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# Higher adenoma detection, sessile serrated lesion detection and proximal sessile serrated lesion detection are associated with physician specialty and performance on Direct Observation of Procedural Skills

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## ABSTRACT

**Objective** Adenoma detection rate (ADR) and sessile serrated lesion detection rate (SSLDR) vary among physicians. We sought to determine physician characteristics associated with ADR and SSLDR in a population-based colon screening programme.

**Design** Retrospective study of 50–74 year olds with positive faecal immunochemical test and colonoscopy from 15/11/2013 to 31/12/2018. Physician characteristics included: gender, specialty, year and country of medical school graduation, colonoscopy volume and Direct Observation of Procedural Skills (DOPS) performance. Multivariable regression was performed on the following dependent variables: ADR, advanced ADR, proximal and distal ADR, SSLDR, proximal and distal SSLDR.

**Results** 104 326 colonoscopies were performed by 261 physicians. A higher ADR was associated with gastroenterology (OR for general surgery 0.87, 95% CI 0.80 to 0.95; OR for general/family/internal medicine 0.70, 95% CI 0.55 to 0.88), fewer years since graduation (OR for graduation ≥2000 10.48, 95% CI 1.30 to 1.69 compared with <1980) and DOPS performance (OR for lowest DOPS performance 0.64, 95% CI 0.50 to 0.82 compared with highest DOPS performance). SSLDR was associated with gastroenterology (OR for general surgery 0.89, 95%, CI 0.81 to 0.97; OR for general/family/internal medicine 0.67, 95% CI 0.49 to 0.92) and DOPS performance (OR for lowest DOPS performance 0.71, 95% CI 0.51 to 0.99 compared with highest DOPS performance). Proximal SSLDR was associated with gastroenterology (OR for general surgery 0.90, 95% CI 0.82 to 0.99; OR for general/family/internal medicine 0.69, 95% CI 0.50 to 0.97) and DOPS performance (OR for lowest DOPS performance 0.68, 95% CI 0.47 to 0.99).

**Conclusion** Higher ADR, SSLDR and proximal SSLDR was associated with gastroenterology specialty and improved performance on DOPS.

### Summary box

**What is already known about this subject?**

► A physician's adenoma detection rate may be associated with specialty training, volume of colonoscopies performed and years in practice.

**What are the new findings?**

► Physician's adenoma detection rate, sessile serrated lesion detection rate and proximal sessile serrated lesion detection rate are higher with gastroenterology specialty training and improved performance on Direct Observation of Procedural Skills (DOPS).

**How might it impact on clinical practice in the foreseeable future?**

► These results support standardisation of colonoscopy training among specialties and training completion as well as ongoing credentialing based on competency assessment with DOPS.

## INTRODUCTION

Colorectal cancer (CRC) screening, starting at age 50 years is recommended for all individuals to decrease CRC incidence and mortality.[1 2] High-quality colonoscopy is essential to effective CRC screening, whether as the primary test or to follow-up a positive faecal immunochemical test (FIT). Adenoma detection rate (ADR) is a quality indicator of colonoscopy and patients of physicians' with a lower ADR have a higher risk developing and dying from postcolonoscopy CRC.[3 4]

Although the association between patient and procedure-related variables with ADR has been well described in the literature,[5–8] until recently, physician characteristics have been limited to specialty and colonoscopy volume.[9 10] Mehrotra *et al* explored the association between multiple physician characteristics and a composite outcome, which included the detection of CRC, adenoma or serrated lesion in a heterogeneous cohort of

diagnostic and screening colonoscopies.[11] In this study, a higher detection rate was associated with female gender of the endoscopist, a primary specialty of gastroenterology and more recent residency completion. However, these findings were attributed to confounding in a subsequent publication by a different group, who included an expanded set of patient variables to control for potential confounding.[12] Sessile serrated lesion (SSL) detection rate, particularly detection of proximal SSLs, has also been proposed as a colonoscopy quality indicator.[13] Proximal sessile serrated lesion detection rate (SSLDR) was associated with shorter years in practice and higher number of annual colonoscopies performed;[12] however, assessment of the relationship between SSL detection and physician variables has produced inconsistent results.[14] Differences among studies assessing the relationship between physician characteristics and ADR or SSLDR may arise from different definitions of ADR, different inclusion criteria for physicians, different patient populations and uncontrolled confounding within models.

In British Columbia, Canada, the population-based Colon Screening Program (BCCSP) prospectively collects data on participants undergoing colonoscopy to follow-up a positive FIT. Despite a single indication for colonoscopy, a wide range in physicians' ADR has been noted. The objective of this study is to evaluate whether physician characteristics are associated with ADR, advanced ADR and SSL detection rate, both proximal and distal, using standard pathology definitions in a large cohort of patients and physicians. The results of this study may help inform programme initiatives to improve detection rates among physicians performing colonoscopy within BCCSP.

## METHODS

This is a population-based, retrospective, cohort study assessing physician characteristics associated with adenoma and SSL detection.

### Study setting and participants

Colonoscopies performed in the BCCSP to follow-up a positive FIT from 15 November 2013 to 31 December 2018 were included. The BCCSP is available to residents in four of the five provincial health authorities, accounting for 94.5% of the age-eligible population in the province. Men and women, age 50–74 years complete FIT every 2 years and undergo colonoscopy to follow-up a positive FIT result. A quantitative FIT (NS-Plus, Alfresa Pharma, Japan) with a positivity threshold of 10 mcg globin/g stool was used. Patients with a positive FIT are assessed by health authority staff, given a standardised bowel preparation and offered the first available colonoscopy.

Colonoscopies were excluded if there were incomplete data, the cecum was not intubated or the bowel preparation was poor according to the Aronchick scale. Individuals with a personal history of adenomas, a single first degree relative diagnosed with CRC at less than 60 years of age or two or more first degree relatives diagnosed with CRC at any age undergo colonoscopy every 5 years within BCCSP and were not included in this study. Individuals with a personal history of CRC or inflammatory bowel disease are not eligible to participate in the BCCSP.

Physicians performing BCCSP colonoscopies include surgeons, gastroenterologists and internists and family physicians who have completed dedicated colonoscopy training. Trainees do not perform programme colonoscopies. Physicians are strongly encouraged to complete Direct Observation of Procedural Skills (DOPS) for Colonoscopy, but it is not mandatory (online supplemental appendix).

### Variable sources and definitions

The BCCSP maintains an electronic platform of all registered participants. Prospectively entered data includes: patient date of birth, gender, quantitative FIT results, physician performing the colonoscopy, colonoscopy quality indicators, colonoscopy findings and pathology of all specimens removed during colonoscopy.

Physician specialty, gender, year of graduation from medical school and country of medical school were obtained from the College of Physicians and Surgeons of British Columbia physician directory. Physician screening programme colonoscopy volume was obtained from the BCCSP database; only programme colonoscopies were used to calculate individual physician volume consistent with prior studies.[3 9 15]

DOPS for colonoscopy is a validated assessment of a physician's technical skill during colonoscopy as well as the physician's judgement and interaction with the patient and staff (online supplemental appendix).[16] Two trained assessors observe the physician perform two colonoscopies and provide written and verbal feedback, in a formative manner, to the physician being assessed. There are several items on which the physician is evaluated and assigned a level of achievement. The items are classified, based on their individual importance, into either a major or minor criterion. The levels of achievement are scaled as follows: acceptable standards not yet met (grade 1), some standards not yet met (grade 2), competent and safe (grade 3) and highly skilled performance (grade 4). Grades 3 and 4 are considered acceptable. DOPS is supported administratively and financially by the BCCSP and all DOPS results are maintained in a central database. Participation in DOPS every 3 years is recommended for all physicians performing BCCSP colonoscopies.

The outcomes of interest were adenoma detection, advanced adenoma detection, SSL detection, proximal adenoma detection, distal adenoma detection, proximal SSL detection and distal SSL detection. Adenoma detection was defined as a colonoscopy with at least one adenoma. Advanced adenoma detection was defined as at least one tubular adenoma ≥10 mm, an adenoma with high-grade dysplasia or an adenoma with greater than 75% villous features. SSL detection was defined as a colonoscopy with at least one SSL detected. The proximal

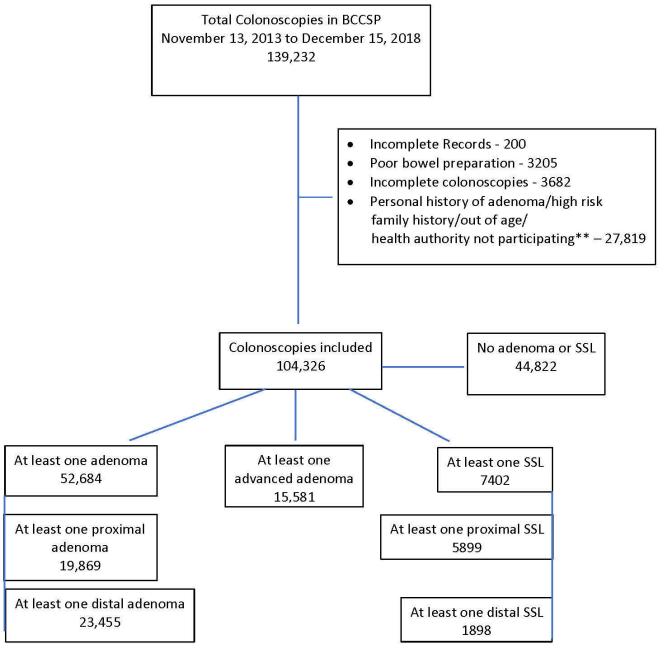


**Figure 1** Participant Inclusion. Flow of participants undergoing colonoscopy for a positive FIT from 13/11/2013 to 15/12/2018 and colonoscopy findings. BCCSP, British Columbia, Canada, population-based Colon Screening Program; FIT, faecal immunochemical test; SSL, sessile serrated lesion. *Final categories are not mutually exclusive and will not sum to the total; **1 to 5 provincial health authorities is not participating in BCCSP, accounting for 5.5% of age-eligible population.

colon included the cecum, ascending colon and transverse colon. The distal colon included the descending colon, sigmoid colon and rectum.

## Statistical analysis

Patient age and physician colonoscopy volume were handled as continuous variables and were centred and scaled before their use in the multivariable model. Year of medical school graduation was treated as a categorical variable to better accommodate for data outliers. FIT value was treated as a categorical variable both to accommodate outlying data and to align with clinical practice of interpreting FIT as either positive or negative. The screening round was treated as a binary variable, first FIT and subsequent FITs.

DOPS categories were as follows: physician receiving a grade of 1 on any of the major criteria, physician receiving a grade of 2 on any of the major criteria, physician receiving grades of 3 or 4 on all of the major criteria and physician had not completed DOPS.

Multivariable mixed effects logistic regression was used to adjust for multiple patients seen by the same physician and to model the association between detection of the outcome and physician characteristics, adjusting for patient level variables that are known to affect adenoma detection: patient age and gender, and FIT value. P<0.05 was considered significant.

**Table 1** Physician characteristics

| Total physicians | 261 |
|---|---|
| Male gender, n (%) | 198 (76%) |
| Specialty, n (%) | |
| General surgery | 169 (65%) |
| Gastroenterology | 82 (31%) |
| Internal medicine | 7 (3%) |
| Family/general medicine | 3 (1%) |
| Year of graduation from medical school, n (%) | |
| <1980 | 36 (14%) |
| 1980–1989 | 50 (19%) |
| 1990–2000 | 71 (28%) |
| After 2000 | 101 (39%) |
| North American Medical School, n (%) | 225 (86%) |
| Median physician colonoscopy volume, % (10th, 90th percentiles) | 70 (17, 159) |
| Median physician ADR, % (10th, 90th percentiles) | 50% (36, 61) |
| Median physician advanced ADR %(10th, 90th percentiles) | 14% (9, 21) |
| Median physician SSL detection rate, % (10th, 90th percentiles) | 7% (4, 10) |
| Completion of DOPS, n (%) | 188 (72%) |
| Not completed | 73 (28%) |
| Achieved a 1 on any major criteria | 7 (3%) |
| Achieved a 2 on any major criteria | 73 (28%) |
| Achieved 3 or 4 on all major criteria* | 104 (40%) |

*Considered as meeting all accepted standards in colonoscopy performance.
ADR, adenoma detection rate; DOPS, Direct Observation of Procedural Skills; SSL, Sessile Serrated Lesion.

All clinically relevant interactions were investigated. All tests used were two-sided with statistical significance fixed at 0.05. Data extraction and modelling was performed using SAS V.9.4 (SAS Institute, Cary, North Carolina) and R V.3.5.1.[17]

## RESULTS

A total of 139 232 colonoscopies were completed in the BCCSP from 15 November 2013 to 31 December 2018. Included in this study were 104 326 colonoscopies performed by 261 physicians (figure 1). The median age of patients in this study was 62 years (10th, 90th percentiles: 53, 71) and 55% were men. Of the 104 326 colonoscopies included in this study, 52 684 had at least one adenoma removed, 15 581 at least one advanced adenoma, 7402 at least one SSL, 19 869 at least one proximal adenoma, 23 455 at least one distal adenoma, 5899 at least one proximal SSL and 1898 at least one distal SSL. Of the advanced adenomas detected, 8383 (54%) of these were greater than or equal to 10 mm in size.

Table 2 Physician characteristics associated with adenoma detection

| Variable | OR | 95% CI | P value |
|---|---|---|---|
| Male physician | 0.98 | 0.88 to 1.08 | 0.633 |
| Specialty training | | | |
| Gastroenterology | Reference | | |
| Surgery | 0.87 | 0.80 to 0.95 | **0.001** |
| Internal medicine/family practice | 0.70 | 0.55 to 0.88 | **0.003** |
| Year of medicine graduation | | | |
| <1980 | Reference | | |
| 1980–1990 | 1.25 | 1.09 to 1.42 | **0.002** |
| 1990–2000 | 1.32 | 1.15 to 1.50 | **<0.001** |
| After 2000 | 1.48 | 1.30 to 1.69 | **<0.001** |
| North American Medical School | 0.95 | 0.84 to 1.07 | 0.368 |
| Colonoscopy volume | 1.00 | 0.96 to 1.06 | 0.856 |
| DOPS | | | |
| Achieved 3 or 4 on all major criteria | Reference | | |
| Achieved a 2 on any major criteria | 0.97 | 0.89 to 1.07 | 0.551 |
| Achieved a 1 on any major criteria | 0.64 | 0.50 to 0.82 | **<0.001** |
| No DOPS | 0.92 | 0.83 to 1.02 | <0.095 |
| Patient age | 1.30 | 1.29 to 1.32 | **<0.001** |
| Patient male gender | 1.97 | 1.92 to 2.02 | **<0.001** |
| First FIT | 1.16 | 1.14 to 1.19 | **<0.001** |
| FIT value | | | |
| FIT 10–15 mcg/g | Reference | | |
| FIT 15–20 mcg/g | 1.24 | 1.19 to 1.29 | **<0.001** |
| FIT 20–40 mcg/g | 1.37 | 1.32 to 1.42 | **<0.001** |
| FIT>40 mcg/g | 1.87 | 1.81 to 1.93 | **<0.001** |

p-value of less than or equal to 0.05 is considered statistically significant and is highlighted in bold
DOPS, Direct Observation of Procedural Skills; FIT, faecal immunochemical test.

Physician characteristics are shown in table 1. The median physician ADR was 50% (10th, 90th percentiles: 36, 61).

Physician characteristics associated with a higher ADR, controlling for patient characteristics, FIT value and screening round, included specialty training in gastroenterology, a more recent year of medical school graduation and a higher DOPS performance (table 2). These findings were not driven by preferential detection of proximal or distal adenomas (online supplemental appendix). A lower advanced adenoma detection was associated with training in internal or family medicine (table 3). Table 4 demonstrates improved SSL detection was associated with specialty training in gastroenterology and a higher DOPS grade. A higher proximal SSL detection was also associated with specialty training in gastroenterology and with a higher DOPS performance (table 5). A lower distal SSL detection was associated with training in internal or family medicine (online supplemental appendix).

## DISCUSSION

There was a large variability of adenoma and SSL detection among physicians in a population-based colon screening cohort of FIT positive patients. While controlling for patient age, gender, FIT value, screening round and adjusting for multiple patients seen by the same physician via the means of mixed effects modelling, a higher physician ADR, SSLDR and proximal SSLDR was associated with gastroenterology fellowship training and a higher grade on DOPS.

The higher detection rates observed in physicians who had completed gastroenterology fellowship has been demonstrated in other cohorts from other countries[10 11 18] and may reflect differences in the respective training programmes with regard to emphasis on colonoscopy technique and volume. In 2013, a Canadian survey of general surgery trainees was presented at the Canadian Surgery Forum assessing the state of endoscopic training. The results revealed variability in the number of endoscopic procedures undertaken, curriculum, objectives and access to endoscopic simulators.[19] There was

Table 3 Physician characteristics associated with advanced adenoma detection

| Variable | OR | 95% CI | P value |
|---|---|---|---|
| Male physician | 0.96 | 0.87 to 1.06 | 0.438 |
| Specialty training | | | |
| Gastroenterology | Reference | | |
| General surgery | 0.96 | 0.88 to 1.04 | 0.318 |
| Internal medicine/family practice | 0.73 | 0.57 to 0.94 | **0.014** |
| Year of medicine graduation | | | |
| <1980 | Reference | | |
| 1980–1990 | 1.08 | 0.94 to 1.23 | 0.286 |
| 1990–2000 | 1.09 | 0.96 to 1.23 | 0.201 |
| After 2000 | 1.04 | 0.91 to 1.18 | 0.571 |
| North American Medical School | 1.03 | 0.92 to 1.16 | 0.566 |
| Colonoscopy volume | 1.02 | 0.97 to 1.07 | 0.372 |
| DOPS | | | |
| Achieved 3 or 4 on all major criteria | Reference | | |
| Achieved a 2 on any major criteria | 1.10 | 1.00 to 1.20 | 0.039 |
| Achieved a 1 on any major criteria | 1.21 | 0.95 to 1.53 | 0.119 |
| No DOPS | 1.07 | 0.97 to 1.19 | 0.171 |
| Patient age | 110 | 1.08 to 1.12 | **<0.001** |
| Male patient | 1.29 | 1.24 to 1.33 | **<0.001** |
| First FIT | 1.36 | 1.33 to 1.38 | **<0.001** |
| FIT value | | | |
| FIT 10–15 mcg/g | Reference | | |
| FIT 15–20 mcg/g | 1.19 | 1.12 to 1.25 | **<0.001** |
| FIT 20–40 mcg/g | 1.41 | 1.34 to 1.48 | **<0.001** |
| FIT>40 mcg/g | 2.18 | 2.09 to 2.28 | **<0.001** |

p-value of less than or equal to 0.05 is considered statistically significant and is highlighted in bold
DOPS, Direct Observation of Procedural Skills; FIT, faecal immunochemical test.

also a range in the graduating general surgery resident's level of comfort for independent endoscopy. In 2015, a commentary by former residency directors acknowledged these results and suggested improved standardisation in colonoscopy teaching for general surgery residents.[20] This is further supported by an Irish study demonstrating a significantly lower ADR among surgical trainees when compared with gastroenterology trainees, despite similar volumes of colonoscopy.[21] In contrast, Sharvepalli *et al* did not demonstrate an association between ADR or proximal SSLDR and physician specialty.[12] The authors attributed their results to incorporating more patient related variables and thus accounting for confounding present in other publications. However, the study did not present the data for the multivariable analysis which makes it difficult to interpret their results. Furthermore, this study did not include physicians who had done fewer than 100 colonoscopies during the study period, which may have excluded more non-gastroenterologists with lower ADRs. In addition, our data were manually curated and may have been of higher quality than automatically abstracted data. Finally, the different results could be due to increased power with inclusion of a larger number of colonoscopies and physicians in the current study. Physicians performing colonoscopy who had neither gastroenterology nor surgical specialty training, had lower detection of adenomas, advanced adenomas and SSLs. Colonoscopy training in this group of physicians is not standardised and has not been well studied. As training programmes focus on competence based evaluation rather than assuming competence based on a minimum number of procedures or duration of training, differences in colonoscopy performance by specialty should disappear.[22–24]

DOPS was developed and validated in England as a tool for peer performance assessment of technical and non-technical colonoscopy skills.[16] All physicians performing programme colonoscopies are encouraged to undergo DOPS every 3 years by assessors trained and funded by the BCCSP; however, participation is not mandatory. BCCSP DOPS is a formative process with verbal and written feedback to the physician performing the colonoscopy. Seventy-two per cent of physicians in this study have had at least one DOPS assessment and those meeting

Table 4 Physician characteristics associated with sessile serrated lesion detection

| Variable | OR | 95% CI | P value |
|---|---|---|---|
| Male physician | 0.95 | 0.85 to 1.07 | 0.417 |
| Specialty training | | | |
| Gastroenterology | Reference | | |
| General surgery | 0.89 | 0.81 to 0.97 | **0.010** |
| Internal medicine | 0.67 | 0.49 to 0.92 | **0.014** |
| Year of medicine graduation | | | |
| <1980 | Reference | | |
| 1980–1990 | 0.98 | 0.84 to 1.15 | 0.802 |
| 1990–2000 | 1.07 | 0.92 to 1.24 | 0.373 |
| After 2000 | 1.00 | 0.86 to 1.16 | 0.999 |
| North American Medical School | 1.10 | 0.96 to 1.26 | 0.182 |
| Colonoscopy volume | 1.00 | 0.96 to 1.06 | 0.874 |
| DOPS | | | |
| Achieved 3 or 4 on all major criteria | Reference | | |
| Achieved a 2 on any major criteria | 1.00 | 0.91 to 1.11 | 0.963 |
| Achieved a 1 on any major criteria | 0.71 | 0.51 to 0.99 | **0.043** |
| No DOPS | 1.04 | 0.93 to 1.17 | 0.471 |
| Advanced adenoma detection | 1.83 | 1.70 to 1.98 | **<0.001** |
| Patient age | 1.12 | 1.08 to 1.16 | **<0.001** |
| Male patient | 1.33 | 1.24 to 1.42 | **<0.001** |
| First FIT | 1.26 | 1.19 to 1.31 | **<0.001** |
| FIT value | | | |
| FIT 10–15 mcg/g | Reference | | |
| FIT 15–20 mcg/g | 1.21 | 1.10 to 1.35 | **<0.001** |
| FIT 20–40 mcg/g | 1.31 | 1.19 to 1.43 | **<0.001** |
| FIT>40 mcg/g | 1.43 | 1.32 to 1.55 | **<0.001** |

p-value of less than or equal to 0.05 is considered statistically significant and is highlighted in bold
DOPS, Direct Observation of Procedural Skills; FIT, faecal immunochemical test.

acceptable standards on all major criteria of colonoscopy performance had a higher ADR, SSLDR and proximal SSLDR. This is likely due, in part, to variations in withdrawal technique including the adequacy of mucosal visualisation, which is an important determinant of polyp detection, and is evaluated and graded during the DOPS assessment.[25] Importantly, the provision of feedback and peer performance enhancement training of practicing physicians has been shown effective at increasing ADR.[26]

The phenomenon of a higher ADR observed in physicians with later years of graduation is in keeping with current literature.[11] Indeed, physician years in practice has been shown to negatively correlate with overall quality of patient care.[27] This may be due to improvements in training over time or deterioration of skills with a longer duration of practice. Surprisingly, SSLDR was not associated with time in practice in this study, as in other studies.[12 18] SSLs are a more recent target during colonoscopy and are often more difficult to recognise endoscopically than conventional adenomas, requiring development of different pattern recognition skills than those used to identify an adenoma. Hence, more recent graduates would have access to training specific to SSL detection.

The associations between SSL detection rate and adenoma detection as well as a physician's SSL detection rate and ADR have been well described.[13 28–30] Certainly, physicians with excellent withdrawal technique can be expected to detect lesions that are more difficult to identify such as small adenomas and SSLs. This is supported by non-advanced adenomas being the main contribution to gains made in an individual physician's ADR over time.[31] Prior publications have concluded that SSLs are unlikely to lead to a positive FIT and that this may be a limitation of FIT based screening programmes.[32] Our findings that increasing FIT value was significantly associated with SSLDR, while adjusting for advanced adenoma detection, was interesting and warrants future investigation within our cohort.

Unlike prior studies, the current study did not demonstrate an association between physician colonoscopy volume and ADR[9 33] or SSLDR.[12 18] However, the investigators did

Table 5 Physician characteristics associated with proximal sessile serrated lesion detection

| Variable | OR | 95% CI | P value |
|---|---|---|---|
| Male physician | 0.94 | 0.84 to 1.07 | 0.361 |
| Specialty training | | | |
| Gastroenterology | Reference | | |
| General surgery | 0.90 | 0.82 to 0.99 | **0.027** |
| Internal/family medicine | 0.69 | 0.50 to 0.97 | **0.031** |
| Year of medicine graduation | | | |
| <1980 | Reference | | |
| 1980–1990 | 1.02 | 0.86 to 1.21 | 0.832 |
| 1990–2000 | 1.07 | 0.92 to 1.26 | 0.379 |
| After 2000 | 1.04 | 0.88 to 1.22 | 0.661 |
| North American Medical School | 1.13 | 0.97 to 1.30 | 0.110 |
| Colonoscopy volume | 1.12 | 0.97 to 1.30 | 0.119 |
| DOPS | | | |
| Achieved 3 or 4 on all major criteria | Reference | | |
| Achieved a 2 on any major criteria | 1.00 | 0.90 to 1.12 | 0.933 |
| Achieved a 1 on any major criteria | 0.68 | 0.47 to 0.99 | **0.041** |
| No DOPS | 1.02 | 0.90 to 1.15 | 0.750 |
| Advanced adenoma | 1.82 | 1.67 to 1.98 | **<0.001** |
| Patient age | 1.12 | 1.08 to 1.16 | **<0.001** |
| Male patient | 1.30 | 1.21 to 1.40 | **<0.001** |
| First FIT | 1.26 | 1.19 to 1.32 | **<0.001** |
| FIT value | | | |
| FIT 10–15 mcg/g | Reference | | |
| FIT 15–20 mcg/g | 1.19 | 1.06 to 1.34 | **<0.001** |
| FIT 20–40 mcg/g | 1.39 | 1.20 to 1.47 | **<0.001** |
| FIT>40 mcg/g | 1.47 | 1.34 to 1.61 | **<0.001** |

p-value of less than or equal to 0.05 is considered statistically significant and is highlighted in bold
DOPS, Direct Observation of Procedural Skills; FIT, faecal immunochemical test.

not have access to each physician's total colonoscopy volume therefore, in keeping with previous study designs,[3 9 15] our study only captured screening programme colonoscopies.

Among the ADR subgroups, the differences in physician ADR were only seen in the total ADR and not driven by difference in detection in proximal or distal. Nor were differences seen in advanced ADR, with the exception of specialty training in internal or family medicine. This may be due to the majority of advanced adenomas in our cohort being large polyps and thus easier to see.

Strengths of this study include the large patient cohort, with a common indication for colonoscopy, derived from a prospective population database containing a pathology diagnosis and colon site on every polyp removed. This allowed separate analyses of ADR and SSLDR rather than grouping different polyp histology as well as analyses of the subgroups advanced ADR, and proximal and distal ADR and SSLDR. Also, a large number of physicians from various training backgrounds were included. Important limitations should also be noted. First, a physician's colonoscopy volume within the BCCSP may not reflect the relative total colonoscopy volume. However, there may also be advantages to including only colonoscopies performed by BCCSP standards which include an outpatient setting, centralised assessment and distribution of patients to physicians on a first-available model, standardised bowel cleansing protocols and no trainee involvement. For instance, this model of patient distribution among physicians may provide a more equal distribution of patient characteristics that potentially affect the prevalence of adenomas and SSLs and reduce potential confounding. While analysing only FIT positive colonoscopies may have decreased the heterogeneity of our cohort, it also limits the external validity to other colonoscopy indications. Also, DOPS was not completed by 28% of the physicians included which may affect the models' results. A sensitivity analysis excluding those physicians who had not completed DOPS did not change the models' results. Last, the investigators did not have access to physician participation in colonoscopy skills improvement courses or other colonoscopy based continuing medical education that could have influenced detection rates.

In conclusion, physician factors associated with higher detection rates were gastroenterology specialty and improved performance on DOPS. These findings support standardisation of colonoscopy training among specialties with training completion and ongoing credentialing of practicing physicians based on competency assessment with objective tools such as DOPS.

**Contributors** Study design: JT, SP, LGo, LGe and RE. Analysis of data: LGo. Interpretation of analysis: JT, LGo, LGe and RE. Drafting of article: SP, LGe, LGo and JT. Critical revision of article: all authors. Final approval of article: all authors.

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**Patient consent for publication** Not required.

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**Data availability statement** Data are available on reasonable request. Deidentified participant level data is not available. Protocol and statistical analysis plan and code are available on reasonable request.



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