 (0.96 - 1.27)	1.07 (0.87 - 1.31)	1.16 (0.95 - 1.42)
$60,000 - $79,999	1.68 (1.45 - 1.94)	1.39 (1.17 - 1.64)	1.45 (1.16 - 1.82)	1.36 (1.07 - 1.73)
$80,000 - $99,999	1.76 (1.50 - 2.08)	1.32 (1.10 - 1.58)	1.33 (1.02 - 1.74)	1.34 (1.04 - 1.73)
$100K and over	1.99 (1.77 - 2.24)	1.40 (1.21 - 1.62)	1.49 (1.21 - 1.83)	1.32 (1.07 - 1.61)
Perceived Health Status				
Poor	1.0 (ref)			
Good	1.29 (1.02 - 1.64)	1.17 (0.92 - 1.49)	1.09 (0.75 - 1.57)	1.21 (0.87 - 1.69)
Great	1.51 (1.20 - 1.89)	1.06 (0.84 - 1.35)	0.93 (0.67 - 1.30)	1.15 (0.82 - 1.62)
Weight				
Normal	1.0 (ref)			
Overweight	1.28 (1.14 - 1.44)	1.15 (1.02 - 1.30)	1.15 (0.97 - 1.37)	1.12 (0.95 - 1.33)
Obese	1.30 (1.15 - 1.46)	1.11 (0.97 - 1.28)	1.10 (0.90 - 1.33)	1.11 (0.94 - 1.32)
Regular Healthcare Provider				
No	1.0 (ref)			
Yes	4.16 (3.57 - 4.84)	3.62 (3.08 - 4.26)	3.70 (2.93 - 4.66)	3.50 (2.75 - 4.46)

Physical Activity Level				
Inactive	1.0 (ref)			
Moderately Active	1.33 (1.18 - 1.50)	1.18 (1.04 - 1.34)	1.18 (0.97 - 1.43)	1.17 (1.00 - 1.37)
Very Active	1.53 (1.36 - 1.72)	1.33 (1.17 - 1.51)	1.34 (1.11 - 1.63)	1.30 (1.09 - 1.56)
Smoking				
Daily smoker	1.0 (ref)			
Occasional smoker	1.33 (1.01 - 1.75)	1.28 (0.95 - 1.72	1.11 (0.74 - 1.67)	1.54 (1.03 - 2.32)
Non-smoker	1.76 (1.55 - 2.00)	1.53 (1.32 - 1.77)	1.41 (1.14 - 1.73)	1.65 (1.35 - 2.01)
Race				
White	1.0 (ref)			
Arab/West Asian	0.55 (0.31 - 0.96)	0.76 (0.41 - 1.41)	0.69 (0.29 - 1.59)	0.83 (0.32 - 2.14)
Black	1.07 (0.69 - 1.65)	1.10 (0.68 - 1.80)	0.92 (0.40 - 2.08)	1.20 (0.68 - 2.15)
East Asian	0.74 (0.56 - 0.96)	0.81 (0.61 - 1.09)	0.82 (0.51 - 1.32)	0.79 (0.53 - 1.17)
Latin American	0.67 (0.36 - 1.24)	0.82 (0.44 - 1.53)	0.55 (0.18 - 1.67)	1.26 (0.54 - 2.96)
South-East Asian	0.54 (0.35 - 0.83)	0.48 (0.29 - 0.78)	0.46 (0.23 - 0.93)	0.49 (0.25 - 0.97)
South Asian	0.72 (0.50 - 1.05)	0.65 (0.44 - 0.95)	0.44 (0.24 - 0.81)	0.89 (0.53 - 1.49)
Others/Multi-racial	1.24 (0.85 - 1.79)	1.33 (0.86 - 2.06)	1.27 (0.71 - 2.25)	1.31 (0.66 - 2.58)
Immigration Status				
Canada Born	1.0 (ref)			
New Immigrant	0.67 (0.46 - 0.99)	0.91 (0.61 - 1.37)	0.92 (0.49 - 1.72)	0.84 (0.47 - 1.48)
Old Immigrants	0.84 (0.74 - 0.95)	0.90 (0.77 - 1.06)	0.88 (0.70 - 1.12)	0.94 (0.75 - 1.17)
Pap Smear test				
Yes				1.0 (ref)
No				0.41 (0.35 - 0.47)
Mammogram				
Yes				1.0 (ref)
No				0.17 (0.14 - 0.20)

Abbreviations: AB, Alberta; BC, British Columbia; MB, Manitoba; NB, New Brunswick; NL, Newfoundland & Labrador; NS, Nova Scotia; ON, Ontario; PEI, Prince Edward Island; QC, Quebec; SK, Saskatchewan

4.6. Discussion

Our study offers a comprehensive assessment of the racial and sociodemographic distribution of CRC screening participation in Canada. We find that while CRC screening participation rates seem to be on an upward trajectory in Canada (compared to findings from previous studies), as provinces establish and implement CRC screening programs, significant disparities persist across various socioeconomic, geographical, and racial or ethnic groups.

Our findings suggest that CRC screening participation rates have improved for most provinces and socio-demographic groups. For example, compared to CRC screening average participation rate of 16.1% between 2009 and 2011 (across five Provinces) reported by Major et al. (2013) and 55.2% reported by Singh et al. (2015) using data from the 2012 CCHS, our study found a screening rate of 59.8% across Canada in 2017. Similarly, uptake of fecal test, which is the primary test promoted through the CRC screening programs, increased while uptake of endoscopy tests reduced. The overall increase in proportion of the target population (people aged 50-74) who are up to date with CRC screening and the comparatively higher uptake of the fecal tests, point to, at least in part, the positive effect of organised screening programs (Blair et al., 2020).

However, the observed disparities in CRC screening participation align with prior research, particularly the work of Blair et al. (2019), which also detailed income-related disparities in CRC screening rates within Canada. This relationship between socioeconomic status and health behaviour may be partially explained by the concept of health literacy (Kobayashi et al., 2014). Health literacy refers to an individual's capacity to acquire, process, and understand basic health information and services necessary to make informed health decisions. Individuals with higher education and income levels tend to possess better health literacy, facilitating informed health decisions, including participation in preventive measures like CRC screening. Moreover, income level may enable greater access to healthcare resources and services or lower prioritisation of preventive health services that are freely available, such as CRC screening, due to challenges that often characterise low income (Baccolini et al. 2022; Horshauge et al. 2020; Kobayashi et al. 2014). This persistent income-related disparity in screening participation suggests a need for public health interventions designed to address socioeconomic barriers. It underscores the importance of facilitating access to screening services across all income levels by, for example, improving public awareness regarding the availability and importance of CRC screening.

Geographical disparities also emerged, with provinces running longer-duration CRC screening programs, such as Manitoba and Alberta, showing higher screening participation rates. This likely reflects the positive effect of organised screening programs on screening uptake, as argued by Blair et al. (2020). However, disparities persist even within jurisdictions that implemented the screening programs around the same time period. This suggest that local sociodemographic distribution, administration of the screening program, such as policies around recruitment/invitation and/or navigational support, and resource allocation (to program promotion, for example), might influence CRC screening participation rates (Darvishian et al. 2023; Singh et al. 2015; Tung et al. 2018). Particularly, the lower screening rates in provinces like Newfoundland & Labrador suggest potential systemic barriers, warranting further investigation into specific program or geographical characteristics that might help address these disparities effectively (Darvishian et al. 2023). We expect that such research could also shed light on how provinces could 'learn' and adapt best practices from one another.

Our findings draw particular attention to the lower CRC screening rates among immigrant and minority ethnic groups, particularly among those from South-East Asia and South Asia. There are sparse data for comparison to ascertain how screening rates have changed over the years within these groups. There is evidence, however, that acculturation and cultural perceptions of disease and prevention can greatly influence health behaviours, including participation in preventive measures such as CRC screening (Shen et al. 2018). Language barriers, limited familiarity with the Canadian healthcare system, and difficulties in accessing healthcare services may also contribute to the lower screening rates observed among these immigrant and ethnic groups (Crawford et al. 2016; Shen et al. 2018; Tatari et al. 2020). Our findings corroborate previous studies

(Crawford et al. 2016; Shen et al. 2018) where lower screening uptake among South Asian immigrants in the United Kingdom, United States and Canada, was reported. This overlap in findings suggests there is a critical need for culturally tailored and targeted health promotion initiatives to enhance screening awareness, acceptance and participation within these communities. Such efforts can address cultural barriers and misconceptions, and foster trust in the healthcare system, promoting better engagement with screening programs.

Interestingly, similar to Hategekimana and Karamouzian (2016) our study also found a significant association between self-perceived health status and CRC screening uptake. While they highlighted the role of self-perceived mental health status, our research focused on overall self-perceived health status. This finding emphasises the potential impact of individuals' perception of their health on their likelihood participating in preventive health initiatives like cancer screening. Therefore, health promotion strategies could consider enhancing individuals' health awareness and perceptions, which could subsequently improve engagement in preventive health behaviors.

The role of healthcare providers in influencing CRC screening behaviour also needs careful attention. Healthcare providers are often the primary source of health information for their patients and play a pivotal role in initiating discussions about preventive healthcare (Zhu et al, 2022). In our study, many individuals cited their healthcare provider's perception of the test as unnecessary as a barrier, indicating a potential disconnect between clinical guidelines and patient-provider communications. This suggests the need for better collaboration between screening program administrators and healthcare providers to ensure consistent messaging regarding the importance of CRC screening (Zhu et al, 2022).

In light of the projected increase in the burden of cancer in Canada (Poirier et al., 2019; Tung et al., 2018), our findings become even more crucial. The projected rise in cancer cases, especially in Atlantic Canada (Poirier et al., 2019), amplifies the urgency to develop and implement efficient, inclusive, and targeted strategies to improve CRC screening participation rates across all demographic groups in Canada. Consequently, efforts should emphasise reducing disparities, enhancing public awareness, facilitating accessibility, and ensuring the cultural appropriateness of CRC screening interventions.

While this research sheds light on several key disparities in CRC screening uptake, it's important to acknowledge that future research is warranted to shed more light on the nuanced contributors to these disparities and to develop interventions tailored to these specific barriers. Longitudinal studies could provide valuable insights into trends and shifts in CRC screening behaviours over time, while qualitative studies could offer a deeper understanding of individual experiences and perceptions underpinning screening behaviours. Such research efforts could further our understanding of CRC screening disparities in Canada, allowing decision-makers to develop evidenced-informed effective, targeted strategies to enhance screening rates, mitigate the burden of CRC, and ultimately contribute to a healthier, cancer-free Canada.

4.6.1. Implications of findings for Public Health Policy and Practice

This study offers critical insights for policy and practice. The observed socioeconomic disparities in CRC screening participation highlight the need for policies that address socioeconomic barriers to screening and ensure equal access across all income and education levels. Public health interventions should focus on enhancing health literacy, particularly among individuals in lower socioeconomic groups.

Lower screening rates among immigrant and minority ethnic groups point to the need for culturally sensitive and targeted health promotion initiatives. Policymakers and healthcare practitioners must consider language barriers, cultural perceptions, and unfamiliarity with the healthcare system when designing interventions.

Lastly, the apparent disconnect between current evidence on cancer screening, clinical guidelines and the perceptions of patients underscores the need for consistent messaging regarding the importance of CRC screening. Healthcare providers and CRC screening program managers must work together to ensure the correct and consistent communication of preventive healthcare measures.

4.6.2. Strength and Limitations.

The main strength of this study lies in its analysis of CRC screening participation rates across various sociodemographic, geographical, and ethnic groups in Canada. Our study benefits from the use of the Canadian Community Health Survey, a large national data source, representative of the Canadian population that offers valuable insights into health determinants, health resource utilisation and behaviors across the country.

However, there are limitations inherent to using such large survey data. One notable limitation is recall bias, where respondents may not accurately remember or report their screening behaviors. As such, inaccuracies in participants' recollections or report of their CRC screening history may lead to over- or under-estimation of screening participation. Further, small sample sizes for most of the ethnic and immigrant groups meant that, one, analysis could not be disaggregated by province or other factors and, two, the data must be interpreted with caution. Lastly, the 2018 to 2022 CCHS collected CRC screening data from only a few provinces, so the 2017 CCHS provides the most recent screening data from all ten provinces available for analyses.

Despite these limitations, the findings of this study make significant contributions to our understanding of CRC screening disparities in Canada and provides evidenced-based information that can inform effective and targeted strategies to enhance screening rates across all demographic groups in Canada.

4.7. Conclusion.

The current study shows that despite average CRC screening participation rate across Canada almost at the national target, significant disparities remain to be addressed. These disparities manifest across socioeconomic, geographical, and racial or ethnic divide. Addressing these disparities is crucial, especially considering the projected rise in cancer incidences over the next decade. Therefore, future efforts should focus on reducing disparities, enhancing public awareness, facilitating accessibility, and ensuring the cultural appropriateness of CRC screening initiatives. By tackling these issues head-on, we can improve cancer screening uptake, mitigate the burden of CRC, and contribute to a healthier Canada.

Chapter Five

Paper 3: Factors associated with concurrent Participation in Breast, Cervical, and Colorectal Cancer among Canadian Women - a cross-sectional study.

Adefemi, K., Knight, J. C., Zhu, Y. and Wang, P. P. Sociodemographic correlates of concurrent participation in breast, cervical and colorectal cancer screening among women in Canada –a cross sectional study.

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5.1. Abstract

Background

Colorectal cancer (CRC), breast (BC), and cervical (CC) cancers represent a significant disease burden among Canadian women. While organised screening programs aim to reduce this burden, participation rates remain suboptimal among several population groups, particularly for CRC screening.

Aim

This study examined factors associated with CRC screening uptake among women who report participating in BC and CC screening ('screen-aware' women), investigated patterns of concurrent participation across all three programs, and identified associated factors.

Methods

Cross-sectional data from the 2017 Canadian Community Health Survey were analyzed for women aged 50-69 years eligible for BC, CC, and CRC screening (n=10,426). Multivariable logistic regression evaluated factors associated with CRC screening among 'screen-aware' women. Multinomial logistic regression assessed factors related to full (all three), partial (any two), single, or non-participation across screening programs, using 'no screening' as the reference.

Results

While 87% participated in at least one cancer screening program, only 27% reported full participation in all three. CRC screening (53.7%) lagged BC and CC (~ 64%) participation. Among 'screen-aware' women, older age (AOR 1.43, 95% CI 1.17 - 1.74), higher income (AOR 1.34, 95% CI 0.97 - 1.84), self-rated health as 'great' (AOR 1.62, 95% CI 1.16 - 2.25), and having regular healthcare provider (AOR 1.87, 95% CI 1.14 - 3.07) were associated with higher CRC participation. Having multiple chronic conditions reduced CRC screening likelihood (AOR 0.76, 95% CI 0.55-0.94). Higher income, self-rated health, regular healthcare provider, and physical activity increased odds of full participation, while smoking and Asian identity reduced the odds of full concurrent screening participation.

Conclusions

CRC screening uptake remains low among Canadian women, even those participating in other cancer screening programs. Socioeconomic, health-related, and systemic factors influence concurrent screening participation. Tailored interventions addressing health literacy and promoting equitable access to screening for disadvantaged populations are crucial for improving cancer prevention efforts.

5.2. Co-authorship Statement

Kazeem Adefemi drafted this chapter and substantively revised it, made substantial contributions towards the study design, data acquisition, analysis, and interpretation of the study results. Dr. Peter Wang substantively revised the work, and made substantial contributions towards study design, data acquisition, analysis, and interpretation. Dr. John C. Knight substantively revised the work, and made substantial contributions to the study design, data acquisition and interpretation. Dr. Yun Zhu revised the work and made substantial contributions towards study design and analysis.

All authors read and approved the submitted version of this chapter.

5.3. Introduction

Colorectal (CRC), breast (BC), and cervical (CC) cancers represent a major disease burden in Canada, accounting for a significant proportion of cancer incidence and mortality (Brenner et al., 2022). In 2023 alone, these three cancers account for 36% of all new cancer incidence and 25% of cancer-related deaths among women in Canada (Canadian Cancer Statistics, 2023). To address this burden, organised screening programs have been established nationwide, guided by recommendations from the Canadian Task Force on Preventive Health Care (CTFPHC) (Canadian Partnership Against Cancer, 2019). The CTFPHC recommends:

- BC screening with mammography every 2–3 years for women aged 50–74 years.
- CC screening with a Pap test every 3 years for asymptomatic women aged 25–69 years.
- CRC screening with fecal tests every 2 years or either flexible sigmoidoscopy or colonoscopy (endoscopy tests) every 10 years for people aged 50-74 years at average risk of CRC (Chaput et al., 2021).

While screening has been recognised as an essential public health measure to reduce cancer incidence and mortality (Chaput et al., 2021; Major et al., 2015), participation rates remain well below national targets in many population groups (Alam et al., 2022; Blair et al., 2019; Sabatino et al., 2015; Schoenborn et al., 2019). This suboptimal uptake has public health consequences, as evidenced by the proportion of cancers diagnosed at later stages, when treatment is more challenging and survival outcomes are poorer. This disparity is particularly striking for CRC, where 49% of new cases are diagnosed at stage III or IV, compared to 17.3% of breast cancers and 28.3% of cervical cancers (Canadian Cancer Statistics, 2018).

The lower uptake of CRC screening compared to BC and CC screening is a persistent issue, even when controlling for well-known sociodemographic (education, income, race) and health service (health insurance, lack of a regular health care provider, provider recommendations etc.) factors shown to be associated with non-participation across all screening programs (Farr et al., 2022; Lo et al., 2013; Sabatino et al., 2015). The recency and multifaceted nature of CRC screening, with its variety of approved testing modalities, along with the potential influence of health beliefs and risk perception, have been suggested as likely factors contributing to the lower participation in CRC screening (Farr et al., 2022; Rebolj et al., 2020).

Additionally, there is growing interest in investigating factors associated with concurrent participation in multiple cancer screening programs among women who are eligible for all three programs (Bonafede et al., 2019; Dawidowicz et al., 2019; Larsen et al., 2018). International studies indicate that a surprisingly low proportion of women participate in all three or any combination of screening, and that CRC screening alone or in combination with any other screening, is generally lower compared to BC and CC screening rates (Bonafede et al., 2019; Dawidowicz et al., 2019; Larsen et al., 2018). Such findings highlight the need to investigate patterns of screening participation and the sociodemographic factors associated with participation in all three programs versus partial (any two combinations), single or non-screening (Ishii et al., 2021; Kregting et al., 2022; Njor et al., 2023) within the Canadian context. Understanding the factors associated with lower CRC participation is similarly crucial for designing strategies to promote greater cancer screening rates.

To guide our analysis and interpretation of the findings, we utilise Andersen's Behavioral Model of Health Services Use (Andersen, 1995). This model posits that an individual's decision to utilise healthcare services, such as preventive screenings, is influenced by predisposing factors (e.g., sociodemographic characteristics, health beliefs), enabling factors (e.g., access to resources, healthcare provider recommendation), and need factors (e.g., perceived and actual health status) (Alkhawaldeh et al., 2023; Jin et al., 2019; Lee et al., 2020). By examining screening participation through the lens of this framework, we can better understand the interplay of individual, social, and systemic factors that influence cancer screening behaviors.

This study offers a unique contribution by being the first in Canada to examine the factors influencing participation in any one, two, or all three cancer screening programs among women, utilising nationally representative data from the 2017 Canadian Community Health Survey. The study aims to:

- Examine factors associated with CRC screening among women who participate in other screening programs ('screen-aware' individuals).
- Investigate patterns of combined/concurrent participation in any one, two, all three, or none of the three cancer screening programs.
- Identify factors associated with concurrent participation in one, any two, all three, or none of the cancer screening programs.

Insights from this study have the potential to inform tailored interventions that effectively address barriers and improve overall screening participation. A better understanding of the factors associated with participation in all, some, or none of the cancer screening programs could support the design of effective strategies within screening programs, such as the invitation, appointment, recall, or follow-up systems (Ishii et al., 2021; Wirth et al., 2014). This knowledge may ultimately contribute to reducing the burden of cancer in Canada.

5.4. Methods

5.4.1. Design and Population

This cross-sectional study included all women from the ten Canadian provinces aged between 50 and 69 years of age who participated in the 2017 CCHS. The 2017 CCHS was selected for this study as it is the most recent iteration that includes CRC screening participation data for all Canadian provinces. Details about the CCHS has been provided previously (Statistics Canada, 2017). But briefly, the CCHS is national survey that collects a wide array of sociodemographic, health status, health service utilisation, and determinants of health from a representative sample of Canadians aged 12 years and over (Statistics Canada, 2017). The CCHS employs a complex, multi-stage sampling process to efficiently capture a representative sample from diverse geographic and demographic groups across the country. The sample excludes full-time members of the armed forces and residents of some remote communities and government reserves, collectively constituting about 3% of the Canadian population. The 2017 CCHS provides data for almost 57,000 respondents, with a response rate of 87% (Statistics Canada, 2017).

In this study, the term ‘concurrent participation’ refers to participation in multiple cancer screening programs. Further, the 50-69 age bracket was specifically selected to include only women who are eligible for all three screening programs in line with current guidelines.

5.4.2. Variables

The main outcome variables were participation in BC and CC within 3 years, and participation in either CRC fecal test within 2 years or CRC endoscopy tests within 10 years. Respondents in the CCHS are asked whether they have ever participated in these cancer screening tests (Yes/No) and the last time they completed the tests. Participation in the screening was determined based on a 'yes' response and within the recommended guideline (fecal tests ≤2years, endoscopy test ≤10years for CRC, mammography ≤3years for BC and Pap test ≤3years for CC). Additionally, eight (8) concurrent screening patterns were created to capture participation in all three, any two, one or none of the screening programs. Women outside of the 50-69 age bracket, women who reported a history of mastectomy or hysterectomy or who completed mammography as follow-up to BC treatment or due to breast problems were excluded from the analysis. The final analytic sample for this study (n) was *10,426.*

In line with previous studies (Dawidowicz et al., 2019; Ishii et al., 2021; Larsen et al., 2018; Njor et al., 2023; Wirth et al., 2014) and data availability within the CCHS, the following categorical variables were primary independent variables in the analysis: age categories (50-59 and 60-69), household income ((aggregated into - less than $40k, $40-$80k, and above $80k), marital status (single, married/common law relationship, or widowed/divorced/separated) and the number of chronic health conditions reported (0, 1-3, 4+). Respondents were asked "Do you have Asthma/high blood pressure/diabetes/Alzheimer's Disease etc. (Yes/No/Don't know), the 'yes' responses were aggregated as number of chronic health conditions reported. Age, racial and immigrant status were aggregated into larger categories as Statistics Canada limits the release of small cell counts in any level or (sub) categories of analysis outputs to minimise the risk of identification. Additional covariates used in the analysis included current smoking status (daily, occasional or non-smoker), self-reported health (five categories in the CCHS aggregated into Poor, Good and Great), physical activity levels – based on World Health Organization (WHO) guidelines (Very active, moderately active, inactive) and having a regular healthcare provider (Yes/No). Due to sample size limitations, racial categories in the CCHS were aggregated into five broad categories, White, Hispanic (Latin American), Black, Asian (South Asian, Chinese, Filipino, Arab, Southeast Asian, West Asian, Korean and Japanese) and Other/multi-racial (Other racial or cultural origin, and multiple racial or cultural origins). Immigration status was categorised as Canada-born (non-immigrant) and immigrant (landed immigrant and non-permanent resident) – see Appendix C for relevant sections of the CCHS questionnaire.

'Don't know', 'Refusal' and 'Not stated' responses were aggregated as missing data. Also, as the proportion of missing was relatively small (less than 5% on average), we choose to use a complete case analysis and exclude missing data from the analysis.

5.4.3. Statistical Analysis

Data analysis was conducted with SAS 9.4, using its specialised survey procedures. Survey weights provided by Statistics Canada were applied to account for the complex, multi-stage sampling technique of the CCHS. To ensure accurate variance estimates, bootstrapped analyses were performed using 500 replicate bootstrap sampling weights. Descriptive statistics were calculated to present the distribution of various sociodemographic characteristics in the analytic sample. The combinations of screening participation in the three cancers were categorised into eight patterns 1 (BC+CC+CRC – full participation), 2 (BC+CRC), 3 (CC+CRC), 4 (BC+CC), 5 (CRC only), 6 (BC only), 7 (CC only) and 8 (non-participation). The distribution of these screening patterns across women's sociodemographic characteristics was presented using descriptive statistics. We conducted multivariable logistic regression analysis to examine factors associated with CRC screening participation among women who reported participation in BC and CC screening (i.e. 'screen-aware'). Multivariable multinomial logistic regression analysis was conducted to examine factors associated with full, partial or no-screening participation, using 'no screening' as the reference category and adjusting for age, marital status, household income, self-rated health, physical activity levels, smoking status, racial and immigrant status and number of reported chronic health conditions. This approach allowed us to directly compare factors associated with full participation versus partial, single, or non-participation patterns. Multicollinearity between independent variables, particularly age and income, was tested using an inflation factor of 5 as the cutoff. Educational attainment was not included in the regression analyses due to correlation with household income. Results are reported as weighted proportions and adjusted odds ratios (AOR) with 95% confidence intervals (95% CI), in compliance with Statistics Canada's confidentiality and data protection requirements. The threshold for significance was $p < 0.05$.

5.5. Results

The final analytic sample of women aged 50-69 years from the ten Canadian provinces who met the inclusion criteria for this analysis was (*n)= 10,426* respondents. Table 5.1 presents detailed demographic characteristics of the respondents across the individual provinces. In summary, slightly over half of the respondents (52%) were aged between 50-59, almost 70% were married or in a common law relationship, 60% reported having post secondary education and 50% had a total annual household income of over $80,000. With regards to health and lifestyle characteristics, 60% were overweight or obese, 84% reported that they do not smoke, about 73% were reportedly ‘very’ or ‘moderately’ active while 91% reported having a regular healthcare provider. However, over 76% had one or more chronic health conditions (19% had four or more chronic conditions), and 16% reported their health status to be ‘poor’. With regards to racial and immigrant status, majority of the respondents (82.5%) identified as Whites with Asians a distant second at 11.8%, and 73% were non-immigrant (Table 5.2).

5.5.1. Distribution of screening participation

Slightly over half of all the respondents reported participation in CRC screening (53.7%) with fecal tests (FIT) the most common CRC screening test at 36%. In comparison, about 64% of the respondents have participated in both BC and CC screening, respectively. (Table 5.2).

Table 5.3 presents the various patterns of concurrent cancer screening participation among Canadian women aged 50-69. Participation in all three cancer screening programs (full participation) was reported by 26.7% of respondents. The most common pattern was participation in any two of the three recommended screening programs (partial participation), reported by 35.5% of the respondents. Within this partial screening group, the most frequent combination was BC and CC screening (BC+CC,19.7%). However, 13.4% reported no participation in any of the three screening programs. Participation in only one cancer screening program was reported by 24.4% of the women. Among respondents reporting single participation, CC only was the most common pattern (10.5%), followed by BC only at 9.0%, and CRC only (4.9%).

Table 5.1: Demographic Distribution of Women Aged 50-69 – CCHS 2017

Variable	Canada	**Provinces; % of Population**									
	% of Population	AB	BC	MB	NB	NL	NS	ON	PEI	QC	SK
Age											
50-59	52.1	56.1	51.8	54.6	51.7	43.2	53.8	52.2	48.2	50.2	55.2
60-69	47.9	43.9	48.2	45.4	48.3	56.8	46.2	47.8	51.8	49.8	44.8
Marital status											
Married/Common law relationship	68.9	72.5	70.9	70.7	70.6	69.2	71.3	69.2	70.8	64.2	69.9
Divorced/widow/separated	21.0	20.6	21.1	19.4	22.3	22.9	19.8	20.2	18.6	24.1	19.0
Single	9.9	6.7	7.6	9.8	7.1	7.7	8.9	10.3	10.5	11.7	11.1
Missing	0.2	0.3	0.4	.	.	0.2	.	0.3	0.2	0.0	0.1
Educational attainment											
Post high school	60.0	62.9	57.9	58.0	53.9	49.8	62.1	61.7	59.2	57.1	56.0
High school	25.9	27.5	30.5	26.1	27.9	25.4	19.3	24.5	20.9	24.7	33.1
Less than high school	11.7	7.3	9.8	13.5	16.0	23.6	14.3	11.2	17.1	15.4	9.2
Missing	2.4	2.3	1.7	2.4	2.2	1.2	4.3	2.7	2.7	2.8	1.7
Household income											
$80,000+	50.4	61.1	48.6	48.7	39.9	37.0	46.4	54.3	45.6	42.2	42.4
$40,000 - $80,000	29.3	25.2	31.0	37.7	34.7	30.6	32.2	26.7	32.6	31.8	37.7
<$40, 000	20.3	13.7	20.4	13.7	25.5	32.4	21.4	19.1	21.8	25.9	19.9

Have Regular Healthcare provider											
Yes	91.6	91.7	89.9	94.7	95.5	93.0	90.7	94.1	88.3	88.0	90.6
No	7.6	8.1	9.1	5.3	4.2	7.0	9.3	4.3	11.7	11.8	9.3
Missing	0.9	0.2	1.0	.	0.4	.	0.1	1.7	.	0.2	0.1
Physical activity level											
Very active	34.7	37.8	44.7	33.1	26.2	30.5	30.0	33.6	31.0	30.8	31.0
Moderately active	38.7	22.8	19.0	21.7	27.3	24.4	28.7	24.5	21.3	24.6	23.0
Inactive	23.4	37.0	32.2	43.8	40.8	40.4	37.6	38.1	45.6	42.8	42.3
Missing	3.1	2.4	4.1	1.4	5.7	4.7	3.7	3.8	2.0	1.8	3.6
Smoking Status											
Non-smoker	84.3	86.9	89.7	85.3	86.1	76.5	82.5	85.2	81.2	80.9	81.7
Occasional smoker	3.1	1.9	2.4	3.1	2.4	4.8	3.2	2.5	5.9	4.7	2.8
Daily smoker	12.6	11.2	7.9	11.5	11.4	18.6	14.3	12.3	12.9	14.4	15.5

Abbreviations: AB, Alberta; BC, British Columbia; MB, Manitoba; NB, New Brunswick; NL, Newfoundland & Labrador; NS, Nova Scotia; ON, Ontario; PEI, Prince Edward Island; QC, Quebec; SK, Saskatchewan

Table 5.2: Population characteristics, women aged 50-69, Canada – CCHS 2017

Characteristics	% of Population
Racial group	
White	82.5
Asian	11.8
Black	2.0
Hispanic	1.1
Others/multi-racial	2.7
Immigrant status	
Canada born	73.2
Immigrant	26.8
Self-reported no. of chronic conditions	
0	23.4
1-3	57.9
4+	18.7
Self-reported health status	
Great	53.7
Good	30.2
Poor	16.0

Screening Participation	
CC (≤3yrs)	64.4
BC (≤3yrs)	63.7
CRC (Fecal test ≤2yrs)	36.0
CRC (Endoscopy test ≤10yrs)	17.7
Either/both CRC tests	53.7

Abbreviations: CC, cervical cancer screening; BC, breast cancer screening; CRC, colorectal cancer screening

5.5.2. Distribution of screening patterns across sociodemographic characteristics

The distribution of screening participation patterns presented in Table 5.4 shows significant variations across sociodemographic categories. Overall, participation in any two of the three cancer screening programs (partial participation) was the most common pattern, with the combination of BC and CC screening being the most prevalent. For example, while 27.5% of women aged 50-59 and 25.7% of those aged 60-69 reported full participation, 22.6% and 16.6% of both age groups, respectively, reported participation in BC+CC only. But while 9.6% of people with no regular health care provider and 15.6% of 'daily smokers' report full participation, 15% and 18.7% reported BC+CC screening pattern, respectively. However, 'no screening' (pattern 8) was also relatively common, especially among women with lower educational attainment (21.2%), lowest income bracket (24.3%) and ‘daily smokers’ (25.8%).

Women with post-high school education had the highest participation in all three programs (29.5%), while those with less than high school education had the lowest (16.1%). Household income followed a similar gradient, with the individuals in the highest income bracket reporting the highest rates of full participation (31.6%). Additionally, respondents with a regular healthcare provider reported substantially higher participation in all screening combinations. In contrast, women without a regular healthcare provider frequently reported no screening participation (38.7%). Lastly, self-rated health, physical activity levels, and smoking status exhibited correlations with screening participation rates. Women reporting ‘great’ health (31.3%), very active lifestyles (31.0%), and non-smoking status (28.4%) reported the highest rates of full participation.

Table 5.3: Patterns of Concurrent Cancer Screening Participation among women aged 50-69, Canada – CCHS 2017

Pattern	**Screening Programs**			**% of Population**	**Screening Participation**
	BC	**CC**	**CRC**		
1 – BC+CC+CRC	X	X	X	26.7	Full Screening Participation
2 – BC+CRC	X	-	X	8.3	Partial (Any 2) Screening Participation - **35.5%**
3 – CC+CRC	-	X	X	7.5	
4 – BC+CC	X	X	-	19.7	
5 – CRC only	-	-	X	4.9	Single (only one) Screening Participation - **24.4%**
6 – BC only	X	-	-	9.0	
7 – CC only	-	X	-	10.5	
8 - None	-	-	-	13.4	No Screen Participation

Key: X = Yes, - = No

Abbreviations: CC, cervical cancer screening; BC, breast cancer screening; CRC, colorectal cancer screening

Table 5.4: Distribution of screening participation pattern by sociodemographic characteristics among women aged 50-69, Canada – CCHS 2017

Variable	**1- BC+CC+CRC** %	**2 – BC+CRC** %	**3 – CC+CRC** %	**4 – BC+CC** %	**5 – CRC only** %	**6 – BC only** %	**7 – CC only** %	**8 – None** %
Age		%	%	%	%	%	%	%
50-59	27.5	5.2	7.0	22.6	3.7	7.4	13.7	12.8
60-69	25.7	11.6	8.0	16.6	6.2	10.8	7.0	14.1
Marital status								
Married/Common law relationship	28.5	8.8	7.7	19.9	4.8	8.4	10.3	11.6
Divorced/widow/separated	22.9	7.4	7.6	18.0	5.2	10.5	10.8	17.5
Single	22.0	6.5	6.1	21.9	5.0	9.8	11.7	17.1
Educational attainment								
Post high school	29.5	7.2	8.1	20.8	4.1	8.1	11.4	10.7
High school	26.1	9.0	7.3	20.7	4.8	8.7	9.1	14.3

Less than high school	16.1	12.1	5.8	12.8	7.5	15.2	9.3	21.2
Household income								
$80,000+	31.6	6.7	8.2	21.5	3.9	7.7	11.4	9.1
$40,000 - $80,000	24.6	10.1	7.4	18.2	5.9	10.1	10.2	13.4
<$40, 000	17.3	9.8	5.9	17.3	5.8	10.7	8.8	24.3
Have a Regular Healthcare provider								
Yes	28.1	8.7	7.8	20.2	5.0	8.8	10.4	10.9
No	9.6	4.3	3.9	15.0	4.3	11.6	12.6	38.7
Self-rated health status								
Great	31.3	8.0	7.1	21.4	3.8	7.8	10.7	10.0
Good	24.4	8.5	8.4	17.8	5.0	10.6	10.8	14.6
Poor	15.4	9.0	7.3	17.8	8.2	10.3	9.2	22.7
Physical activity level								
Very active	31.0	7.2	9.0	19.5	3.5	7.0	11.6	11.1
Moderately active	26.8	8.3	6.9	20.5	5.0	9.8	10.7	12.0

Inactive	21.4	9.9	6.2	18.8	6.6	10.6	9.2	17.2
Smoking Status								
Non-smoker	28.4	8.8	7.8	19.6	4.6	8.9	10.2	11.7
Occasional smoker	23.6	5.4	6.5	25.4	6.5	10.3	13.1	9.2
Daily smoker	15.6	5.9	5.9	18.7	6.2	9.6	12.3	25.8

Abbreviations: CC, cervical cancer screening; BC, breast cancer screening; CRC, colorectal cancer screening

5.5.3. Reported barriers to screening participation.

Table 5.5 presents the various barriers reported for non-screening across the different cancer screening programs. Among women reporting no screening participation, a significant proportion (23.4% to 34.2%) stated they did not believe the test was necessary. This was highest for colonoscopy/sigmoidoscopy (34.2%). For both CRC screening options, the most frequently cited barrier was their healthcare provider deeming the test unnecessary (40.1% for fecal test and 52.7% for endoscopy tests). Lack of time was reported as a barrier for 13.9% of women with no BC screening but this was less reported for other screening tests. Fear or discomfort, lack of knowledge about the test, and lack of a regular healthcare provider were reported by a much smaller proportion of women across all screening programs (ranging from 0.3% to 10.7%). While notable proportion of women reported they and/or their healthcare provider deemed screening as 'unnecessary, particularly for CRC tests, our analyses of predictors, provided below, show that factors such as income, self-rated health status, and access to healthcare providers are potentially stronger influences on overall screening participation patterns.

Table 5.5: Self reported barriers to Cancer Screening among women aged 50-69, Canada CCHS 2017

Reported barrier	% of women with **No BC**	% of women with **No CC**	% of women with **No CRC** *(Fecal test)*	% of women with **No CRC** *(Colonoscopy/Flexible sigmoidoscopy)*
Respondent didn’t think test was necessary	34.0	23.4	27.4	34.2
Doctor deems test unnecessary	17.1	19.0	40.1	52.7
Fear and/or Discomfort	10.0	3.1	1.3	2.2
Lack of time	13.9	5.4	4.1	1.4
No doctor	4.8	6.9	2.8	2.2
Hysterectomy/Mastectomy/Had Other CRC screening test	1.6	31.4	15.1	2.4
Other	18.6	10.7	7.0	3.4
Did not know about test	Not asked	Not asked	1.6	1.1
No access to test	Not asked	Not asked	0.6	0.3

5.5.4. Factors Associated with Concurrent Screening Participation

Tables 5.6 presents the odds ratio for CRC screening participation among all respondents, and those who reported BC only and BC+CC screening participation. After adjusting for household income, marital status, access to healthcare provider, lifestyle factors, racial and immigrant status, older age, that is, 60-69 (AOR 1.50; 95% CI 1.31 - 1.71), belonging to high income household (AOR 1.37; 95% CI 1.13 - 1.67), self-rated health as 'great' (AOR 1.31; 95% CI 1.05 - 1.63) and access to a regular health care provider (AOR 3.29; 95% CI 2.45 - 4.40) were associated with higher odds of CRC screening participation. Also, being a daily smoker and an immigrant (AOR 0.73; 95% CI 0.56 - 0.94) were associated with lower likelihood of CRC screening. Marital status, physical activity levels, racial identity and having multiple chronic health conditions were not associated with CRC screening participation.

In multivariable logistic regression analysis stratified by participation in BC only, and BC+CC screening, household income and smoking status were no longer associated with CRC screening among this sub-population. However, older women (aged 60-69) who were BC+CC (AOR 1.43; 95%CI 1.17 - 1.74) or BC only (AOR 1.37; 95%CI 1.15 - 1.64) still had higher likelihood of CRC participation compared to younger women (50-59) in the same screening pattern. Similarly, self-rated health, access to regular health care provider and immigrant status were all associated with CRC participation among women who reported BC only or BC+CC screening, while presence of four or more chronic health conditions (AOR 0.72; 95%CI 0.55 - 0.94) was associated with lower likelihoods of CRC screening participation.

Table 5.6: Factors associated with CRC screening among women with BC and BC+CC screening participation.

Factors	**AOR** (95% CI)- All Women	**AOR** (95% CI) - Women with BC screening	**AOR** (95% CI) - Women with BC+CC screening
Age			
50-59	1.0 (ref)	1.0 (ref)	1.0 (ref)
60-69	1.50 (1.31 - 1.71)	1.37 (1.15 - 1.64)	1.43 (1.17 - 1.74)
Household income			
<40k	1.0 (ref)	1.0 (ref)	1.0 (ref)
$40k - $80k	1.35 (1.09 - 1.67)	1.11 (0.86 - 1.44)	1.22 (0.88 - 1.68)
>$80k	1.37 (1.13 - 1.67)	1.14 (0.89 - 1.46)	1.34 (0.97 - 1.84)
Marital Status			
Single	1.0 (ref)	1.0 (ref)	1.0 (ref)
Widow/separated/divorced	1.11 (0.85 - 1.45)	1.16 (0.82 - 1.65)	1.18 (0.75 - 1.84)
Married/common law relationship	1.18 (0.91- 1.54)	1.24 (0.88 - 1.75)	1.08 (0.70 - 1.66)
Smoking			
Daily smoker	1.0 (ref)	1.0 (ref)	1.0 (ref)
Occasional smoker	1.30 (0.85 - 2.00)	0.98 (0.57 - 1.69)	1.11 (0.55 - 2.23)

Non-smoker	1.58 (1.27 - 1.97)	1.33 (0.98 - 1.80)	1.38 (0.94 - 2.04)
Physical activity level			
Inactive	1.0 (ref)	1.0 (ref)	1.0 (ref)
Moderately active	1.01 (0.84 - 1.21)	1.03 (0.81 - 1.31)	1.10 (0.82 - 1.48)
Very active	1.15 (0.94 - 1.39)	1.21 (0.95 - 1.54)	1.26 (0.93 - 1.72)
Self-rated health			
Poor	1.0 (ref)	1.0 (ref)	1.0 (ref)
Good	1.19 (0.95 - 1.49)	1.25 (0.93 - 1.67)	1.54 (1.07 - 2.21)
Great	1.31 (1.05 - 1.63)	1.39 (1.05 - 1.84)	1.62 (1.16 - 2.25)
Racial identity			
White	1.0 (ref)	1.0 (ref)	1.0 (ref)
Asian	0.90 (0.63 - 1.29)	1.31 (0.83 - 2.07)	1.39 (0.82 - 2.35)
Black	1.15 (0.60 - 2.20)	1.23 (0.57 - 2.63)	1.12 (0.45 - 2.83)
Hispanic	1.00 (0.43 - 2.32)	1.13 (0.40 - 3.16)	1.48 (0.48 - 4.56)
Other/multi-racial	0.95 (0.54 - 1.67)	1.55 (0.70 - 3.40)	1.74 (0.67 - 4.56)
Immigrant status			
Canada born	1.0 (ref)	1.0 (ref)	1.0 (ref)
Immigrant	0.73 (0.56 - 0.94)	0.67 (0.49 - 0.92)	0.68 (0.47 - 0.98)
Have a regular healthcare provider			
No	1.0 (ref)	1.0 (ref)	1.0 (ref)
Yes	3.29 (2.45 - 4.40)	2.26 (1.50 - 3.41)	1.87 (1.14 - 3.07)
Chronic health conditions			

0	1.0 (ref)	1.0 (ref)	1.0 (ref)
1-3	1.11 (0.93 - 1.32)	1.06 (0.86 - 1.30)	1.03 (0.81 - 1.32)
4+	0.89 (0.71 - 1.11)	0.72 (0.55 - 0.94)	0.76 (0.54 - 1.06)

Abbreviations: CC, cervical cancer screening; BC, breast cancer screening; CRC, colorectal cancer screening. AOR, adjusted odds ratio; CI, confidence intervals

Lastly, multivariable multinomial logistic regression analysis was used to evaluate the association between these various variables and the odds of full, partial, or single screening patterns, using ‘no screening’ (pattern 8) as the reference category. The result shows that household income is a strong predictor across all screening patterns. Compared to women in the lowest income bracket (<$40k), those with incomes $40k-$80k had significantly higher likelihood of full participation (AOR 2.30; 95% CI 1.70-3.10), partial participation (AOR 1.77; 95% CI 1.32- 2.36), and single participation (AOR 1.84; 95% CI 1.37-2.46). The association was even stronger in the highest income bracket (>$80k).

Self-rated health was also associated with screening pattern. For full participation, women who reported 'good' (AOR 2.11; 95% CI 1.45-3.08) and 'great' health (AOR 3.09; 95% CI 2.10-4.54) had significantly higher odds of screening participation compared to those reporting 'poor' health. Similarly, physical activity showed a positive association, with 'very active' women having higher odds of full participation (AOR 1.53; 95% CI 1.11-2.09) compared to inactive women.

Having a regular healthcare provider also had a strong influence on screening, with ninefold odds of full participation (AOR 9.08; 95% CI 5.82-14.16), fivefold odds of partial participation (AOR 5.12; 95% CI 3.50 -7.50), and two-fold odds of single program participation (AOR 2.67; 95% CI 1.99-3.58) compared to respondents who reported no regular healthcare provider.

Smoking status was also a significant predictor. Occasional smokers and non-smokers had consistently higher odds of full participation, partial participation, and single program participation compared to daily smokers. Although, occasional smokers had higher odds of full participation (AOR 4.03; 95%CI 2.11 - 7.73) compared to non-smokers (AOR 2.85; 95%CI 1.99 - 4.08).

Additionally, the presence of multiple chronic health conditions was associated with increased odds of partial screening participation (AOR 1.52; 95% CI 1.06 – 2.19 for 4+ conditions) and single program participation (AOR 1.73; 95% CI 1.17 -2.56 for 4+ conditions).

Racial identity showed some significant disparities. Compared to white women, Asian women had lower odds of full participation (AOR 0.68; 95% CI 0.43-0.98), partial (AOR 0.49; 95% CI 0.30-0.82), and single screening participation (AOR 0.64; 95% CI 0.38-0.89). Interestingly, black women had higher odds of full screening participation compared to White women (AOR 3.35; 95% CI 1.92-12.17). Immigration status did not have a statistically significant association with concurrent screening patterns. However, compared to immigrants, Canadian-born women were more likely to have partial (AOR 1.02; 95% CI 0.73-1.43) and single (AOR 1.28; 95% CI 0.86-1.91) screening participation, but less likely to have full participation (AOR 0.76; 95% CI 0.51 - 1.13).

Table 5.7: Multivariable multinomial regression of factors associated with full, partial (any 2), single or no cancer screening participation, using 'no screening' as the reference category.

Variable	Full screening participation ***AOR (95% CI)**	Partial (Any 2) screening participation **AOR (95% CI)**	Single screening participation **AOR (95% CI)**
Age			
50-59	1.0 (ref)		
60-69	1.01 (0.78 - 1.28)	0.97 (0.76 - 1.23)	0.86 (0.69 - 1.07)
Household income			
<40k	1.0 (ref)		
$40k - $80k	2.30 (1.70 - 3.10)	1.77 (1.32 - 2.36)	1.84 (1.37 - 2.46)
>$80k	3.15 (2.27 - 4.37)	2.01 (1.47 - 2.75)	2.04 (1.50 - 2.77)
Marital Status			
Single	1.0 (ref)		
Widow/separated/ divorced	1.05 (0.67 - 1.64)	0.95 (0.68 - 1.33)	0.98 (0.69 - 1.39)
Married/Common law relationship	1.11 (0.72 - 1.71)	1.12 (0.79 - 1.58)	0.99 (0.69 - 1.40)
Self-rated health status			
Poor	1.0 (ref)		
Good	2.11 (1.45 - 3.08)	1.36 (0.99 - 1.88)	1.34 (0.94 - 1.91)
Great	3.09 (2.10 - 4.54)	1.74 (1.24 - 2.43)	1.43 (1.03 - 2.00)

Physical activity level			
Inactive	1.0 (ref)		
Moderately active	1.28 (0.91 - 1.80)	1.13 (0.83 - 1.53)	1.16 (0.86 - 1.55)
Very active	1.53 (1.11 - 2.09)	1.22 (0.93 - 1.60)	1.14 (0.88 - 1.48)
Having Regular Healthcare provider			
No	1.0 (ref)		
Yes	9.08 (5.82 - 14.16)	5.12 (3.50 - 7.50)	2.67 (1.99 - 3.58)
Smoking Status			
Daily smoker	1.0 (ref)		
Occasional smoker	4.03 (2.11 - 7.73)	3.45 (1.93 - 6.18)	3.01 (1.71 - 5.32)
Non-smoker	2.85 (1.99 - 4.08)	2.38 (1.84 - 3.08)	1.91 (1.49 - 2.46)
Chronic Health Conditions			
0	1.0 (ref)		
1-3	1.31 (0.99 - 1.74)	1.31 (1.02 - 1.68)	1.30 (0.97 - 1.72)
4+	1.21 (0.81 - 1.81)	1.52 (1.06 - 2.19)	1.73 (1.17 - 2.56)
****Racial identity**			
White	1.0 (ref)		
Asian	0.68 (0.43 - 0.98)	0.49 (0.30 - 0.82)	0.64 (0.38 - 0.89)
Black	3.35 (1.92 - 12.17)	1.68 (0.42 - 6.72)	1.10 (0.25 - 4.84)
Hispanic	0.51 (0.11 - 0.99)	0.66 (0.05 -1.15)	0.69 (0.10 - 1.94)
Other/multi-racial	0.58 (0.25 - 1.35)	0.30 (0.12 - 0.75)	0.43 (0.16 - 1.12)

Immigration Status			
Immigrant	1.0 (ref)		
Canada born	0.76 (0.51 - 1.13)	1.02 (0.73 - 1.43)	1.28 (0.86 - 1.91)

AOR, adjusted odds ratio; CI, confidence intervals, Partial (Any 2) screening, screening participation in any two of breast, cervical or colorectal cancer screening (patterns 2, 3 or 4); Single screening, participation in only one of the three cancer screening programs (patterns 5, 6 or 7).

AOR describes how each variable is related to the odds of participating in all 3, any 2 or at least one screening programs versus no screening participation.

* Adjusted for age, marital status, household income, self-rated health, smoking status, having a regular healthcare provider, racial and immigration status, and number of chronic health conditions.

**Racial identity should be interpreted with caution due to small sample sizes

5.6. Discussion

Drawing from a nationally representative cross-sectional survey data, this study aimed to examine the demographic, health and lifestyle factors associated with CRC screening among eligible women aged 50-69 years who report participation in BC and CC screening. Additionally, we investigated the factors associated with concurrent participation in some or all of the three cancer screening programs. Our findings show that among women eligible for all three cancer screening programs, participation in CRC screening was lower compared to BC and CC screening. While 87% of women participated in at least one screening program, only 27% were up-to-date with all three, and 13% did not participate in any screening.

The lower participation in CRC screening compared to others aligns with evidence from similar studies in other jurisdictions (Dawidowicz et al., 2020; Farr et al., 2022; Ishii et al., 2021; Kregting et al., 2022; McCowan et al., 2019; Njor et al., 2023; Rebolj et al., 2020; Vahabi et al., 2021). This differential participation suggests varying barriers, perceptions, or access issues associated with each screening program (McCowan et al., 2019; Njor et al., 2023; Rebolj et al., 2020; Vahabi et al., 2021). The comparatively lower CRC screening participation rate suggest that CRC screening programs need to understand and address factors contributing to this disparity among women already engaged in other cancer screenings.

Our study shows that age, perception of health status, access to a regular healthcare provider, and immigrant status were factors associated with CRC screening participation among women up-to-date with the other screening programs. Older women (aged 60-69) had higher odds of CRC participation compared to those aged 50-59, potentially due to increased healthcare encounters, cancer risk awareness, and prior exposure to screening processes (Horshauge et al., 2020; Kobayashi et al., 2014; Schoenborn et al., 2019). Women who perceived their health as 'great' were also associated with higher odds of CRC screening, suggesting an optimism bias or greater motivation for preventive care among those perceiving good health (Smith et al., 2019). Access to a regular healthcare provider, a significant enabling factor suggested in the Andersen's Behavioral Model of Health Services Use (Andersen, 1995), was associated with significantly higher odds of CRC screening, highlighting the pivotal role of healthcare providers in recommending and facilitating screening (Zhu et al., 2022). Notably, a significant proportion of women reported their healthcare provider deeming CRC screening unnecessary, warranting further exploration of provider-patient communication and decision-making processes surrounding CRC screening recommendations.

Other factors have been suggested for the comparatively lower participation rates reported for CRC screening. Historically, public health campaigns have strongly focused on BC and CC awareness, while CRC has received less promotion, potentially impacting overall awareness and screening uptake (Wirth et al., 2014). Additionally, the complex nature of CRC screening, with multiple test modalities and procedures that may be perceived as unpleasant (fecal tests) or invasive (endoscopy tests), might contribute to the misconception that CRC screening is less necessary or desirable compared to BC and CC screening (Farr et al., 2022; Hay et al., 2016; Lin et al., 2020; Lo et al., 2013). This remains an important area for future research.

Regarding concurrent screening participation, our findings align with the wide range of rates reported in other jurisdictions, from around 50% in the Netherlands and Denmark to as low as 11.5% in France (Dawidowicz et al., 2020; Ishii et al., 2021; Kregting et al., 2022; McCowan et al., 2019; Njor et al., 2023; Rebolj et al., 2020). This wide variation might be influenced by differences in screening program designs, implementation strategies, and/or socio-cultural factors such as health beliefs, risk perception, and attitudes towards cancer screening (Crawford et al., 2016; Horshauge et al., 2020; Kregting et al., 2022; Lin et al., 2020; Tatari et al., 2020).

Consistent with previous research, lower income was a dominant predictor of lower concurrent screening participation in our study (Dawidowicz et al., 2020; Ishii et al., 2021; Rebolj et al., 2020; Smith et al., 2019). Andersen's model suggests that individuals with lower incomes might face multiple barriers, including differing health beliefs (predisposing factors), limited resources or time constraints (enabling factors), and potentially poorer perceived health status (need factors), all of which can hinder screening participation (Jin et al., 2019a; 2019b). These findings underscore the need for targeted interventions and policy measures to address the social determinants of health and improve access to cancer screening services for underserved populations.

Furthermore, our findings revealed associations between concurrent screening participation and lifestyle factors such as smoking status and physical activity level. This clustering of health behaviors aligns with the notion that individuals who prioritise proactive health choices in one domain might also be more likely to engage in preventive screenings (Hay et al., 2016; Lin et al., 2020). Racial disparities were also observed, with black women showing higher odds of full screening participation compared to White women. This finding, while at odds with some previous research (Adu et al., 2017; Xiong et al., 2010), probably reflects targeted health promotion efforts or cultural values emphasising preventive care among this group. Further investigation, focusing on health beliefs and access within this population group is needed to fully understand these dynamics. Conversely, Asian women had lower odds of concurrent participation, consistent with previous research highlighting potential cultural, linguistic, or systemic barriers faced by this demographic (Alam et al., 2022; Sun et al., 2010).

Our findings underscore the complex interplay of socioeconomic, cultural, and healthcare system factors influencing cancer screening behaviour among Canadian women. While income emerged as a dominant predictor, other factors such as health perceptions, lifestyle choices, racial identity, and access to healthcare providers are also important. Targeted interventions addressing these multifaceted barriers, coupled with culturally tailored health promotion strategies and improved provider-patient communication, could help bridge the gap in (concurrent) cancer screening participation. It is also noteworthy that a sizable group of women did not participate in any of the screening programs. Understanding whether this non-participation is a result of informed decision-making or a failure of the screening programs to reach this population would significantly inform promotion and educational interventions to promote wider participation in preventive cancer screening.

5.6.1. Implications for Policy and Practice

- Leveraging Screening Programs: The findings suggest that participation in one cancer screening program, especially the more popular ones like BC/CC screening, increases the likelihood of participation in other screening programs. Therefore, policymakers could consider leveraging each screening program as an opportunity to promote overall screening participation. This could involve integrated outreach strategies, such as providing information about other recommended screenings or combined reminders during existing screening appointments or outreach efforts.

- Addressing Socioeconomic Barriers: The pronounced role of income in screening participation underscores the need for policies and interventions that target structural inequities and barriers faced by individuals from lower socioeconomic backgrounds. Initiatives such as subsidised transportation, community-based screening drives in disadvantaged areas, or targeted outreach programs could help bridge this gap and improve access to screening services.
- Cultural Sensitivity and Tailored Strategies: The observed racial disparities highlight the importance of culturally sensitive policies and practices. Tailored communication strategies, collaborations with community leaders, and outreach efforts that resonate with diverse populations can enhance receptivity and participation. Particular attention should be given to developing strategies that address potential cultural or systemic barriers faced by Asian Canadian women.
- Understanding Non-participants: Emphasis should be placed on research to understand the motivations, barriers, or decision-making processes of women who do not participate in any screening program. Insights from such studies could inform more targeted and effective public health

strategies, addressing whether non-participation is due to informed choice or failures in the screening programs' reach.

- Public Health Education and Awareness: Given the influence of personal health perceptions on screening behavior, public health campaigns should emphasise not only the importance of screenings but also broader health consciousness. These campaigns can demystify misconceptions, highlight the benefits of early detection, and promote preventive care regardless of current health status.

5.6.2. Strengths and Limitations

The main strength of this study lies in the broad representativeness of the Canadian Community Health Survey (CCHS) data analysed. The CCHS collects data from a wide and diverse cross-section of Canadians. The study examined screening participation across a wide range of sociodemographic and ethnic groups, as well as investigated factors associated with participation in multiple screening programs, providing a comprehensive picture of cancer screening behaviour among Canadian women.

However, the study has several limitations. Firstly, the CCHS relies on respondents' self-reports, which may be subject to recall biases, misinterpretations, or social desirability bias, where respondents may present themselves in a certain way. Additionally, while the study excluded women who might not fall into the 'average risk' category, the CCHS does not collect adequate information to ensure the exclusion of all individuals who may not meet the criteria for preventive cancer screening, such a history of CRC diagnosis. Furthermore, the small sample sizes for certain racial and immigrant groups may limit the generalizability of findings specific to these populations, and these results should be interpreted with caution.

5.7. Conclusion

This study demonstrates that while a large proportion of Canadian women have participated in at least one of the three major cancer screening programs, CRC screening uptake remains notably lower compared to BC and CC screening. Furthermore, concurrent participation in all three screening programs is suboptimal, with rates lower than those reported in some European countries with similar healthcare structures. The observed disparities in screening participation across socioeconomic and demographic factors underscore the importance of addressing structural inequities in healthcare access and the need for a culturally responsive public health approach. The interconnected nature of these screenings offers a promising avenue for integrated public health initiatives, such as holistic screening programs that leverage participation in one screening to promote involvement in others.

Enhancing cancer screening uptake among Canadian women requires a comprehensive, culturally informed, and collaborative approach. Given the crucial role of early detection in improving cancer outcomes, improving screening rates is of paramount significance for public health in Canada. Targeted interventions, tailored outreach strategies, and concerted efforts to address systemic barriers and promote health education are essential to ensure equitable access to preventive cancer screenings across all segments of the Canadian population.

6. Chapter Six: Summary and Conclusions

Chapter Six: Summary and Conclusions

6.1. Thesis Overview

CRC is perhaps one of the cancers most amenable to prevention and early diagnosis (Tung, et al., 2018). In the last few decades, effective, non-invasive, and inexpensive screening tests have been developed for CRC screening, and organised public health screening programs have been established and promoted in most jurisdictions (Adhikari et. al., 2022; Araghi, et al., 2019; Andersen et al., 2019). Nonetheless, CRC remains a significant public health concern in Canada, representing the third most commonly diagnosed cancer and a leading cause of cancer-related morbidity and mortality (Brenner et al., 2022). There are also concerning trends like increasing incidence among younger adults and projected future increases due to aging populations (Brenner et al., 2017; O'Sullivan et al., 2022; Ruan et al., 2023).

While organised CRC screening programs in the country seem to have contributed to higher screening rates (Singh et al., 2015; Darvishian et al., 2023) and potentially, declining CRC incidence over the past decade (Kalyta et al., 2023; Levin et al., 2018), studies evaluating CRC screening participation rates, and associated factors, at the national level have been sparse. (Kalyta et al., 2021; 2023). This thesis aimed to contribute to filling these gaps by leveraging data from the CCHS to shed light on the effect of organised provincial screening programs on CRC screening participation, particularly in the Atlantic provinces, assess disparities in CRC screening across the country, and evaluate the various factors influencing participation in CRC and concurrent cancer screening.

Drawing from three different but related studies, this thesis provides a broad evaluation of CRC screening participation in Canada in line with the specific thesis objectives set out in chapter one. The first study assessed the effect of organised provincial CRC screening programs in Atlantic Canada on screening participation rates, comparing participation rates and associated factors before and after the establishment of these programs (Paper 1). The second study examined the state of CRC screening participation across Canada, analysing sociodemographic and racial disparities in screening uptake, and identifying associated factors influencing participation (Paper 2). The third study investigated patterns of concurrent participation in BC, CC, and CRC screening among Canadian women, and identified factors associated with concurrent participation in multiple screening programs (Paper 3). Collectively, these studies shed light on the persistent disparities in CRC screening participation across various socioeconomic, demographic, and cultural groups in Canada.

This final chapter summarises key findings from the three studies included in this thesis. It provides a synthesis of key findings using the Andersen Behavioral Model as a framework to interpret and contextualise the findings (Alkhawaldeh et al., 2023; Andersen, 1995). Building on this discussion, the chapter outlines practical implications, including what the Covid-19 pandemic could mean for these findings, highlights the contribution to the body of knowledge on screening behaviours and uptake, and suggests implication for policy and practice, and suggested directions for future research.

6.2. Summary of Findings

The following sections highlight the key findings and the main conclusions from the three studies included in this thesis.

6.2.1. Paper 1: Summary of Findings and Conclusions

The study found a notable increase in CRC screening participation in the Atlantic provinces between 2010 and 2017, following the implementation of organised provincial screening programs. Overall, the proportion of people up-to-date with CRC screening increased from 42% to 54.5% on average but fell short of the national target of 60%. However, the magnitude of this increase differed between the provinces. NB and NS recorded the most significant changes, showing the potential effect of organised screening programs on CRC screening participation.

The study observed a nuanced shift in screening test preferences, with a significant increase in fecal test participation from an average of 19.6% in 2010 to 32.4% in 2017 and a decline in uptake of endoscopy tests. This aligns with the emphasis on fecal tests as the primary screening modality promoted through the CRC screening programs. However, this shift also varied across provinces.

Despite the overall increase in screening, disparities persist. Factors such as age, sex, socioeconomic status (specifically, household income and educational level), health status and lifestyle behaviours such as smoking, continued to influence screening participation. Notably, there was a lower rate of screening among those in their 50s, a demographic that could potentially benefit more from early cancer detection. Additionally, self reported barriers to participation in CRC screening highlight the perception among some that such tests are unnecessary. It also highlights experiences where healthcare providers might be perceived to be discouraging screening. These findings emphasise sociodemographic factors, attitudinal barriers and the role of health care professional as areas requiring attention.

Given these findings, three main conclusions can be drawn from this paper. One, the implementation of organised CRC screening programs in the Atlantic provinces seems to have contributed to positive change in screening participation rates. However, variation in the magnitude and nature of this change underscores the multifaceted determinants of health service utilisation. Factors such as promotional and recruitment strategies of the screening programs, coupled with broader sociodemographic factors, could influence this observed variability in screening uptake across provinces.

Two, despite the positive change in screening, the study found persistent inequalities in CRC screening participation across the Atlantic provinces, particularly related to age, income, education levels, and health status. These disparities, especially among younger adults and those facing socioeconomic disadvantages, are concerning as they represent populations that could potentially benefit more from early cancer detection. The disparities reflect the broader global health challenge of ensuring equitable access to health resources and the multifaceted factors that influence preventive health decisions and behaviors.

The study also highlighted the need to address misconceptions and attitudes toward CRC screening, as a notable segment of respondents deemed the tests unnecessary or reported feeling discouraged by their healthcare providers. Employing frameworks like the Health Belief Model to inform targeted health education materials, emphasising the severity of CRC, and the crucial role of early detection could potentially change these perceptions and improve screening participation.

Overall, the findings underscore the importance of continuous evaluation and adaptation of screening programs to meet the evolving health landscape and address persistent disparities in the Atlantic provinces. Interventions that cater to the diverse needs of different demographic groups and address challenges specific to age, sex, socioeconomic status and geographic distribution are crucial for reducing the burden of CRC in the region.

6.2.2. Paper 2: Summary of Findings and Conclusions

The study found that overall CRC screening participation in Canada has increased since the broader implementation of organised screening programs across the country. However, there were notable variations in screening rates across provinces. AB and MB reported the highest screening participation, while NL reported the lowest in the country.

The study also found screening disparities along socioeconomic, geographical, and racial/ethnic lines. Higher income, higher education, being White, and being a non-immigrant were all associated with higher likelihood of CRC screening participation. These findings confirm that the health equity issue found in paper 1 prevails across the country. Similarly, provinces with longer-established screening programs tend to report higher overall screening participation. However, this did not explain all the provincial variations in screening participation levels, especially in the Atlantic region. Other province-specific factors could potentially explain or affect screening participation.

A key finding from this study is that immigrant and minority ethnic groups, especially those from South-East Asia and South Asia report significantly lower participation in CRC screening. This study also highlighted the misconceptions and attitudes toward CRC screening with notable proportions of respondents reporting that their healthcare provider deems CRC screening as 'unnecessary'. This suggests the need for better alignment between screening guidelines and provider-patient communication.

Again, three main conclusions can be drawn from these findings. While the study suggests CRC screening participation rates are improving in Canada, potentially due, in part, to widespread implementation and promotion of organised screening programs, significant disparities persist. The study draws particular attention to the lower CRC screening rates among immigrant and minority ethnic groups, especially those from South-East Asia and South Asia, across the country. These disparities suggest that screening programs are not 'silver bullets' and must be accompanied by interventions that address specific barriers faced by different socioeconomic, geographic, and racial/ethnic groups to achieve equity and improve screening participation population-wide. The role of healthcare providers in influencing CRC screening behaviour also needs careful attention. Efforts are needed to ensure consistent messaging and proactive recommendation of screening within healthcare settings.

As projected increase in cancer incidence in Canada amplifies the urgency to improve CRC screening rates (Ruan et al., 2023), the findings from this study underscore the need for efficient, inclusive, and targeted strategies to address disparities among different demographic groups.

6.2.3. Paper 3: Summary of Findings and Conclusions

The study found that participation in CRC screening was lower than that of BC and CC screening among Canadian women, even among those who participate in both BC and CC screening programs. Only about a quarter (27%) of women were up-to-date with all three screenings, while 13% did not participate in any, suggesting substantial room for improvement in concurrent screening participation.

Among women who participate in BC and CC screenings, CRC screening was more likely in those who were older (60-69 years old), had higher self-perceived health status, had a regular healthcare provider, and were not immigrants. Income emerged, again, as a strong and consistent factor associated with concurrent screening participation. Individuals with lower income were significantly less likely to participate in full, partial, or even single screening compared to those in higher income brackets. This association further strengthens the argument for socioeconomic disparities in access and/or uptake of screening, with lower-income individuals potentially facing financial barriers, logistical challenges, and/or possibly, lower prioritisation of preventive health services.

The study also found that individuals with 'good' or 'great' self-rated health had higher engagement in full screening participation compared to those reporting 'poor' health, suggesting that those perceiving themselves as healthy might be more motivated to engage in preventive care or vice versa. Women with a regular healthcare provider had significantly higher odds of participating in all variations of screening programs, underscoring the crucial role of primary care providers in recommending preventive screenings.

Additionally, health behaviors such as physical activity and non-smoking seemed to cluster with greater engagement in screening, indicating that those who prioritise one aspect of healthy living may be more receptive to preventive care practices overall. Racial disparities were also observed, with Black women having higher odds of full screening, while Asian women were less likely to be up-to-date, pointing to potential cultural, systemic, or communication-related barriers specific to certain racial groups.

The main conclusions from this study are similar and strengthens findings from the previous two studies. This study further shows that socioeconomic factors, individual health perceptions, lifestyle choices, racial/ethnic identity, and access to healthcare all influence cancer screening behaviour, possibly in a complex interplay. The association between income and screening participation again underscores the need to address social determinants of health and ensure equitable access to screening services.

The findings show opportunities to improve CRC screening participation even among women already engaging in other cancer screening programs, suggesting that strategies are needed to help improve CRC screening within this 'screen-aware' group. Strategies such as targeted interventions aimed at increasing overall health awareness, addressing socioeconomic barriers, and designing culturally sensitive outreach to different racial and ethnic groups could improve CRC, as well as concurrent screening participation.

6.3. Synthesis of Key Findings

Collectively, the findings from the three studies in this thesis provide a broad understanding of the multifaceted landscape of CRC screening participation in Canada, highlighting both apparent progress and persistent challenges. The Andersen Behavioral Model (Andersen model) provides a valuable framework for interpreting and contextualizing these findings, as it outlines the complex interplay of predisposing characteristics, enabling resources, and need factors that shape health services utilisation, such as cancer screening participation (Andersen, 1995; Alkhawaldeh et al., 2023; Jin et al., 2019).

The influence of predisposing characteristics on CRC screening participation was evident across the three studies. Consistent with the Andersen model, older age was associated with higher screening uptake, likely due to increased perceived susceptibility and recognition of the need for screening (Chan et al., 2022). However, the first study's finding of decreased screening among those in their fifties suggests a potential disconnect between perceived risk and benefit in this age group. While this highlight the need for targeted interventions to address this potential knowledge or perception gap among this age group, it could also result from informed decision making, especially since CRC screening recommendations for people aged 50-59 is based weak evidence.

Similarly, socioeconomic disparities, that is, income and education levels, consistently emerged as significant barriers to CRC screening participation. Lower socioeconomic status was associated with lower screening rates, reflecting the potential effect of financial constraints, limited health literacy, and potentially negative attitudes or beliefs about screening, on screening participation (Alkhawaldeh et al., 2023; Lee et al., 2019; Jin et al., 2019). These findings underscore the importance of addressing socioeconomic inequities and providing targeted support to lower-income populations to equitably improve screening rates (Adu et al., 2017).

Additionally, findings from the second study highlight the disparities in screening rates among immigrant and racial/ethnic minority groups, particularly those from

South Asia and Southeast Asia. This shows the influence of cultural beliefs and attitudes towards health and preventive care on screening behaviour. The Andersen model emphasises the role of these predisposing characteristics in shaping an individual's perceptions of disease risk, and consequently, their tendency to seek healthcare (Alkhawaldeh et al., 2023; Babitsch et al., 2012). Also, the third study found that while women generally have higher participation in BC and CC screening, CRC screening participation lags, particularly for those who are immigrants or from Asian communities. This suggests that predisposing factors like cultural beliefs and attitudes may affect participation across different cancer screening programs differently.

Enabling resources play a crucial role in facilitating CRC screening participation (Lee et al., 2019; Jin et al., 2019). The consistent association between higher income and increased screening participation across all three studies showed the importance of financial resources as an ‘enabler’ of access to healthcare services (Jin et al., 2019; Chan et al., 2022). Moreover, access to a regular healthcare provider and, potentially, higher chances of provider recommendation for screening, emerged as strong facilitators of CRC screening uptake. Again, this highlights the importance of healthcare systems and provider-patient communication as ‘enablers’ of access to and utilisation of preventive healthcare services and the role of healthcare providers as ‘gatekeepers to the healthcare system (Davis; et al., 2018).

The first study's finding of positive change in CRC screening rate between 2010 and 2017 in the Atlantic provinces suggest that the implementation of organised screening programs has contributed positively to CRC screening participation, particularly with the increased uptake of fecal tests. This underscores the role of structural-level interventions, such as organised programs, in creating enabling environments for screening uptake (Chan et al., 2022). However, geographical disparities in screening rates within provinces in the region, indicate that the reach and effectiveness of these programs could vary. This could be due to differences in program promotion, recruitment strategies, or variations in how individuals and healthcare providers perceive and discuss screening needs (Davis; et al., 2018; Inadomi et al., 2021).

Need, conceived to encompass both 'perceived' and 'evaluated' need in the Andersen model, also plays a significant role in health service utilisation, such as CRC screening participation (Alkhawaldeh et al., 2023; Lee et al., 2019). The first and second studies highlight the influence of perceived need, with a notable proportion of individuals who have no screening history reporting their perception of CRC screening as unnecessary. This underscores the importance of addressing misconceptions and promoting awareness of the benefits of screening through targeted education and outreach efforts (Lee et al., 2019).

The third study found that participation in CRC screening was lower than that of BC and CC screening among Canadian women, even among those who participate in breast and cervical cancer screening programs. Only about a quarter (27%) of women were up-to-date with all three screenings, while 13% did not participate in any, suggesting substantial room for improvement in concurrent participation in multiple cancer screenings. The disparity in participation rates, even among women already engaged in other cancer screenings, suggests that the perceived need for CRC screening may differ from that of other cancer screenings.

This could be due to various factors, such as differences in perceived risk, knowledge about the disease and screening procedures, or cultural beliefs and attitudes towards different types of cancer (Almadi et al., 2015; Shi et al., 2020). The higher participation in BC and CC screening programs could also be because these two programs have been in existence for much longer, and consequently more established. BC and CC screening programs have been the subject of wide-ranging and long running awareness and education campaigns. If this long-running and established nature of BC and CC screening programs play important roles in screening participation rates, then a move towards integrated screening programs could be one way to ensure newer or future cancer screening programs benefit from the experience and uptake of more established programs.

Overall, the findings from these three studies, when interpreted through the lens of the Andersen model, provide a good understanding of the factors influencing CRC screening participation in Canada. They highlight the complex interplay of predisposing characteristics, enabling resources, and need, emphasising the need for multifaceted interventions that address both individual-level and system-level barriers to screening. By tailoring interventions to the specific needs and challenges of different population groups, healthcare providers, program administrators and policymakers can work towards achieving equitable access to CRC screening and ultimately reduce the burden of this preventable disease.

6.3.1. Implications of Findings for Screening Policy and Practice

The findings from these studies have several practical implications for cancer screening policies and programs in Canada:

1. Addressing socioeconomic disparities: The strong association between income and screening participation rates underscores the need for policies and programs that address the social determinants of health, especially within the most vulnerable population groups.
2. Strengthening primary care systems: Given the critical role of healthcare providers in recommending and facilitating screening, policies should focus on strengthening primary care systems and ensuring that providers have the necessary resources and training to effectively communicate with

patients about cancer screening guidelines and the importance of early detection.

3. Culturally tailored outreach and health promotion: The observed disparities among certain racial and ethnic minority groups, as well as immigrants, highlight the need for culturally tailored outreach and health promotion strategies. This could involve collaborating with community leaders, translating educational materials into multiple languages, and employing culturally relevant messaging to address potential misconceptions or cultural barriers (Inadomi et al., 2021).

4. Targeted interventions for specific age groups: The findings indicating reduced CRC screening participation among younger eligible adults (those in their 50s) suggest the need for targeted interventions and messaging tailored to this age group – especially in the light of projected/increase in early-onset CRC cases (O'Sullivan et al., 2022) and changing screening guidelines in other jurisdictions to capture younger adults (Kalyta et al., 2021). Public health campaigns should emphasise the importance of early detection and preventive measures, even for those who perceive themselves as healthy and/or young.

5. Integrated screening programs: Given the substantial proportion of women who participate in BC and CC screenings but do not undergo CRC screening, policies and programs should explore strategies to promote

integrated screening services. This could involve co-locating screening facilities, streamlining appointment scheduling, or implementing coordinated reminder systems for all recommended cancer screenings (Tangka et al., 2022).

6. Continuous evaluation and adaptation: Cancer screening programs should incorporate regular evaluation and monitoring mechanisms to identify emerging trends, disparities, and barriers to participation. This will allow for the timely adaptation of policies and interventions to address evolving needs and ensure equitable access to screening services across diverse population groups.

Drawing from the practical implications for screening policies and practice highlighted above and from the broader literature on effective interventions, some evidenced-based interventions that could include be implemented to improve CRC screening participation in Canada include:

1. Patient navigation and care coordination: Patient navigation programs can help address barriers related to access, communication, and navigation of the healthcare system and are already in place, to some extent, in most screening programs (Canadian Partnership Against Cancer, 2020). These could be expanded such that trained patient navigators can provide individualised support, coordinate appointments, facilitate communication

with healthcare providers, and assist with addressing logistical challenges, such as transportation or language barriers.

2. Community-based outreach and education: Collaborating with community organisations, faith-based groups, and trusted leaders can enhance the reach and effectiveness of educational campaigns. Culturally tailored and linguistically appropriate educational materials and outreach efforts can help address misconceptions, increase awareness, and promote CRC screening among diverse communities (Davis; et al., 2018; Inadomi et al., 2021).
3. Provider reminders and decision support systems: Implementing provider reminder systems, decision support tools, and clinical decision aids can help ensure that healthcare providers consistently recommend and facilitate CRC screening for eligible patients. These tools can also assist providers in addressing potential barriers or concerns raised by patients (Davis; et al., 2018).
4. Tailored patient reminders: Personalised reminders and navigation support can be effective in promoting screening participation. This could involve sending tailored reminders via mail, phone, or electronic platforms/apps, as well as providing assistance with scheduling appointments or addressing logistical barriers (Brouwers et al., 2011; Inadomi et al., 2021).

5. Reducing structural barriers: Interventions aimed at reducing structural barriers, such as providing extended clinic hours and offering mobile screening units in underserved or remote areas can help increase access to CRC screening services, particularly for populations facing socioeconomic challenges (Inadomi et al., 2021; Sharma et al., 2022).
6. Targeting misconceptions and knowledge gaps: Tailored and targeted health awareness/education campaigns that emphasise the importance of screening and address anxieties associated with screening procedures and/or outcome. Such health awareness campaign must provide clear, accessible information through media that offers the most engagement for specific population groups (Inadomi et al., 2021).

It is important to emphasise that no single intervention will be universally effective. Interventions and strategies must be tailored to local needs, specific sub-populations, and the practical realities of the local healthcare system. They should also combine several different strategies—with patient navigation being a particularly effective strategy among others (Canadian Partnership Against Cancer, 2021). Pilot testing and rigorous evaluation of interventions are vital to determine their impact and to identify areas for refinement. Ultimately, a combination of carefully tailored and evidence-based initiatives that address systemic barriers, increase awareness, empower healthcare providers, and prioritise equitable access will be crucial for achieving the full potential of CRC screening in improving the health of all Canadians.

6.4. The Covid-19 Pandemic and Screening Participation

The COVID-19 pandemic has had a profound impact on healthcare systems globally, disrupting routine preventive services, including cancer screening programs (Yong et al., 2021). The findings from these studies, which were based on CCHS survey data from prior to the pandemic, may have been affected by the widespread disruptions caused by COVID-19.

One of the most significant impacts of the pandemic was from the temporary suspension or scaling back of non-essential healthcare services, including cancer screening programs, in order to prioritise resources for the COVID-19 response (Yong & Garner, 2021). This disruption in service delivery led to a substantial decrease in CRC screening rates, as well as other cancer services, especially during the peak periods of the pandemic (Domper-Arnal et al., 2022; Mazidimoradi et al., 2022). Even though restrictions have eased considerably, factors such as fear of exposure to the virus, reluctance to visit healthcare facilities, and ongoing staffing shortages may continue to pose barriers to screening participation (Nascimento de Lima et al., 2023).

Furthermore, the economic consequences of the pandemic, including job losses, financial insecurity, and increased poverty rates, may have exacerbated existing socioeconomic disparities in access to healthcare services, such as cancer screening. Individuals facing economic hardships may have been forced to prioritise more immediate needs over preventive care, further widening the gap in screening participation among lower-income populations (Nascimento de Lima et al., 2023).

The pandemic also highlighted the vulnerability of certain population groups, such as racial and ethnic minorities, immigrants, and individuals with underlying health conditions, who experienced disproportionately higher rates of COVID-19 infection and adverse outcomes (Mazidimoradi et al., 2022). These same groups may have faced additional barriers to accessing cancer screening services during the pandemic, potentially exacerbating the disparities identified in our findings using pre-pandemic data.

Additionally, the widespread disruption to routine healthcare services and the overwhelming focus on COVID-19 may have impacted provider-patient communication and the prioritisation of cancer screening recommendations. Healthcare providers may have been stretched thin, with limited capacity to engage in comprehensive discussions about cancer screening during the pandemic Yong et al., 2021.

On the other hand, the pandemic also brought heightened awareness of the importance of preventive healthcare and the potential consequences of delayed diagnoses and treatment (Walker et al., 2021; Yong et al., 2021). This heightened awareness, coupled with the adoption of telehealth and remote monitoring technologies, could potentially lead to increased demand for and access to cancer screening services in the post-pandemic era.

Furthermore, the collective experience of the pandemic may have altered individual health beliefs and attitudes towards preventive care, either positively or negatively (Nascimento de Lima et al., 2023). While some individuals may have developed a greater appreciation for early detection and preventive measures, others may have experienced pandemic-related trauma or financial hardships that could negatively impact their willingness or ability to prioritise preventive health care like cancer screening.

As the healthcare system continues to recover from the pandemic, it will be crucial to reassess and adapt cancer screening programs to address the evolving needs and barriers faced by different population groups. Strategies to address COVID-19-related disruptions, such as catch-up campaigns, mobile screening units, and targeted outreach efforts, may be necessary to ensure equitable access and improve CRC screening rates (Domper-Arnal et al., 2022; Decker et al., 2022; Mazidimoradi et al., 2022).

Continuous monitoring and evaluation will be essential to understand the long-term impacts of the pandemic on cancer screening behaviors, identify emerging disparities, and develop tailored interventions to mitigate the adverse effects of the pandemic on preventive care services.

6.5. Recommendations for Future Research

This thesis provides a multifaceted examination of the challenges affecting CRC screening uptake and the opportunities to improve it. However, as this is an evolving field, several areas warrant further research to deepen our understanding and strengthen strategies for addressing low and inequitable cancer screening participation, particularly for CRC.

1. Regional Variations in Screening Behavior: Future studies should investigate the underlying causes of regional disparities in CRC screening rates across Canada. A closer look at local policies, healthcare infrastructure, community awareness programs, and even cultural attitudes towards preventive health could reveal key drivers and potential best practices. Comparative studies between high- and low-performing regions can also provide valuable insights for developing targeted interventions and improving overall screening rates.

2. In-Depth Exploration of Racial and Sociodemographic Disparities: While this thesis examined sociodemographic and racial disparities at a national level, deeper, qualitative research is needed to understand the specific barriers faced by minority and immigrant populations in accessing CRC screening. Personal interviews, focus groups, and community surveys could reveal nuanced cultural, linguistic, or systemic obstacles. Longitudinal studies tracking changes in screening rates over time in relation to evolving demographics could also provide valuable insights.
3. Effectiveness of Integrated Screening Programs**:** Given the correlation between participation in different screening programs, research should investigate the effectiveness of integrated or bundled screening programs that combine CRC screening with other cancer screenings. Pilot programs and randomised controlled trials could assess the impact on uptake and health outcomes. Additionally, understanding the behavioral reasons behind why individuals choose to participate in certain screenings but not others could inform the design of more effective integrated programs.
4. Communication and Education Strategies: To address misconceptions about the value and necessity of CRC screening, rigorous evaluation of different communication strategies is needed. This research could encompass digital campaigns, community outreach, provider training, and the use of culturally tailored interventions. Understanding how different

messaging resonates with diverse populations is crucial for increasing screening awareness and uptake.

5. The Impact of the COVID-19 Pandemic: The COVID-19 pandemic caused significant disruptions to healthcare systems worldwide, including screening programs. Future research should investigate the extent to which the pandemic impacted CRC screening participation in Canada, including delays, missed appointments, and potential long-term consequences. Understanding the specific barriers and facilitators to screening during and after the pandemic could inform strategies to mitigate future disruptions and ensure timely access to lifesaving preventive care.

Addressing these research gaps could considerably improve our understanding of the multifaceted barriers to cancer screening uptake. By informing the development of more effective, equitable, and tailored strategies and interventions, we can improve CRC screening participation and, ultimately, contribute to better health outcomes for all Canadians.

6.6. Concluding Remarks

This thesis aimed to advance the understanding of CRC screening participation in Canada. Through examination of regional variations, racial and sociodemographic disparities, and the patterns of multiple cancer screenings, this thesis offers a multifaceted perspective of the challenges and opportunities to improve CRC screening uptake. The use of nationally representative data ensure the findings and recommendations are relevant for both practical and policy-oriented interventions.

A key strength of this work lies in its nuanced approach. By investigating CRC screening from multiple angles, the research reveals the complex interplay of factors influencing screening behavior. It highlights regional differences, demographic disparities, and behavioral patterns, providing a comprehensive view of the Canadian CRC screening landscape.

In terms of practical contributions, this study has significant implications for healthcare providers, public health practitioners, and policymakers. The findings emphasise the need for population-specific strategies and interventions, considering the unique demographic and healthcare infrastructure of each region. The study also underlines the importance of culturally sensitive and inclusive approaches to health communication and education, particularly for minority and immigrant populations who are less likely to participate in CRC screening. Furthermore, the exploration of concurrent cancer screenings opened a new avenue in cancer prevention strategies, suggesting that integrated screening programs could be key to enhancing overall screening rates.

The policy implications of this study are equally worth mentioning. The examination of regional disparities and sociodemographic factors in CRC screening provides policymakers with an understanding of where and how to direct resources and efforts. The recommendations for targeted interventions and communication strategies, informed by the research findings, can guide the formulation of more effective health policies. Moreover, the call for data-driven decision-making and continuous monitoring underlines the importance of evidence-based policy in public health.

Academically, this thesis contributes to the existing body of knowledge on cancer screening. It not only adds to our understanding of the complexities surrounding CRC screening but also offers a model for examining other types of cancer screenings, especially the multi-dimensional analyses of the various factors affecting screening behaviors, using large, representative datasets and diverse methodology. This thesis represents a significant stride forward in our understanding of CRC screening in Canada. Its comprehensive approach, relevant findings, and practical recommendations contribute to the fields of public health and preventive cancer care and provide a roadmap for practical and policy-oriented applications aimed at improving cancer screening rates and, ultimately, public health outcomes.

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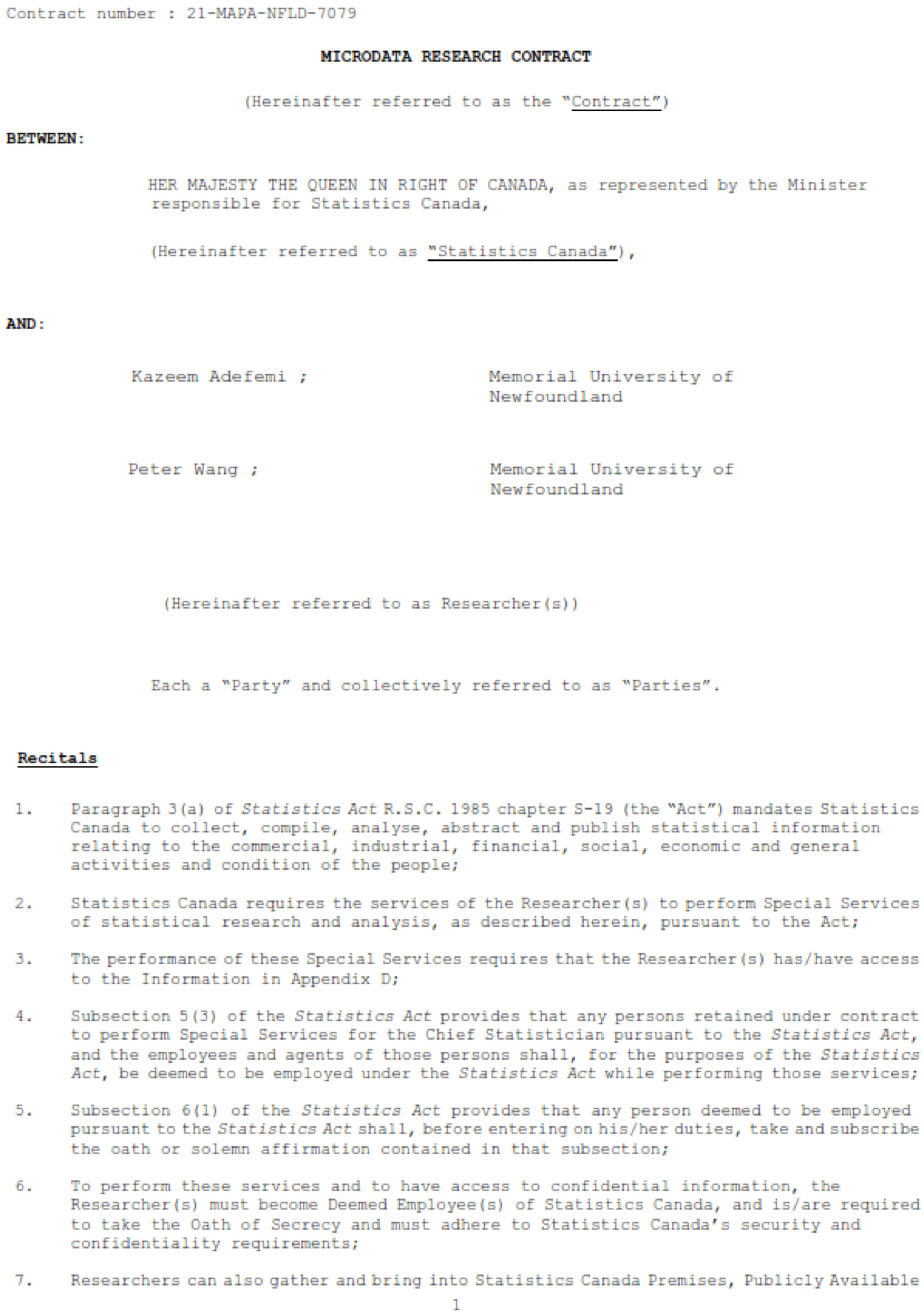
Appendix A: Research Contract/Approval for CCHS Data



Contract number : 21-MAPA-NFLD-7079

MICRODATA RESEARCH CONTRACT

(Hereinafter referred to as the "Contract")

BETWEEN:

HER MAJESTY THE QUEEN IN RIGHT OF CANADA, as represented by the Minister responsible for Statistics Canada,

(Hereinafter referred to as "Statistics Canada"),

AND:

Kazeem Adefemi ;	Memorial University of Newfoundland
Peter Wang ;	Memorial University of Newfoundland

(Hereinafter referred to as Researcher(s))

Each a "Party" and collectively referred to as "Parties".

Recitals

1. Paragraph 3(a) of *Statistics Act* R.S.C. 1985 chapter S-19 (the "Act") mandates Statistics Canada to collect, compile, analyse, abstract and publish statistical information relating to the commercial, industrial, financial, social, economic and general activities and condition of the people;

2. Statistics Canada requires the services of the Researcher(s) to perform Special Services of statistical research and analysis, as described herein, pursuant to the Act;

3. The performance of these Special Services requires that the Researcher(s) has/have access to the Information in Appendix D;

4. Subsection 5(3) of the *Statistics Act* provides that any persons retained under contract to perform Special Services for the Chief Statistician pursuant to the *Statistics Act*, and the employees and agents of those persons shall, for the purposes of the *Statistics Act*, be deemed to be employed under the *Statistics Act* while performing those services;

5. Subsection 6(1) of the *Statistics Act* provides that any person deemed to be employed pursuant to the *Statistics Act* shall, before entering on his/her duties, take and subscribe the oath or solemn affirmation contained in that subsection;

6. To perform these services and to have access to confidential information, the Researcher(s) must become Deemed Employee(s) of Statistics Canada, and is/are required to take the Oath of Secrecy and must adhere to Statistics Canada's security and confidentiality requirements;

7. Researchers can also gather and bring into Statistics Canada Premises, Publicly Available

1

Information required for the purpose of this Contract;

8. The Proposed Output and all materials (excluding Other Source Data) brought into Statistics Canada premises (which includes Research Data Centres) by Researcher(s) pursuant to the execution of the Special Services will be subject to the *Access to Information Act*, R.S.C., 1985, c. A-1 and the *Privacy Act*, R.S.C., 1985, c. P-21;

9. Administrative Data brought into Statistics Canada premises by Researcher(s) pursuant to the execution of the Special Services will be subject to the confidentiality provisions of subsection 17(1) of the Act and subsection 24(1) of the Access to Information Act;

10. Statistics Canada wishes to establish the terms and conditions under which the Researcher(s) is/are retained to perform Special Services for the Minister pursuant to the *Statistics Act*, notably to ensure the appropriate use and the protection of the confidentiality of the Information to which the Researcher(s) may have access during the performance of these Special Services;

NOW THEREFORE the Parties agree as follows:

1. DEFINITIONS AND INTERPRETATIONS

1.1 Definitions

In this Contract, a capitalized term has the meaning given to it in this section, unless the context indicates otherwise:

"Administrative Data"
For the purpose of this contract, Administrative Data means information that is collected by other organizations and departments of governments and individuals for their own purposes and is brought onto Statistics Canada's premises by a Deemed Employee and sought at the micro or aggregate level by Statistics Canada in respect to the objects of the Statistics Act solely for the purpose of the Special Services. It excludes Publicly Available Information and data held by an individual.

"Deemed Employee"
Deemed Employee means any person, not currently an employee of Statistics Canada, retained to perform Special Services for Statistics Canada pursuant to the *Statistics Act*, for which access to Information protected by the *Statistics Act* is required in order to perform the Special Services.

"Information"
Information means the confidential identifiable microdata provided to Researcher(s) by Statistics Canada and listed in Appendix D, pursuant to this Contract, and statistical aggregates thereof that could directly or indirectly identify a Person.

"Person"
Person means an individual, a corporation incorporated under any Act of Canada or a province or territory, a partnership, an association or an unincorporated business.

"Personal Identifiers"
Personal Identifiers refers to information that may lead to the direct identification of an individual.

"Proposed Output"
Proposed Output means output/work created by Deemed Employee(s) as a result of providing Special Services outlined in Appendix C.

"Publicly Available Information"
Publicly Available Information means data obtained from the internet, as well as data obtained under licence with or without a fee, and can be made available

to any member of the public under a licence agreement. Publicly Available Information is not brought into Statistics Canada under the Act.

"Special Services"
Refers to statement of work described in Appendix C.

"Statistics Canada Premises"
Statistics Canada Premises refers to a building or part of a building designated as Statistics Canada premises. This includes all Statistics Canada Research Data Centres.

1.2 Interpretation of Appendices

This Contract contains the following Appendices, which form an integral part of this contract:

(a) Appendix A – Security Requirements
(b) Appendix B – Operational Requirements
(c) Appendix C – Description of Special Services to be provided to Statistics Canada by Researcher(s)
(d) Appendix D – Information and related documentation provided to Researcher(s)
(e) Appendix E – Documents to be provided to Researcher(s)
(f) Appendix F – Conflict of Interest Declaration Form
(g) Appendix G – Administrative Data Metadata

In case of inconsistency or conflict between a provision contained in the part of the Contract preceding the signatures and a provision contained in any of the appendices, the provision contained in the part of the Contract preceding the signatures will prevail.

2. STATEMENT OF WORK

2.1 The Researcher(s) is/are hereby retained to perform the Special Services as documented in Appendix C, for the Minister pursuant to the *Statistics Act*.

2.2 Special Services shall consist of carrying out the research project and in providing the Proposed Output as described in Appendix C, in accordance with the requirements contained in this Contract.

3. INFORMATION ACCESSED BY DEEMED EMPLOYEE(S)

Subject to this Contract, Statistics Canada shall grant Deemed Employees access to the Information required to perform Special Services for Statistics Canada.

4. TERMS AND CONDITIONS OF ACCESS TO THE MICRODATA

4.1 Subject to the terms and conditions contained in this section and the Security Requirements in Appendix A as well as the Operational Requirements in Appendix B, Statistics Canada will provide access to the Information to the Researcher(s) for the purpose of performing the Special Services.

4.2 Such access will be provided only to the extent necessary, at Statistics Canada's discretion, for the performance of the Special Services.

4.3 Such access will only be provided on Statistics Canada premises and using equipment provided and/or specifically designated by Statistics Canada.

4.4 The Researcher(s) acknowledge and agree that, in order to have and maintain access to the Information, the Researcher(s) shall comply with the following pre-access requirements:

4.4.1 Having been granted at minimum, a "Reliability" security status as defined in the federal Policy on Government Security;

4.4.2 Having taken the oath of office, as required by section 6 of the *Statistics Act;*

4.4.3 Having read, understood and will comply with the relevant Statistics Canada policies, directives, guides and guidelines listed in Appendix E;

4.4.4 Having read, understood and will comply with the *Values and Ethics Code for the Public Sector*, Statistics Canada Code of Conduct and the Directive on Conflict of Interest listed in Appendix E;

4.4.5 Having declared in Appendix C:

4.4.5.1 That the sole purpose of the research project is statistical research,

4.4.5.2 The sources of monetary or in kind support they are receiving to carry out the Research Project;

4.4.6 The Researcher(s) understand the potential penalties should they contravene the terms and conditions of access to the Information and the penalties should the Researcher(s) contravene the *Statistics Act* and any applicable related Acts, including the *Income Tax Act* or the *Excise Tax Act*.

5. LIMITATIONS ON USE OF INFORMATION

5.1 The Researcher(s), in the course of carrying out this Contract, may not use any of the information gained by accessing the Information for any other purpose except that which was agreed upon in this Contract.

5.2 Access to the Information is being provided for the statistical and research purpose outlined in the Statement of Work in Appendix C.

5.3 The Researcher(s) shall not disclose any of the Information to anyone other than current Statistics Canada employees involved in the review or evaluation of any aspect of the research project or to other Deemed Employees who have been approved for the same Special Services and therefore are also authorized to have access to the same Information.

5.4 The Researcher(s) shall ensure that no attempts are made to link the Information supplied herein to any other files in order to relate the particulars to any identifiable Person.

6. PENALTIES

As Deemed Employees of Statistics Canada, and having taken the oath/solemn affirmation of secrecy set out in section 6 of the *Statistics Act*, Researcher(s):

6.1 Remains/Remain subject to the oath/solemn affirmation of secrecy even after the term of the Contract has ended.

6.2 Is/are subject to all the applicable penalties provided for in the *Statistics Act* for contravention of any of the confidentiality provisions and are liable on summary conviction to any of the applicable fines or imprisonment terms.

6.3 Is/are prohibited from disclosing information related to any Person (subsection 17(1) of the *Statistics Act*) obtained under the *Statistics Act*. Researcher(s) contravening subsection 17(1) of the *Statistics Act* is/are guilty of an offence and liable on summary conviction to a fine not exceeding one thousand dollars or to imprisonment for a term not exceeding six months or to both (paragraph 30(c) of the *Statistics Act*).

6.4 Is/are prohibited from disclosing confidential information obtained through the course of their employment that might exert an influence on or affect the market value of any stocks, bonds or other security or any product or article, or using the same information to speculate in any stocks, bonds or other security or any product or article (section 34 of the *Statistics* Act). Researcher(s) contravening section 34 of the *Statistics Act* is/are guilty of an offence and liable on summary conviction to a fine not exceeding five thousand dollars or to imprisonment for a term not exceeding five years or to both.

6.5 Is/are reminded that if they are accessing data from sources other than Statistics Canada, in accordance to this Contract, then they are subject to all the applicable penalties provided for in related and applicable laws for contravention of any of the confidentiality provisions and are liable on summary conviction to any of the applicable fines or imprisonment terms.

7. OWNERSHIP AND COPYRIGHT OF INFORMATION

7.1 Statistics Canada is the owner and/or steward of the Information and related documentation listed in Appendix D and Parties agree that this Contract pertains to the use of the Information and related documentation to produce the Proposed Output for Statistics Canada. Nothing contained herein shall be deemed to convey any title or ownership interest in the Information or the related documentation to the Researcher(s).

7.2 Statistics Canada is also the steward of Administrative Data and all associated documentation, as well as Publicly Available Information brought onto Statistics Canada Premises by Researcher(s).

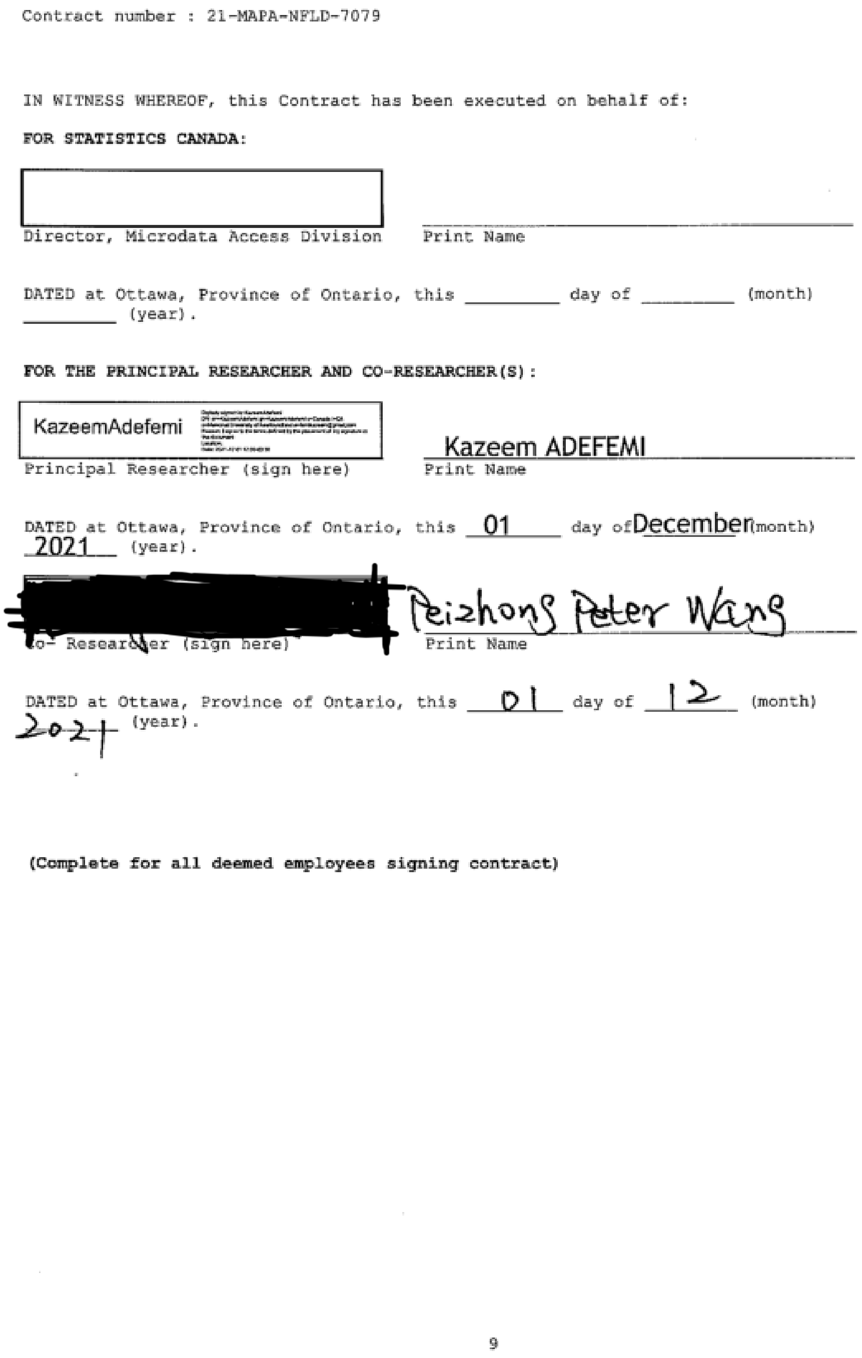
7.3 Copyright in the Proposed Output shall vest in Her Majesty the Queen in Right of Canada. The Researcher(s) may be required to provide to Statistics Canada, at the completion of the Contract, or at such other time as Statistics Canada may require; a written permanent waiver of Moral rights from every author who contributed to the Proposed Output.

7.3 Copyright in any subsequent work created by the Researcher(s) using the Proposed Output shall vest in the Researcher(s).

8. USE OF AND PUBLISHING OF PROPOSED OUTPUT

8.1 Release of the Proposed Output by Statistics Canada may be considered by Statistics Canada in consultation with the Principal Researcher.

8.2 Statistics Canada reserves the right:



Contract number : 21-MAPA-NFLD-7079

IN WITNESS WHEREOF, this Contract has been executed on behalf of:

FOR STATISTICS CANADA:

Director, Microdata Access Division ______ Print Name

DATED at Ottawa, Province of Ontario, this ______ day of ______ (month) ______ (year).

FOR THE PRINCIPAL RESEARCHER AND CO-RESEARCHER(S):

KazeemAdefemi

Principal Researcher (sign here) Kazeem ADEFEMI Print Name

DATED at Ottawa, Province of Ontario, this 01 day of December (month) 2021 (year).

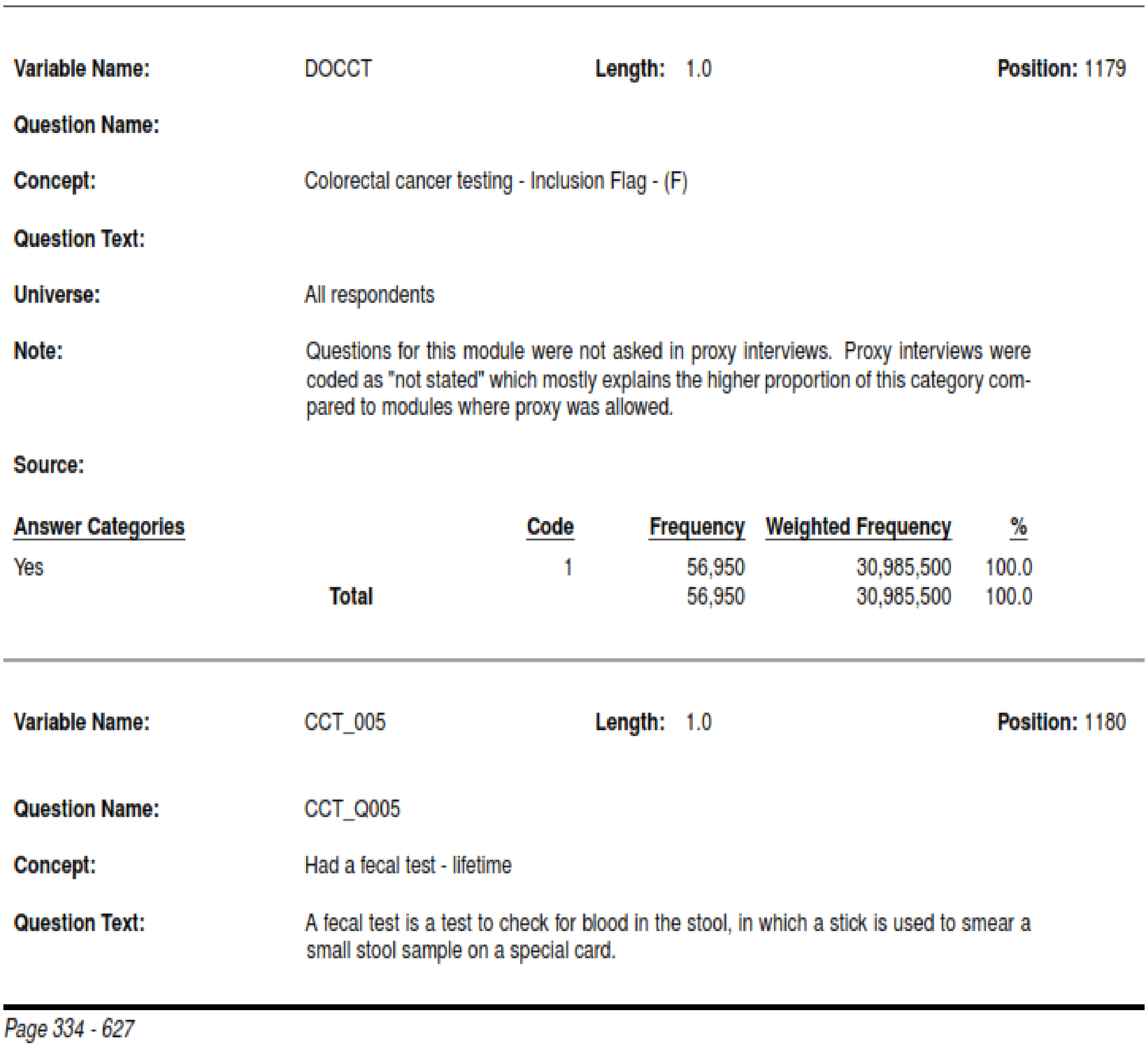
[redacted]

Co- Researcher (sign here) Peizhong Peter Wang Print Name

DATED at Ottawa, Province of Ontario, this 01 day of 12 (month) 2021 (year).

(Complete for all deemed employees signing contract)

Appendix B: CRC Module/Questionnaire in CCHS



Variable Name: DOCCT **Length:** 1.0 **Position:** 1179

Question Name:

Concept: Colorectal cancer testing - Inclusion Flag - (F)

Question Text:

Universe: All respondents

Note: Questions for this module were not asked in proxy interviews. Proxy interviews were coded as "not stated" which mostly explains the higher proportion of this category compared to modules where proxy was allowed.

Source:

Answer Categories		Code	Frequency	Weighted Frequency	%
Yes		1	56,950	30,985,500	100.0
	Total		56,950	30,985,500	100.0

Variable Name: CCT_005 **Length:** 1.0 **Position:** 1180

Question Name: CCT_Q005

Concept: Had a fecal test - lifetime

Question Text: A fecal test is a test to check for blood in the stool, in which a stick is used to smear a small stool sample on a special card.

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Have you ever had this test?

Universe: Respondents aged 40 to 74 with DOCCT = 1

Note: Was not asked in proxy interviews

Source:

Answer Categories		**Code**	**Frequency**	**Weighted Frequency**	**%**
Yes		1	16,100	7,310,000	23.6
No		2	14,050	7,947,500	25.6
Valid skip		6	26,000	15,186,000	49.0
Don't know		7	200	121,500	0.4
Refusal		8	50	80,000	0.3
Not stated		9	500	340,500	1.1
	Total		56,950	30,985,500	100.0

Variable Name: CCT_010 **Length:** 1.0 **Position:** 1181

Question Name: CCT_Q010

Concept: Fecal test - last time

Question Text: When was the last time?

Universe: Respondents aged 40 to 74 who answered CCT_005 = 1

Note: Was not asked in proxy interviews

Source:

Answer Categories		**Code**	**Frequency**	**Weighted Frequency**	**%**
6 months ago or less		1	3,150	1,420,500	4.6
More than 6 months to 1 year ago		2	3,600	1,685,500	5.4
More than 1 year to 2 years ago		3	3,350	1,529,000	4.9
More than 2 years to 5 years ago		4	3,200	1,433,500	4.6
More than 5 years ago		5	2,550	1,158,500	3.7
Valid skip		6	40,050	23,133,500	74.7
Don't know		7	200	81,500	0.3
Refusal		8	0	1,000	0.0
Not stated		9	750	542,000	1.7
	Total		56,950	30,985,500	100.0

Variable Name: CCT_015A **Length:** 1.0 **Position:** 1182

Question Name: CCT_Q015

Concept: No fecal test - 2 yrs - lack of time

Question Text: What are the reasons you did not have a fecal test [in the past 2 years]?
- Lack of time

Universe: Respondents aged 50 to 74 who answered CCT_005 = 2 or (CCT_005 = 1 and CCT_010 = (4 or 5))

Note: Was not asked in proxy interviews

Source:

Answer Categories		Code	Frequency	Weighted Frequency	%
Yes		1	550	273,500	0.9
No		2	12,400	5,891,000	19.0
Valid skip		6	42,850	24,182,500	78.0
Don't know		7	350	135,500	0.4
Refusal		8	0	1,000	0.0
Not stated		9	850	502,000	1.6
	Total		56,950	30,985,500	100.0

Variable Name: CCT_015B **Length:** 1.0 **Position:** 1183

Question Name: CCT_Q015

Concept: No fecal test- 2 yrs - no access to test

Question Text: What are the reasons you did not have a fecal test [in the past 2 years]?
- No access to test (distance, clinic hours or cost)

Universe: Respondents aged 50 to 74 who answered CCT_005 = 2 or (CCT_005 = 1 and CCT_010 = (4 or 5))

Note: Was not asked in proxy interviews

Source:

Answer Categories		Code	Frequency	Weighted Frequency	%
Yes		1	100	41,000	0.1
No		2	12,850	6,123,500	19.8
Valid skip		6	42,850	24,182,500	78.0
Don't know		7	350	135,500	0.4
Refusal		8	0	1,000	0.0
Not stated		9	850	502,000	1.6
	Total		56,950	30,985,500	100.0

Variable Name: CCT_015C **Length:** 1.0 **Position:** 1184

Question Name: CCT_Q015

Concept: No fecal test- 2 yrs - respondent did not think necessary

Question Text: What are the reasons you did not have a fecal test [in the past 2 years]?
- Respondent did not think it was necessary

Universe: Respondents aged 50 to 74 who answered CCT_005 = 2 or (CCT_005 = 1 and CCT_010 = (4 or 5))

Note: Was not asked in proxy interviews

Source:

Answer Categories	Code	Frequency	Weighted Frequency	%
Yes	1	4,200	1,803,000	5.8
No	2	8,750	4,361,500	14.1
Valid skip	6	42,850	24,182,500	78.0

Answer Categories		Code	Frequency	Weighted Frequency	%
Don't know		7	350	135,500	0.4
Refusal		8	0	1,000	0.0
Not stated		9	850	502,000	1.6
	Total		56,950	30,985,500	100.0

Variable Name: CCT_015D **Length:** 1.0 **Position:** 1185

Question Name: CCT_Q015

Concept: No fecal test- 2 yrs - doctor did not think necessary

Question Text: What are the reasons you did not have a fecal test [in the past 2 years]?
- Doctor did not think it was necessary/ he never brought it up

Universe: Respondents aged 50 to 74 who answered CCT_005 = 2 or (CCT_005 = 1 and CCT_010 = (4 or 5))

Note: Was not asked in proxy interviews

Source:

Answer Categories		Code	Frequency	Weighted Frequency	%
Yes		1	5,200	2,682,500	8.7
No		2	7,750	3,482,000	11.2
Valid skip		6	42,850	24,182,500	78.0
Don't know		7	350	135,500	0.4
Refusal		8	0	1,000	0.0
Not stated		9	850	502,000	1.6
	Total		56,950	30,985,500	100.0

Variable Name: CCT_015E **Length:** 1.0 **Position:** 1186

Question Name: CCT_Q015

Concept: No fecal test- 2 yrs - fear / discomfort

Question Text: What are the reasons you did not have a fecal test [in the past 2 years]?
- Feelings of fear or discomfort

Universe: Respondents aged 50 to 74 who answered CCT_005 = 2 or (CCT_005 = 1 and CCT_010 = (4 or 5))

Note: Was not asked in proxy interviews

Source:

Answer Categories		Code	Frequency	Weighted Frequency	%
Yes		1	250	98,000	0.3
No		2	12,700	6,066,500	19.6
Valid skip		6	42,850	24,182,500	78.0
Don't know		7	350	135,500	0.4
Refusal		8	0	1,000	0.0
Not stated		9	850	502,000	1.6
	Total		56,950	30,985,500	100.0

Note: Was not asked in proxy interviews

Source:

Answer Categories		Code	Frequency	Weighted Frequency	%
It was the first time		01	2,500	1,262,500	4.1
More than once a year		02	250	107,500	0.3
Every year		03	2,250	1,046,000	3.4
Every 2 years		04	2,950	1,281,000	4.1
Less than once every 2 years		05	500	227,500	0.7
No fixed frequency		06	1,650	702,500	2.3
Valid skip		96	45,850	25,726,000	83.0
Don't know		97	200	86,500	0.3
Refusal		98	0	3,000	0.0
Not stated		99	750	543,000	1.8
	Total		56,950	30,985,500	100.0

Variable Name: CCT_025 **Length:** 1.0 **Position:** 1193

Question Name: CCT_Q025

Concept: Had sigmoidoscopy / colonoscopy - lifetime

Question Text: A sigmoidoscopy and a colonoscopy are two tests in which a tube is inserted into the rectum in order to detect signs of cancer or other health problems.
A colonoscopy examines the entire colon, while a sigmoidoscopy only examines the first section of the colon. The sigmoidoscopy requires less preparation.
Have you ever had either one of these tests?

Universe: Respondents who answered CCT_005 = (1, 2 or 7) and CCT_015 = (1, 2, 3, 4, 5, 6, 8, 9, 96, 97 or 98)

Note: Was not asked in proxy interviews.
If a respondent answered CCT_015 = 7, the variable CCT_025 was given the value of 1.

Source:

Answer Categories		Code	Frequency	Weighted Frequency	%
Yes		1	12,850	5,964,500	19.2
No		2	17,400	9,330,000	30.1
Valid skip		6	26,000	15,186,000	49.0
Don't know		7	100	76,500	0.2
Refusal		8	0	8,000	0.0
Not stated		9	550	420,500	1.4
	Total		56,950	30,985,500	100.0

Variable Name: CCT_030A **Length:** 1.0 **Position:** 1194

Question Name: CCT_Q030

Concept: No sigmoidoscopy / colonoscopy - lack of time

Question Text: What are the reasons you have not had these tests?
- Lack of time

Variable Name: CCT_030F **Length:** 1.0 **Position:** 1199

Question Name: CCT_Q030

Concept: No sigmoidoscopy / colonoscopy - no doctor

Question Text: What are the reasons you have not had these tests?
- Don't have a doctor

Universe: Respondents aged 50 to 74 who answered CCT_025 = 2

Note: Was not asked in proxy interviews

Source:

Answer Categories	Code	Frequency	Weighted Frequency	%
Yes	1	350	157,000	0.5
No	2	11,200	5,330,500	17.2
Valid skip	6	44,650	24,995,500	80.7
Don't know	7	200	86,500	0.3
Refusal	8	0	3,000	0.0
Not stated	9	600	412,500	1.3
Total		56,950	30,985,500	100.0

Variable Name: CCT_030G **Length:** 1.0 **Position:** 1200

Question Name: CCT_Q030

Concept: No sigmoidoscopy / colonoscopy - had a fecal test

Question Text: What are the reasons you have not had these tests?
- Had a fecal test instead

Universe: Respondents aged 50 to 74 who answered CCT_025 = 2

Note: Was not asked in proxy interviews.
If CCT_005 <> 1 this category was not an available option.

Source:

Answer Categories	Code	Frequency	Weighted Frequency	%
Yes	1	650	282,000	0.9
No	2	10,850	5,205,500	16.8
Valid skip	6	44,650	24,995,500	80.7
Don't know	7	200	86,500	0.3
Refusal	8	0	3,000	0.0
Not stated	9	600	412,500	1.3
Total		56,950	30,985,500	100.0

Variable Name: CCT_030H **Length:** 1.0 **Position:** 1201

Question Name: CCT_Q030

Concept: No sigmoidoscopy / colonoscopy - did not know it existed

Variable Name: PAADVWHO **Length:** 1.0 **Position:** 825

Question Name:

Concept: Physically active based on WHO guidelines - (D)

Question Text:

Universe: See documentation on derived variables.

Note:

Source: Derived from DHH_AGE, PAADVVOL

Answer Categories	Code	Frequency	Weighted Frequency	%
Active	1	20,150	11,656,000	37.6
Moderately active	2	8,250	4,831,000	15.6
Somewhat active	3	10,950	5,838,000	18.8
Sedentary	4	11,650	5,641,500	18.2
Valid skip	6	4,400	2,235,000	7.2
Not stated	9	1,550	784,000	2.5
Total		56,950	30,985,500	100.0

Variable Name: PAADVMON **Length:** 1.0 **Position:** 826

Question Name:

Variable Name: SMK_005 **Length:** 1.0 **Position:** 549

Question Name: SMK_Q005

Concept: Type of smoker (daily / occasionally / not at all) - presently

Question Text: At the present time, do you smoke cigarettes every day, occasionally or not at all?

Universe: Respondents with DOSMK = 1

Note:

Source:

Answer Categories	Code	Frequency	Weighted Frequency	%
Daily	1	7,400	3,577,000	11.5
Occasionally	2	2,400	1,429,000	4.6
Not at all	3	47,100	25,966,500	83.8
Don't know	7	0	2,500	0.0
Refusal	8	0	10,500	0.0
Total		56,950	30,985,500	100.0

Variable Name: SMK_010 **Length:** 1.0 **Position:** 550

Question Name: SMK_Q010

Concept: Smoked - 30 d

Variable Name: SDCDVCGT **Length:** 2.0 **Position:** 1810

Question Name:

Concept: Cultural / racial background - (D)

Question Text:

Universe: See documentation on derived variables.

Note:

Source: Derived from SDC_015, SDC_020A, SDC_020B, SDC_020C, SDC_020D, SDC_020E, SDC_020F, SDC_020G, SDC_020H, SDC_020I, SDC_020J, SDC_020K, SDC_020L

Answer Categories	Code	Frequency	Weighted Frequency	%
White only	01	46,450	22,387,500	72.3
South Asian only	02	1,200	1,405,000	4.5
Chinese only	03	1,300	1,203,000	3.9
Black only	04	850	828,000	2.7
Filipino only	05	700	708,500	2.3
Latin American only	06	450	476,500	1.5
Arab only	07	450	416,000	1.3
Southeast Asian only	08	300	351,000	1.1
West Asian only	09	150	168,500	0.5
Korean only	10	150	151,500	0.5
Japanese only	11	100	74,500	0.2
Other racial or cultural origin (only)	12	550	433,000	1.4
Multiple racial or cultural origins	13	850	723,000	2.3
Valid skip	96	2,850	1,132,000	3.7
Not stated	99	600	528,000	1.7
Total		56,950	30,985,500	100.0