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Five-Year Experience of Nationwide Implementation of Colorectal Cancer Screening in Sweden

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ABSTRACT

Background: Colorectal cancer (CRC) is a major health concern. In Sweden, a CRC screening program was implemented nationwide between 2019 and 2022. This study evaluated participation, colonoscopy adherence, and diagnostic outcomes for the program's first five years.

Methods: The target group of screening was all residents 60–74 years old. Data were retrieved from SveReKKS, the Swedish national quality register for CRC screening and colonoscopies. A positive FIT test was defined as ≥ 40 μg Hb/g for females, ≥ 80 μg Hb/g in feces for males. Participation, FIT positivity, colonoscopy adherence, quality indicators, and neoplasia detection rates were assessed.

Results: Among 884,866 invitees, the overall participation rate was 64.3%. Participation was higher in older age groups, among females, but lower in regions with low population density. FIT positivity was 2.7%, with no major variation by age or sex. Colonoscopy adherence among FIT-positive individuals was 82%, with lower adherence among men and regional variation. The detection rate for CRC was 6.6%, 29.9% for advanced adenomas and adenocarcinoma, and an overall adenoma detection rate of 49.7%. Quality metrics were high: 98% had adequate bowel preparation, caecal intubation rate was 96%, and the complication rates (bleeding and perforation) were low (0.5% early, 0.7% late).

Conclusion: The first 5 years of the implementation of CRC screening in Sweden demonstrated high participation and excellent diagnostic performance, although colonoscopy adherence fell slightly below the guideline targets. These findings support the effectiveness of FIT-based screening and highlight areas for further improvement, including enhancing colonoscopy uptake among men and in low-density regions.

1 | Introduction

In 2022, colorectal cancer (CRC) was the third most frequently diagnosed cancer worldwide and the second leading cause of cancer death [1], and in 2040, the CRC burden is estimated to have risen to 3.2 million new cases and 1.6 million disease-specific deaths [2]. Colorectal cancer (CRC) is one of the most common cancers in Sweden. According to the Swedish Cancer Registry, in 2023, the age-standardized incidence of colorectal cancer was 108.5 for

For a complete listing of the members of the National Working Group for Colorectal Cancer Screening in Sweden (NWGCRCSS), see Acknowledgements.

Key Summary

- Summarize the established knowledge on this subject
  - The effect of invitation to colorectal cancer (CRC) screening with fecal immunochemical test (FIT) has been demonstrated to be non-inferior to colonoscopy regarding CRC mortality in a recently published pragmatic randomized trial (COLONPREV).
- What are the significant and/or new findings of this study?
  - Sweden's nationwide screening program has been successful. Rigorous planning, including the establishment of the Swedish quality register for colorectal cancer screening and colonoscopies, along with centralized national coordination, has contributed to high participation (64.3%) and excellent detection rates for cancer (6.6%) and adenomas (49.7%). The primary area for improvement is colonoscopy adherence after a positive test (82%), which falls slightly below the guideline targets, especially for men.

males and 83.7 for females per 100,000 inhabitants in Sweden [3].

The primary purpose of CRC screening is to reduce death from the disease by detecting cancer at an early, curable stage. Both larger precursors (adenomas) and cancer may bleed, which enables the detection of occult blood in the stool with fecal occult blood tests (FOBT) before symptoms arise. As removal of adenomas, at follow-up colonoscopy after a positive FOBT, has a protective effect against the development of CRC [4, 5], screening programs have the potential to reduce CRC incidence.

In 2003, the European Commission issued recommendations to screen for CRC with FOBT in men and women aged 50–74 [6], and in 2006, national CRC screening programs started in European countries [7, 8]. The recommendations were based on results from randomized controlled trials (RCT) of population-based screening with guaiac-based FOBT (gFOBT), demonstrating a CRC mortality reduction of approximately 15% [9–11]. In 2022, fecal immunochemical test (FIT) was recommended as the triage screening test for referral of individuals to follow-up colonoscopy [12]. High-quality colonoscopies are essential, and there are numerous quality indicators related to the technical performance of the colonoscopy, for example, adenoma detection rate (ADR), bowel preparation adequacy rate, and rate of caecal intubation [13].

In Sweden, the regions of Stockholm and Gotland (healthcare region Stockholm-Gotland), covering approximately 25% of the Swedish population, initiated a FOBT screening program in 2008, with a gradual expansion of the biennial invitation of all 60–69-year olds [14]. After 14 years of follow-up, the routine screening program demonstrated a CRC mortality reduction in line with the older RCTs [15]. In 2019–2022, the screening program was implemented nationwide in Sweden, including all 60–74 years old.

The aim of this study was to evaluate participation, colonoscopy adherence, and outcomes in the first 5 years of screening in the country.

2 | Material and Methods

2.1 | Study Design and Setting

This was a register study obtaining data from the Swedish quality register for colorectal cancer screening and colonoscopies (SveReKKS) introduced in April 2019. Data entry is prospective and mandatory for screening participants.

In 2014, the Swedish National Board of Health and Welfare issued recommendations on the implementation of colorectal screening [16]. Based on these recommendations, the Regional Cancer Centers (RCC) of Sweden collaborated to write national guidelines for the implementation of colorectal cancer [17]. While the RCC coordinated the overall implementation and centralized key components, such as the invitation process and the analysis of fecal immunochemical tests (FIT), the responsibility for launching and running the screening program lay with each of Sweden's 21 administratively independent health care regions. The regions handled downstream processes, including colonoscopy follow-up for individuals with positive FIT results. Implementation across the country began in 2019, targeting all eligible individuals aged 60 years (based on the Swedish Population Register including all Swedish citizens), and was progressively expanded to additional age groups at different time points through 2022.

Outcomes were registered in the official national database SveReKKS (Supporting Information S1: Figure S1). The outcomes of the ongoing screening program of Stockholm and Gotland were registered in SveReKKS at the start of the registration in April 2019. For this study, only the first colonoscopies registered in SveReKKS for each subject were included. The target group of the program includes all 60–74-year-old residents according to the Swedish population register. The age groups that have been screened vary as not all regions have had the same inclusion time schedule (Supporting Information S1: Figure S2). In the program, FIT tests are sent out biannually for each specified age class and so the age cohort invited reflect that (i.e. the individual is invited every other year and only at specified ages, Supporting Information S1: Figure S2).

2.2 | Invitations and Participation

Screening invitations, sent to individuals' homes, included information on CRC screening, a test-kit of FIT (OC-Sensor [Eiken Chemical Co, Tokyo, Japan]), instructions, and a prepaid return envelope addressed to the laboratory of Karolinska University Hospital, Stockholm, Sweden, where all FIT analyses were performed. Invitees had 6 months to respond to the invitation. Participants with a negative test result, below or equal to the cut-off level of 40 μg Hb/g feces in women and 80 μg Hb/g in men [18], were informed by a letter of the negative result and re-invited in 2 years. This process was centrally coordinated at the national level by the RCC. The use of higher FIT cut-off levels for men was based on previous Swedish studies demonstrating that this approach equalizes the positivity rate and cancer detection rate between sexes [18].

Individuals with a positive FIT result were electronically referred by the RCC for a colonoscopy to the Swedish region where the subject was registered. Participants with incomplete tests received new test-kits and invitees who did not return tests were sent a reminder 8 weeks after the original invitation (Supporting Information S1: Figure S3).

2.3 | Colonoscopies

Each Swedish region was responsible for booking and performing colonoscopies as well as reporting outcomes in SveReKKS. In SveReKKS, the quality indicators recommended by the ESGE guidelines are included [19]. According to the Swedish national screening guidelines, individuals with a positive FIT result were to receive a letter informing them of the finding and providing a telephone number to contact specially trained screening nurses for colonoscopy scheduling. If subjects did not initiate contact, they were to be contacted by telephone, and if they were not reachable, up to two reminder letters were sent to the subject. Colonoscopies were to be carried out within 4 weeks after telephone contact with the patient.

Recommendations regarding objective markers of experience level of the endoscopist performing the screening colonoscopy were as follows: (1) > 1000 colonoscopies performed in total and no less than 150 yearly, (2) adenoma detection rate (ADR) > 25%, (3) caecal intubation rate (CIR) > 90%, and (4) complication rate < 0.1% for diagnostic and < 5% for therapeutic procedures [17].

All identified polyps were intended for removal and histopathological analysis, but the endoscopists were given the option of leaving < 5 mm polyp in the rectosigmoid that had a hyperplastic appearance [17]. The "Resect and Discard" strategy was not permitted according to the colorectal cancer screening guidelines [17]. Of all polyps removed, the three most significant ones were reported in SveReKKS by size, location, method of removal and whether they were sent for histopathological analysis or not. Once histopathological analysis was performed by a certified pathologist, the histopathological diagnosis was registered in SveReKKS, either by the endoscopist himself or personnel designated to do so. Although only the three most significant polyps were recorded, endoscopists were also required to register the total number of polyps found during colonoscopy, and once histopathological analysis was performed to report the number of adenomas and high-grade dysplasia/adenocarcinoma in any of the remaining polyps.

Patients with screen-detected CRC were referred by the endoscopy clinic to the surgical department in Sweden responsible for the course of care of CRC patients. Patients with large, advanced lesions with high-grade dysplasia or early cancer were either removed endoscopically or surgically, depending on local expertise and/or decision by multidisciplinary team conference.

2.4 | Outcomes and Definitions

The main outcomes of the study were colorectal cancer, advanced adenoma and adenocarcinoma (AAA), and adenoma detection rate. Other outcome measures included participation rates, factors associated with FIT- and colonoscopy participation, and colonoscopy quality parameters, for example, CIR, Boston Bowel Preparation Score (BPPS), withdrawal time, early (during colonoscopy) and late (< 7 days from colonoscopy) complications.

Adenomas were defined as and classified by histopathology in SveReKKS as follows: (1) tubular adenomas with low-grade dysplasia, (2) tubular adenomas with high-grade dysplasia, (3) tubulovillous/villous adenomas with low-grade dysplasia, (4) tubulovillous/villous adenomas with low-grade dysplasia, and (5) adenocarcinoma. *Advanced adenomas* were defined as adenomas ≥ 10 mm, or adenomas with tubulovillous/villous component, or adenomas with high-grade dysplasia. The composite outcome of *advanced adenomas and adenocarcinoma (AAA)* was defined according to SveReKKS guidelines [20]. *Adequate BBPS* was defined as six or more on BBPS and not lower than two in any segment.

2.5 | Data Retrieval

Pseudonymized individual data on screening outcomes were retrieved from SveReKKs between April 1st, 2019, and December 31st, 2023. Invitees returning a complete test ≤ 6 months were defined as participants and invitees returning the tests > 6 months after invitation, an incomplete test, or no test, were defined as non-participants. The final data set comprised data regarding; residency, date of invitation, reminder, result of test, referral to colonoscopy, date of colonoscopy, information on center and endoscopist, descriptive information of the colonoscopy procedure, for example, bowel cleaning (BBPS), medications, withdrawal time, size, number, and location of adenomas and/or cancer or other findings, early or late complications of the colonoscopy (e.g., perforation and bleeding or cardio- and cerebrovascular incidents) and histopathological analysis of lesions removed or biopsied.

The study protocol was designed in accordance with the ethical guidelines of the 1975 Declaration of Helsinki. The study was approved by the Swedish Ethical Review Authority (application number: 2024-01125-01). As the study was register-based and utilized fully anonymized, unidentifiable data, the ethical review board waived the requirement for individual informed consent.

2.6 | Statistical Methods

Descriptive statistics for continuous variables are summarized as mean and standard deviation (SD). Categorical variables were summarized as percentages. For key outcome estimates, such as detection rates and odds ratios, we present two-sided 95% confidence intervals (CI) to quantify uncertainty. Age was arbitrarily categorized into 60–64 years, 65–69 years, and 70–74 years. To assess factors associated with participation, a mixed logistic regression model was used, with participation as the dependent variable, age and sex as independent variables and region was entered as a random intercept effect to account for heterogeneity between regions. The intraclass correlation coefficient (ICC) for the region with participation as an outcome was low (0.005), but the region was kept as a random effect to

ensure robustness of standard errors. For assessing variables associated with undergoing colonoscopy after a positive test result (dependent variable), the same fixed and random effects were applied. The ICC for region with colonoscopy rate as outcome was 0.05, indicating non-trivial heterogeneity. Results were presented as odds ratios (OR) with 95% confidence intervals (CI). R (version 4.4.1) and Rstudio (2024.04.2) were used for statistical analysis.

3 | Results

During the study period, 884,866 invitations to screening were sent out and 579,254 tests were turned in. After excluding 7678 (0.87%) tests returned > 6 months after invitation and 2399 (0.27%) incomplete tests, there were 569,177 complete tests that remained, resulting in a national participation rate of 64.3% (Figure 1). The mean age of participants was 62.9 (SD 2.8) and 47.3% were male.

3.1 | Participation

When comparing participants and non-participants, subjects of higher age were more likely to participate in screening, and females were more likely to participate compared to males (Table 1).

Of all fecal tests turned in, 15,244 (2.7%, 95% CI 2.6, 2.7) were positive, with no statistically significant differences observed across age or sex (Table 2). Among the test positives, 47.7% (95% CI 46.9, 48.5) were men and 52.3% (95% CI 51.5, 53.1) women.

3.2 | Colonoscopy Adherence

Among those 15,244 patients with a positive FIT, 82% underwent colonoscopy. The colonoscopy rate varied considerably between regions (65%–93%, Figure 1). Women were more likely to undergo colonoscopy after a positive FIT test compared to males (OR 1.16, 95% CI 1.06, 1.26), but there was no apparent association between age and colonoscopy adherence (Table 3).

3.3 | Outcomes and Quality Measures

Regarding outcomes of colonoscopy, the overall histopathologically verified cancer detection rate was 6.6% (95% CI 6.1, 7.0), AAA detection rate was 29.9% (95% CI 29.1, 30.8.), and the overall adenoma detection rate (ADR) was 49.7% (95% CI 48.8, 50.6), as shown in Figure 2 along with breakdown of detection rates by gender and age.

Regarding other quality indicators, 98% had adequate bowel preparation, the caecal intubation rate was 96%, and 99% reported withdrawal of ≥ 6 min or biopsy/endoscopic therapy during withdrawal. Both early and late complications were rare, 0.5% and 0.7%, respectively (Table 4).

4 | Discussion

The results of the current study indicate that the implementation of the colorectal cancer screening program in Sweden was successful. The participation rate was relatively high, with females and older individuals being more likely to participate.

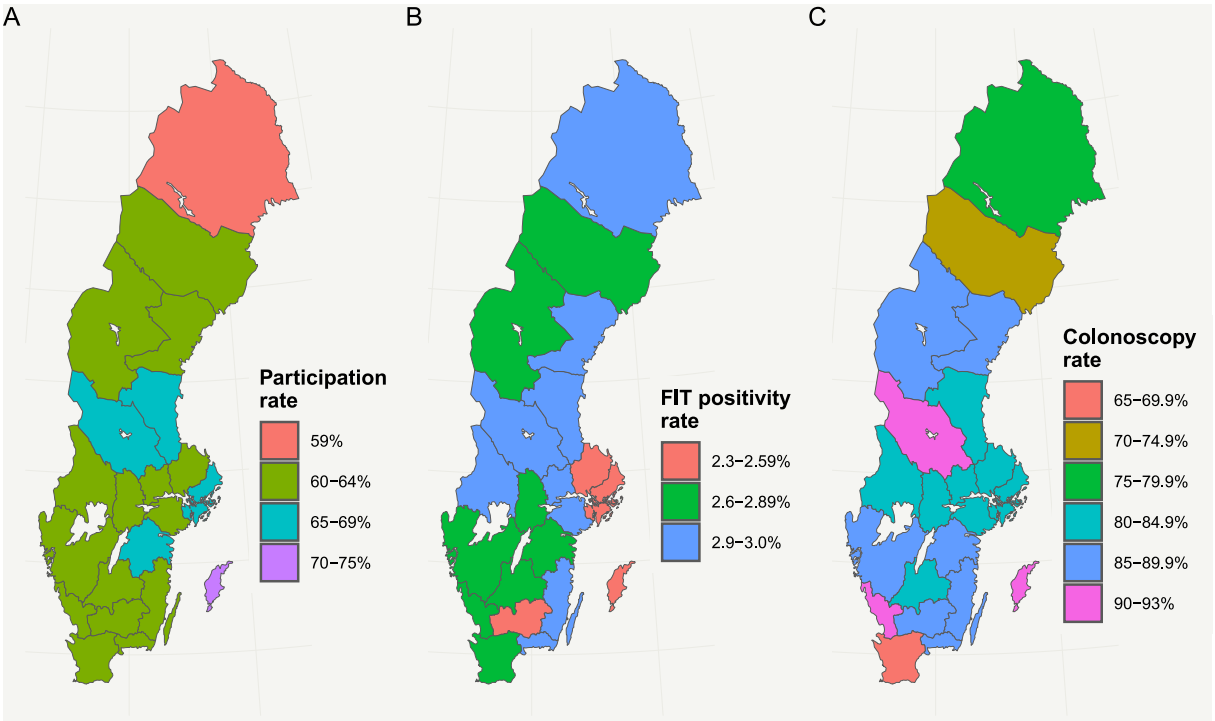

FIGURE 1 | Participation rate (A), fecal immunochemical test (FIT) positivity rate (B) and colonoscopy rate (C) by region in the Swedish colorectal cancer screening program.

TABLE 1 | Comparison of participants and non-participants. Odds ratios (OR) and their 95% CI (confidence intervals) are derived from a mixed logistic regression model with random intercept for region, with participation as outcome and age categories and gender as independent variables.

Characteristic	Non-participant *N* = 315,689	Participant *N* = 569,177	OR (95% CI)
Age			
60–64	254,291 (80.6%)	432,585 (76.0%)	—
65–69	60,492 (19.2%)	131,888 (23.2%)	1.24 (1.23, 1.26)
70–74	908 (0.3%)	4420 (0.8%)	2.42 (2.25, 2.60)
Gender			
Males	173,744 (55.0%)	269,302 (47%)	—
Females	141,947 (45.0%)	299,874 (53%)	1.36 (1.35, 1.37)

TABLE 2 | Positivity rate and their 95% CI (confidence intervals) by age and sex in nationwide CRC screening in Sweden 2019–2023.

Test result	60–64 *N* = 432,859	65–69 *N* = 131,888	70–74 *N* = 4430	Males *N* = 269,302	Females *N* = 299,875
Positive FIT	2.6% (2.5, 2.6)	2.9% (2.9, 3.0)	2.9% (2.4, 3.4)	2.7% (2.6, 2.8)	2.7% (2.6, 2.7)

TABLE 3 | Comparison of those who underwent colonoscopy after a positive FIT test and those who did not in nationwide CRC screening in Sweden 2019–2023. Odds ratios (OR) and their 95% CI (confidence intervals) are derived from a mixed logistic regression model with region as the random intercept effect.

Characteristic	Colonoscopy *N* = 12,496	No colonoscopy *N* = 2748	OR (95% CI)
Age			
60–64	9240 (73.9%)	1988 (72.3%)	—
65–69	3150 (25.2%)	739 (26.9%)	0.94 (0.86, 1.04)
70–74	106 (0.8%)	21 (0.8%)	0.95 (0.59, 1.53)
Gender			
Males	5881 (47.1%)	1387 (50.5%)	—
Females	6615 (52.9%)	1361 (49.5%)	1.16 (1.06, 1.26)

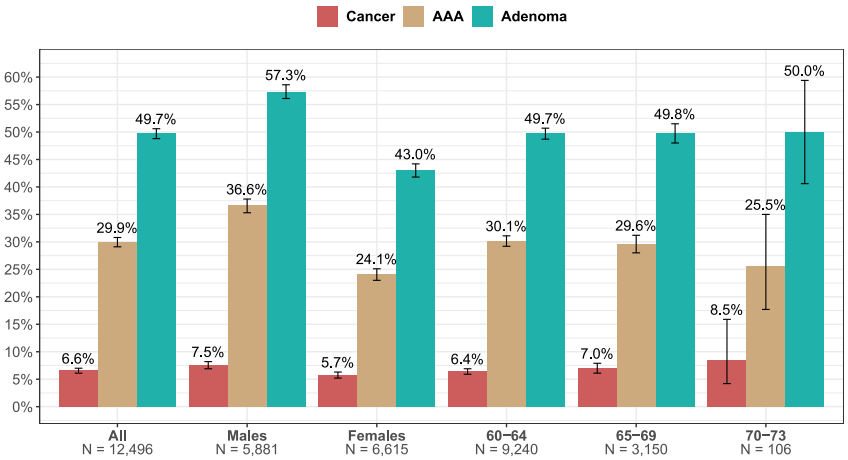

FIGURE 2 | Cancer, advanced adenoma and adenocarcinoma (AAA), and adenoma detection rates in the colorectal cancer screening program of Sweden.

TABLE 4 | Colonoscopy quality indicators but neoplastic findings in population-based CRC screening in Sweden 2019–2023.

Characteristic	$N = 12{,}496$[a]
Split dose bowel prep	12,063 (97%)
Overall Boston ≥ 6 and ≥ 2 in each segment	11,895 (98%)
Unknown	301
Cecal/ileal intubation	12,049 (96.4%)
Cecum	5181 (41%)
Terminal ileum	6868 (55%)
Other according to plan	53 (0.4%)
No	394 (3.2%)
Withdrawal time	
0–5 min	44 (0.4%)
6–9 min	1296 (10%)
≥ 10 min	1977 (17%)
Therapy/biopsy	8635 (72%)
Missing	544
Early complication	60 (0.5%)
Late complication	76 (0.7%)
Missing data	1585

[a]n (%).

Colonoscopy adherence was somewhat limited, with males being less likely to undergo the procedure. High detection rates of pathology were observed and performance on other quality measures was high.

4.1 | Participation Rate

The national participation rate in the Swedish CRC screening program was relatively high at 64.3%, which is in line with European guidelines where a participation rate of > 45% is defined as the minimum acceptable, but > 65% is desirable [21]. Participation rates in other European countries differ significantly from 17–77 [22]. Strategies that were implemented to maximize participation in Sweden included a free FIT test sent directly to the address of each potential participant, reminders were sent out after 8 weeks of non-response, and an effort was made to make the information and instructions for screening simple, visual, and understandable to all groups of society.

Countries in Europe that have even higher participation rates than Sweden include Finland (77%) [23] and the Netherlands (69%) [24]. These countries have employed similar methods to maximize their participation rate. However, they have also made certain efforts that may partly explain higher participation rates compared to Sweden. In Finland, two reminder letters are dispatched, as compared to one in Sweden. The reason for the two reminders is that a pilot study in Finland showed that sending a second reminder letter yielded a 5.2% increase in the participation rate [23]. In the Netherlands, a pre-invitation is sent to subjects notifying them that they will soon receive a formal invitation to undergo CRC screening. This approach is based on results from a randomized controlled trial demonstrating an approximate 3.2% higher participation with a pre-invitation letter compared to a single invitation [25]. Finally, and more speculatively, the different participation rates may partly be explained by cultural differences between the nations.

4.2 | Colonoscopy Adherence Rate

The colonoscopy adherence rate in the Swedish screening program was somewhat lower nationally (82%) than recommended by European- and Swedish guidelines, where 85% is the lower limit but > 90% is desirable; however, it varied between 79%–95% in the different regions [6, 17]. Possible reasons for not undergoing colonoscopy were as follows: (1) the participant did not initiate contact with the colonoscopy unit or was not reachable, and (2) the participant declined invitation to colonoscopy. Possible reasons for the colonoscopy not being registered in SveReKKS were as follows: (1) the participant underwent a colonoscopy at a private clinic (rare as private services are only available in a few Swedish regions), (2) the colonoscopy was not yet registered in SveReKKS, or (3) the colonoscopy was booked but not performed yet at date of data retrieval.

However, despite the suboptimal colonoscopy adherence rate in Sweden, there are few countries that report higher colonoscopy adherence rates in Europe. In Denmark, the reported colonoscopy adherence rate in colorectal cancer screening is approximately 90% [26]. Denmark and Sweden are culturally similar, but an obvious difference lies in population density, and subjects in rural areas have been shown to be less likely to undergo

colonoscopy for screening purposes [27]. Denmark has a population density more than five times higher than Sweden (141 vs. 26 people/km^2) [28]. Considering Sweden's overall lower population density, and particularly the very low density in its northernmost regions (2.5–5.1 people/km^2), where colonoscopy adherence is also low (Figure 1), this demographic factor may partly explain the suboptimal adherence to colorectal cancer screening in Sweden compared to Denmark.

The colonoscopy adherence rate in Slovenia has been reported to be high (> 90%) [29]. As compared to Sweden, the key differences in the Slovenian CRC screening program are that the call center booking colonoscopies is centralized, that subjects can choose which endoscopic center performs the colonoscopy and that the colonoscopy is free of charge [29]. In Sweden, a modest payment of 300 SEK (~30 Euros) is required. These differences suggest potential aspects that could be adjusted in Swedish CRC programs to increase colonoscopy adherence.

The lowest colonoscopy adherence rate was reported in region Skåne (< 70%), the southernmost region in Sweden. When assessing possible explanations for this, population factors that are known to affect screening adherence, that is, proportion of foreign-born residents and education level [30, 31], were compared to regions with higher population density (region Stockholm) and lower (region Västmanland). The regions were similar in these aspects [32], offering no explanation for the low colonoscopy adherence rate in Skåne. The demonstrated regional differences in colonoscopy adherence highlights the need for further studies scrutinizing the reasons for non-adherence to colonoscopy within screening.

4.3 | Detection of Pathology and Other Quality Parameters

The detection rates of colorectal cancer, AAA, and adenoma were high in the current study. The ADR was 50%, well above the general 25% benchmark recommended by the European [6, 19] and Swedish guidelines [17]. However, it is crucial to recognize that the expected ADR in a FIT positive population is substantially higher, but no formal recommendations exist on specific thresholds in Europe [19]. In a study of the screening program in France, a minimum ADR of 55% and desired 70% was proposed in a FIT positive population with a cut-off of 30 μg Hb/g [33]. Identifying the desirable cut-off for FIT is challenging, as cut-offs in colorectal screening programs in Europe vary considerably. Italy, France and Spain use relatively low cut-offs of 20–30 μg Hb/g [33–35], the Netherlands are mid-range with 47 μg Hb/g [36], while the United Kingdom has high cut-offs (80 in Scotland and Wales, 120 in England and Northern Ireland) [37]. Lower cut-off values reduce the risk of missed cancers but increase the number of so-called false positive FITs and the number of colonoscopies performed, thereby placing greater demands on healthcare resources demand even though many examinations yield negative findings [38].

The decision to apply different cut-off values in Sweden was based on earlier studies that demonstrated a lower sensitivity in women (22.4%–32.2%) compared with men (43.2%–52.0%) for detecting cancer using guiaiac-based fecal occult test at the same cut-off level, indicating substantially higher false negative rates among women [39]. Furthermore, positivity rates are unequal for men and women when using the identical FIT cut-offs, but by using the FIT using the sex-specific cut-off levels currently applied in the Swedish colorectal cancer screening program, the positivity rate was shown to be equal in men (2.5%) and women (2.6%) [18]. The proportion of missed cancers among women when using the same cut-off as for men (80 μg Hb/g) has shown to be high in Sweden; more specifically, 23% of screen detected cancers would have been missed [40].

Taken together, the ADR of 50% in the Swedish CRC screening program is high and previous studies indicate that the ADR may lie within reasonable thresholds [33, 41, 42].

Other quality parameters such as caecal intubation rate, withdrawal time, adequate BBPS and complication rates all achieved desirable levels according to European recommendations [19].

4.4 | Factors Associated With Participation and Colonoscopy Adherence

Factors associated with participation in the Swedish CRC screening program included higher age and female gender, in line with previous studies [14]. However, women were also more likely to undergo colonoscopy, but in the majority of European countries, females have similar, or lower, colonoscopy adherence rates compared to males [43]. The explanation for these findings is unclear; one part of the explanation may reflect the sex-specific FIT cut-offs used in the Swedish program. By applying a lower threshold in women (40 μg Hb/g vs. 80 μg Hb/g in men), the positivity rate was equalized across sexes. However, this approach may also select a group of women with relatively lower disease burden and higher health awareness, potentially contributing to higher colonoscopy uptake. It may also be speculated that women are more accustomed to cancer screening, given the long-standing national programs for breast and cervical cancer screening in Sweden. Further studies are required on the subgroups of individuals that are non-adherent to screening in general and to subsequent colonoscopy when FIT-positive.

4.5 | Strengths and Limitations

A main strength of the study is its large sample size, nationwide nature and synchronization, as well as mandatory data entry in SveReKKS. Limitations include that all data regarding colonoscopy and pathology were self-reported by the endoscopist or delegated to local personal. Furthermore, a large size of the sample comes from the regions of Stockholm and Gotland, as they were first to implement screening and by initiation of SveReKKS in 2019, already had the infrastructure and logistics to carry out full-scale screening, which might lead to somewhat skewed results. The SveReKKS registry does not include staging data and therefore stage-shift analysis cannot be carried out. A future linkage between the Swedish Cancer Registry and SveReKKS is planned and will be crucial for evaluating the program's impact on stage-shift and mortality. The registry protocol, which requires reporting only the three most significant polyps

removed, is another limitation. This design was intended to streamline data entry but may lead to an underestimation of the total polyp burden, especially the number of sessile serrated lesions (SSLs) as endoscopists may prioritize reporting adenomas over SSLs. Therefore, analysis of SSLs was not performed. It is worth noting that part of the study period spans the COVID-19 pandemic, which may have affected participation and colonoscopy adherence. Finally, data on complications was missing for approximately 13% of the patients, which may result in falsely low complication rates.

The odds ratios presented in the manuscript should be interpreted as measures of the strength of association; however, they may overestimate the relative risk and results must be interpreted with that in mind [44].

5 | Conclusion

The implementation of colorectal screening in Sweden seems to have been successful with high participation and pathology detection rates. The colonoscopy adherence rates were suboptimal but high in comparison to other countries in Europe. Furthermore, the current study highlights areas for further improvement in the Swedish colorectal cancer screening program. The results of this study and suggestions of potential improvement may provide guidance to optimize population-based colorectal cancer screening programs in other countries.

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Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

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Supporting Information

Additional supporting information can be found online in the Supporting Information section.

Supporting Information S1: ueg270152-sup-0001-suppl-data.docx.