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Post-colonoscopy colorectal cancer and the association with endoscopic findings in the Danish colorectal cancer screening programme

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ABSTRACT

Objective Colorectal cancer (CRC) is the third most common cancer in Denmark, with a 5-year mortality of 40%. To reduce CRC incidence and mortality, a faecal immunochemical test (FIT)-based screening programme was introduced in 2014. Adenoma detection rate (ADR) is an established quality marker inversely associated with post-colonoscopy CRC (PCCRC), but evidence mainly stems from non-FIT populations. Using ADR in a FIT-based setting may be costly due to histopathological examination. Alternative markers like polyp detection rate (PDR) and sessile serrated lesion detection rate (SDR) could be viable but lack evidence for their association with PCCRC.

Methods We conducted a nationwide cohort study of 77 009 FIT-positive participants undergoing colonoscopy (2014–2017). National registry data on CRC outcomes were linked, and endoscopy units were grouped by ADR, PDR and SDR levels. Poisson regression adjusted for age, sex and comorbidities was used to assess PCCRC risk.

Results Among 70 009 colonoscopies within 6 months of FIT positivity, 4401 (92.7%) had CRC, while 342 (7.2%) were PCCRC cases. PCCRC risk was inversely associated with ADR, PDR and SDR. High ADR endoscopy units had a 35% lower PCCRC risk than low ADR units. Similar associations were found for PDR and SDR, with high SDR units showing a 33% lower PCCRC risk than low SDR units.

Conclusions ADR, PDR and SDR predict PCCRC risk, with SDR emerging as a feasible, cost-efficient quality marker in FIT-based screening. This study supports SDR as a primary performance indicator in future protocols.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Adenoma detection rate is a key performance indicator to reduce the risk of post-colonoscopy colorectal cancer.

WHAT THIS STUDY ADDS

⇒ The adenoma detection rate is inversely related with post-colonoscopy colorectal cancer in the Danish screening programme. Moreover, the same relationship was seen for polyp detection rate and sessile serrated lesion detection rates.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ The use of polyp detection rate or sessile serrated lesion detection rate might be a better more cost-efficient alternative to the adenoma detection rate for monitoring colonoscopy quality in colorectal cancer screening programmes.

INTRODUCTION

Colorectal cancer (CRC) is the third most common cancer in Denmark. Around 40% succumb to the disease within 5 years.[1] The faecal immunochemical test (FIT)-based colorectal cancer screening programme was introduced in Denmark in 2014 in an attempt to reduce CRC incidence and mortality. A prerequisite for a successful screening programme is a high-quality colonoscopy service. Despite the best of efforts, CRCs can occur after a negative colonoscopy (a colonoscopy without malignant findings).

A post-colonoscopy colorectal cancer (PCCRC) rate can be used to track performance but requires years of follow-up and high-volume data, making it less useful for everyday performance monitoring. The adenoma detection rate (ADR) (the proportion of colonoscopies with at least one resected adenoma) has been shown to be inversely related to the PCCRC rate.[2 3] However, the majority of studies have been conducted in a general endoscopy or non-FIT-based screening setting with an inherent lower ADR. The evidence of the inverse relation between PCCRC and ADR related to FIT-based screening is limited.[4] A stark difference in ADR among endoscopy units has been present in the Danish colorectal cancer screening programme since the initiation in

2014 and could indicate potential quality differences in the endoscopy service.[5 6]

The use of ADR as a performance marker has an expensive drawback as it requires every diminutive polyp to be examined with histopathology thus driving up costs. An alternative might be the use of polyp detection rate (PDR) (that does not require histopathology) or sessile serrated lesion detection rate (SDR). Sessile serrated lesions (SSLs) account for a smaller proportion of removed polyps. If a similar inverse relationship with PCCRC and PDR or SDR could be established, it could be a viable alternative.

The aim of this study was to investigate the association between PCCRC and the ADR, PDR, and SDR in the Danish colorectal cancer FIT-based screening programme.

METHODS

Setting and design

The Danish colorectal screening programme was introduced in 2014. Asymptomatic individuals between 50 and 74 years of age are invited to participate free of charge as Danish healthcare is based on a free-for-all public health system. Eligible individuals receive a FIT (Eiken Chemical Co. Ltd.) for at-home testing. Test subjects with a haemoglobin concentration ≥20 µg/g of faeces are referred to the regional endoscopy unit for colonoscopy. The follow-up colonoscopies related to a positive FIT are distributed among 20 endoscopy units. Subsequent surveillance colonoscopies are scheduled depending on the number of polyps, polyp size and degree of dysplasia. The participation rate in the screening programme is ~60%, with the highest participation rates being in the oldest age group and of female sex.[6]

We conducted a nationwide cohort study using data from the first round of CRC screening (from March 2014 until December 2017). The study is in full accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement and the STROBE checklist is appended in the online supplemental material.[7]

Data sources

The study was conducted using Danish national registers, which cover all Danish citizens and can be linked using individual social security numbers.

The Danish Colorectal Cancer Screening Database was used to extract each individual undergoing CRC screening and to identify participants with a positive FIT.[8]

Data regarding the colonoscopy after a positive FIT was extracted from the Danish National Patient Register using Nordic Medico-Statistical Committee (NOMESCO) classification of surgical procedures KUJF32 and KUJF35.

To identify the participants who develop CRC, we used the Danish Colorectal Cancer Database. The database contains every CRC diagnosed in Denmark, both in relation to screening and outside the screening programme. CRC were identified using the following International Classification of Disease, 10th revision (ICD-10) codes DC18, DC19 and DC20.

Age at the time of FIT, sex and comorbidities for each participant in the screening programme were extracted from the Danish National Patient Register. We calculated the Charlson Comorbidity Index (CCI) based on the ICD-10 codes received 5 years prior to screening. The calculation method was based on an adapted version by Quan *et al*.[9] Patients were grouped into three (0, 1–2, ≥3).

The findings at colonoscopy were identified using the Danish Pathology Register. Polyps were defined according to the Systematized Nomenclature of Medicine (SNOMED) coding system. An Adenoma was defined as: M8213F (flat adenoma), M82110 (tubular adenoma), M82630 (tubulovillous adenoma), M82611 (villous adenoma), M82130 (traditional serrated adenoma) and M8213M (sessile serrated lesion with dysplasia). The definition of adenomas was in accordance with the definition made by the Danish Colorectal Cancer Screening Database (essentially polyps with dysplasia and sessile serrated lesions with dysplasia are included in the 'Adenoma' definition). An SSL was defined as: M8213S (sessile serrated lesion) or M8213M (sessile serrated lesion with dysplasia). A polyp was defined as SNOMED codes for adenomas+the SNOMED codes for SSLs with the addition of M72040 (hyperplastic polyp).

Definitions

Participants were deemed eligible if they had a positive FIT (from March 2014 until December 2017) and received a colonoscopy up to 2 months after a positive screening test. Each participant was followed until event of PCCRC, death or 3 years after colonoscopy.

The definition of PCCRC was based on the standard recommendation from the World Endoscopy Organizations (WEO) consensus statement.[10] A diagnosed cancer (DC) was defined as a CRC diagnosed <6 months from colonoscopy. A PCCRC was defined as a CRC diagnosed 6–36 months from colonoscopy.

A colonoscopy was defined to have rendered a finding (polyps, or adenomas, or SSLs) if there was a histopathological finding within 6 months of the colonoscopy.

Participants were grouped according to age in four groups (50–56, 57–63, 64–70 and 71–78 years of age). The screening programme in Denmark was rolled out over a period of 4 years and all citizens with an age between 50 and 74 years of age were invited. To accommodate the capacity of the regional endoscopy units, all individuals were not invited simultaneously but in a 'randomized fashion' (based on month of birth). This inherently implies that participants' age could exceed the age cap of 74 years of age.

Statistical analysis

The number and proportions of participants receiving a colonoscopy after a positive FIT are presented according to DC, PCCRC, along with the findings at colonoscopy

(polyps, adenomas and SSLs). To examine the relationship with age, sex and comorbidity, the data was compared using the χ^2 test.

The endoscopy units were divided into three groups according to PDR, ADR and SDR respectively (low, medium and high) for the subsequent three separate analyses. To compare the risk of PCCRC according to detection rates, we compared the proportion of PCCRCs of all cancers detected (PCCRC/PCCRC+DC) between the different groups. Moreover, univariable and multivariable Poisson regression was used to evaluate this relationship. The outcome variable was PCCRC, and the exposure variables were PDR, ADR and SDR. The potential confounders were age, sex and CCI.

To visualise the cumulative incidence of PCCRC, the Aalen Johansen estimator was used. The cumulative incidence was grouped according to detection rates with death as a competing event.

In order to show the relationship between the number of colonoscopies and the risk of PCCRC, we calculated the number of colonoscopies between each PCCRC according to PDR, ADR and SDR respectively.

All statistical analyses were conducted using RStudio, version 3.4.[11] Data were analysed from 1 January to 30 September 2024.

Patient and public involvement

There was no involvement of screening participants, staff at the endoscopy units or other third parties in the design or conduct of this study.

RESULTS

We identified 77 009 participants receiving a colonoscopy after a positive FIT. Demographics according to CRC and polyps are presented in table 1. Participants receiving a colonoscopy after a positive FIT were predominantly male, aged between 64 and 70 years of age and with no comorbidities (CCI=0). A total of 4743 CRCs were identified in the study period of which 4401 (92.7%) were DCs and 342 (7.3%) were PCCRCs. The incidence of PCCRC increased with age but did not seem to be associated with sex or increasing comorbidity. The detection of polyps, adenomas or SSLs was associated with male sex, increasing age and inversely associated with CCI.

The overall mean PDR, ADR and SDR were 52.2%, 50.6% and 6,0% respectively.

To evaluate if the regional differences in ADR, PDR and SDR could explain PCCRC, we grouped the endoscopy units by tertiles. Tertile grouping of endoscopy units by ADR, PDR and SDR were not identical, although few endoscopy units changed tertiles depending on grouping methodology. The endoscopy units were grouped by PDR in three groups: low (38.7%–48.7%, mean=46.8%), medium (48.8%–53.4%, mean=51.1%) and high (55.3%–69.7%, mean=59.8%). The endoscopy units were grouped by ADR in three groups: low (38.7%–47.1%, mean=45.6%), medium (47.7%–52.0%, mean=49.3)

Table 1 Demographics according to colonoscopy, diagnosed cancers, post-colonoscopy colorectal cancers and endoscopic findings

		Total	DC		PCCRC		Polyp		Adenoma		SSL	
		(n=77 009)	(n=4401)	p value	(n=342)	p value	(n=40 231)	p value	(n=38 944)	p value	(n=4590)	p value
Sex	Male	43 265 (56.2)	2660 (60.4)		188 (55.0)		25 251 (62.8)		24 671 (63.3)		2577 (56.1)	
	Female	33 744 (43.8)	1741 (39.6)	<0.001	154 (45.0)	0.691	14 980 (37.2)	<0.001	14 273 (36.7)	<0.001	2013 (43.9)	1.0
Age	50–56	16 270 (21.1)	450 (10.2)		35 (10.2)		6591 (16.4)		6327 (16.2)		699 (15.2)	
	57–63	17 214 (22.4)	843 (19.2)		43 (12.6)		9085 (22.6)		8779 (22.5)		1046 (22.8)	
	64–70	23 736 (30.8)	1526 (34.7)		119 (34.8)		13 439 (33.4)		13 022 (33.4)		1635 (35.6)	
	71–78	19 789 (25.7)	1582 (35.9)	<0.001	145 (42.4)	<0.001	11 116 (27.6)	<0.001	10 816 (27.8)	<0.001	1210 (26.4)	<0.001
CCI	0	58 999 (76.6)	3514 (79.8)		254 (74.3)		31 207 (77.6)		30 185 (77.5)		3609 (78.6)	
	1–2	14 475 (18.8)	753 (17.1)		66 (19.3)		7399 (18.4)		7190 (18.5)		801 (17.5)	
	≥3	3535 (4.6)	134 (3.0)	<0.001	22 (6.4)	0.242	1625 (4.0)	<0.001	1569 (4.0)	<0.001	180 (3.9)	0.002

The total number and proportions (%) of colonoscopies (Total) according to sex, age group and Charlson Comorbidity Index (CCI). The diagnosed cancers (DCs) and post-colonoscopy colorectal cancers (PCCRC) are also provided along with the findings at the colonoscopy. Polyp reflects the number of colonoscopies where a polyp is found. Adenoma reflects the number of colonoscopies where an adenoma is found. SSL reflects the number of colonoscopies where a sessile serrated lesion (SSL) is found. P values are calculated using the χ^2 test.

Table 2 Diagnosed cancers and post-colonoscopy colorectal cancers according to detection rate

		DC (n=4401)	PCCRC (n=342)	Total (n=4743)	P value
PDR	Low	1425 (90.7)	146 (9.3)	1571 (100.0)	
	Medium	1560 (93.1)	115 (6.9)	1675 (100.0)	
	High	1416 (94.6)	81 (5.4)	1497 (100.0)	<0.001
ADR	Low	1321 (90.8)	134 (9.2)	1455 (100.0)	
	Medium	1664 (92.9)	127 (7.1)	1791 (100.0)	
	High	1416 (94.6)	81 (5.4)	1497 (100.0)	<0.001
SDR	Low	1198 (91.0)	119 (9.0)	1317 (100.0)	
	Medium	1749 (92.7)	137 (7.3)	1886 (100.0)	
	High	1454 (94.4)	86 (5.6)	1540 (100.0)	0.002

The number and proportion (%) of diagnosed cancer (DC) and post-colonoscopy colorectal cancer (PCCRC) according to endoscopic units with varying detection rates of polyps, adenomas and sessile serrated lesions. Polyp detection rate (PDR) reflects the proportion of colonoscopies in which one or more polyps are found. The endoscopic units are grouped by PDR in three groups: low (38.7%–48.7%), medium (48.8%–53.4%) and high (55.3%–69.7%). Adenoma detection rate (ADR) reflects the proportion of colonoscopies in which one or more adenomas are found. The endoscopic units are grouped by ADR in three groups: low (38.7%–47.1%), medium (47.7%–52.0%) and high (53.7–67.6). Sessile detection rate (SDR) reflects the proportion of colonoscopies in which one or more sessile serrated lesions are found. The endoscopic units are grouped by SDR in three groups: low (0.2%–4.4%), medium (4.6–7.0) and high (7.1–13.6). P values are calculated with the χ^2 test.

and high (53.7–67.6, mean=57.8). The endoscopy units were grouped by SDR in three groups: low (0.2%–4.4%, mean=3.8%), medium (4.6–7.0, mean=6.0%) and high (7.1–13.6, mean=8.4%). The proportion of PCCRCs according to all CRCs detected is visualised in table 2. Moreover, the cumulative incidence of PCCRC is shown in figure 1. The data clearly shows an inverse relationship between the proportion of PCCRC according to PDR, ADR and SDR respectively.

To evaluate this relationship further, we used Poisson regression. Once again, the inverse relationship was shown (table 3). The PCCRC could be reduced by 35% if the participants were examined in an endoscopy unit with a high ADR compared with units with a low ADR.

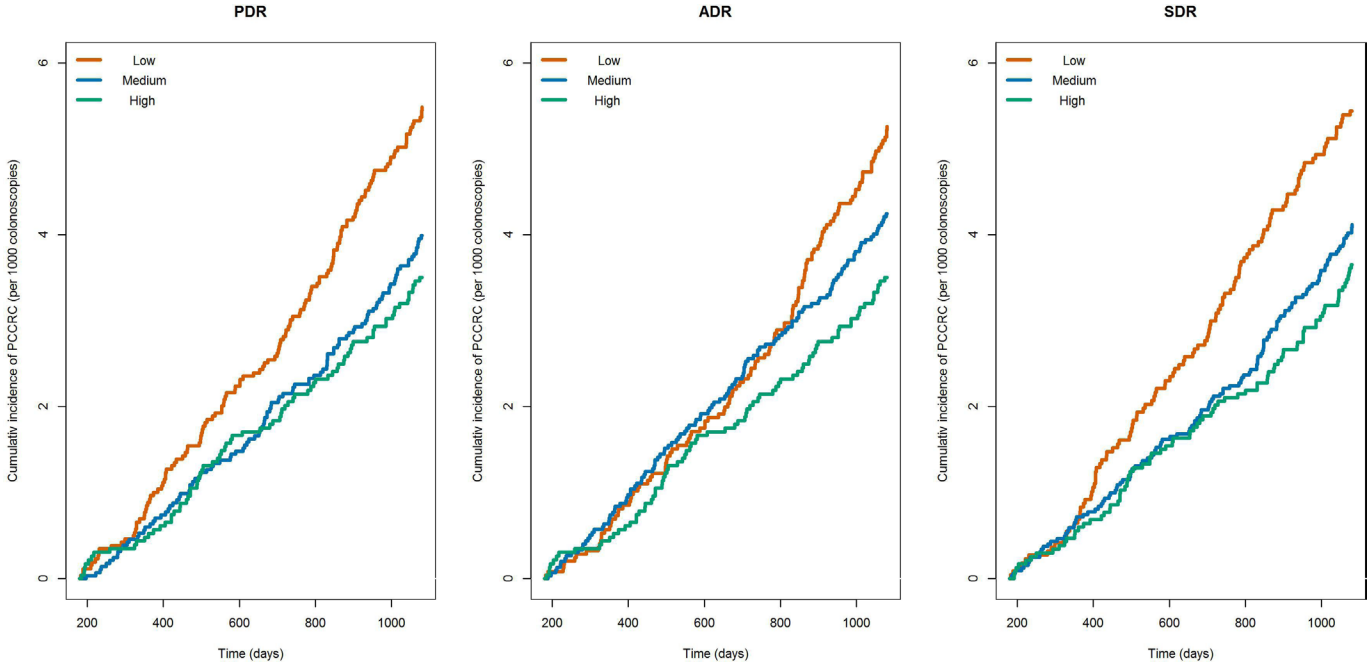

Figure 1 Cumulative incidence of post-colonoscopy colorectal cancer The cumulative incidence of post-colonoscopy colorectal cancer (PCCRC) according to centre with varying polyp detection rates (PDR), adenoma detection rates (ADR) and sessile serrate lesion detection rates (SDR). The endoscopy units are grouped by PDR in three groups: low (38.7%–48.7%), medium (48.8%–53.4%) and high (55.3%–69.7%). The endoscopy units are grouped by ADR in three groups: low (38.7%–47.1%), medium (47.7%–52.0%) and high (53.7–67.6). The endoscopy units are grouped by SDR in three groups: low (0.2%–4.4%), medium (4.6–7.0) and high (7.1–13.6).

Table 3 Poisson regression for the risk of post-colonoscopy colorectal cancer

		Univariable			Multivariable		
		RR	95% CI	p value	RR	95% CI	p value
PDR	Low	Ref			Ref		
	Medium	0.72	(0.56; 0.92)	0.009	0.72	(0.57; 0.92)	0.010
	High	0.63	(0.48; 0.83)	<0.001	0.63	(0.48; 0.83)	<0.001
ADR	Low	Ref			Ref		
	Medium	0.78	(0.61; 1.00)	0.048	0.78	(0.62; 1.00)	0.051
	High	0.65	(0.49; 0.86)	0.002	0.65	(0.49; 0.86)	0.002
SDR	Low	Ref			Ref		
	Medium	0.78	(0.61; 1.00)	0.046	0.78	(0.61; 1.00)	0.049
	High	0.67	(0.51; 0.89)	0.005	0.67	(0.51; 0.88)	0.004

The relative rate (RR) is calculated from univariable and multivariable Poisson regression. The outcome variable is post-colonoscopy colorectal cancer (PCCRC), and the exposure variables are the polyp detection rate (PDR), adenoma detection rate (ADR) and sessile serrated lesion detection rate (SDR) according to endoscopy unit. The endoscopy units are grouped by PDR in three groups: low (38.7%–48.7%), medium (48.8%–53.4%) and high (55.3%–69.7%). The endoscopy units are grouped by ADR in three groups: low (38.7%–47.1%), medium (47.7%–52.0%) and high (53.7–67.6). The endoscopy units are grouped by SDR in three groups: low (0.2%–4.4%), medium (4.6–7.0) and high (7.1–13.6). The multivariable models were adjusted for age, sex and Charlson Comorbidity Index.

Interestingly, the same relationship was seen for SDR, with a reduction of 33%. The multivariable regression did not alter any of the estimates obtained from univariable regression (table 3). The association is also seen in table 4. The endoscopic units with the highest ADR would conduct 282 colonoscopies before encountering a PCCRC; whereas, a PCCRC would be encountered at 170 colonoscopies in low ADR centres.

DISCUSSION

The main findings of this study were inverse relationship between PCCRC and both ADR, PDR and SDR in the Danish colorectal cancer screening programme. The inverse relationship between ADR and PCCRC has been established in general colonoscopy populations previously, but few studies have shown the association in a FIT-based screening setting.[4] Wisse *et al* examined the relationship between ADR and PCCRC (in selected patients recommended for a surveillance colonoscopy) related to the Dutch FIT-based screening programme and found the lowest PCCRC rate in individual endoscopist with an ADR >70%.[4] The mean ADR in our high ADR group was 57.8%, highlighting that there is room for improvement even in our high ADR group. If the ADR in our low and middle tertile group could improve corresponding to the high ADR group,

Table 4 Post-colonoscopy colorectal cancer detection rate according to number of colonoscopies related to polyp detection rate, adenoma detection rate and sessile serrated lesion detection rate

		Colonoscopies	PCCRC	PCCRC rate*	NNS
PDR	Low	25 894	146	5.6	177
	Medium	28 299	115	4.1	246
	High	22 816	81	3.6	282
ADR	Low	24 518	134	5.5	183
	Medium	29 675	127	4.3	234
	High	22 816	81	3.6	282
SDR	Low	21 686	119	5.5	182
	Medium	32 060	137	4.3	234
	High	23 263	86	3.7	270

The number of colonoscopies and post-colonoscopy colorectal cancers (PCCRCs) according to the polyp detection rate (PDR), adenoma detection rate (ADR) and sessile serrated lesion detection rate (SDR). The endoscopy units are grouped by PDR in three groups: low (38.7%–48.7%), medium (48.8%–53.4%) and high (55.3%–69.7%). The endoscopy units are grouped by ADR in three groups: low (38.7%–47.1%), medium (47.7%–52.0%) and high (53.7–67.6). The endoscopy units are grouped by SDR in three groups: low (0.2%–4.4%), medium (4.6–7.0) and high (7.1–13.6). The PCCRC rate* reflects the proportion of PCCRCs per 1000 colonoscopies (the asterix is added to reflect the difference from the PCCRC rate in the previous tables, which only reflect the rate of PCCRC among all CRCs). The number needed to scope (NNS) reflects the number of colonoscopies between each PCCRC.

we could potentially reduce the number of PCCRCs by ~35% (within 3 years). It should be noted that the potential for preventing PCCRC by a thorough examination (measured by high ADR) extends far beyond 3 years (at least 17 years) implying that a subpar ADR will have long-lasting implications as additional CRC could likely have been prevented.[4 12 13] The Danish colorectal cancer screening programme is generally well implemented and randomised studies have shown CRC screening to reduce incidence and mortality.[14 15] However, the latest Danish colorectal cancer screening annual report showed that a large variation in ADR among endoscopy units remains (ADR range: (47–72)).[6] In most endoscopy units, there seems to be room to improve ADR which could improve the efficacy of the screening programme. Our 3-year PCCRC rate (PCCRC-3yr) of 7.3% was not calculated according to the WEO methodology and thus difficult to compare, but Danish colorectal cancer screening PCCRC-3yr rates according to WEO methodology have been published in January 2025 with a PCCRC-3yr rate of 7.7% for the year 2020.[6] The PCCRC-3yr rate is higher than previously reported from the English National Health Service bowel cancer screening programme (3.6%) and from the Dutch colorectal cancer screening programme (2.7%).[16 17] The Danish WEO PCCRC-3yr rate was 7.9% in 2012 (for all colonoscopies, before the introduction of the Danish colorectal cancer screening programme) and it seems somewhat disappointing that the PCCRC-3yr rate remains high.[18] Both the English and the Dutch screening programmes have strict requirements for colonoscopists that likely filter out the best colonoscopists for screening procedures. Such requirements do not exist in the Danish colorectal cancer screening programme and there are no nationwide training programmes, although some endoscopy units have held endoscopy training courses conducted by English experts, which previously has been shown to improve ADR.[19] The ADR has increased over time in the Danish colorectal cancer screening programme from 49% in 2014 to 61% in 2023 indicating increasing quality over the last decade.[5 6] Other quality initiatives such as individual colonoscopist performance tracking (based on ADR and SDR) are currently being implemented and are expected to be up and running within a year. Hopefully, it will result in future lower PCCRC-3yr rates.

ADR is generally believed to be one of the most important colonoscopy performance markers, but the future use was questioned at the recent 10-year Danish colorectal cancer screening symposium held in May 2024.[20] The main concern was related to the increased workload in the regional pathology departments with approximately 20 000 polyps being removed in the Danish screening programme annually.[6] The risk of CRC in diminutive adenomas (<10 mm) is extremely low. A study by Ponugoti *et al* examined more than 30 000 adenomas <10 mm without a single cancerous polyp being identified.[21] A 'resect and discard' protocol (for diminutive polys <10 mm) was examined in a study from Japan without a single recurrence after 1 year follow-up.[22] The DISCARD3 study examined whether adenomas could be optically diagnosed alone with an accuracy of 82% for ≤5 mm polyps and 93% for 6–9 mm polyps compared with histopathology (in a highly trained endoscopist group). It did result in 98% concordance with histopathology when assigning the correct surveillance intervals according to the European Society of Gastrointestinal Endoscopy.[23] A 'resect and discard' protocol would however hinder the use of ADR as a future performance marker. PDR is commonly considered a marker for ADR but naturally less rigorous and open to endoscopist interpretation. The inverse relationship between PDR and PCCRC has been established in studies from Germany and Poland, although in non-FIT screening populations.[12 24] In our study, the ADR and PDR regression models were basically identical with almost similar coefficients (tables 2 and 3). The main explanation being that ADR and PDR were inseparable with an ADR/PDR ratio of 97%. The ratio is remarkably high compared with the Polish study (median 51.7%) and previously reported data from the USA (mean 67%).[12 25] Our inclusion of 'sessile serrated adenomas with dysplasia' as an adenoma could have elevated the ratio slightly but far from enough to account for the discrepancy. It seems somewhat unlikely that Danish endoscopists should be vastly superior compared with others in differentiating adenomas from non-dysplastic lesions. The US and Polish studies might be affected by gaming or 'one and done' practice either due to higher reimbursement (for polypectomy procedures) or intense endoscopic surveillance of endoscopists (Hawthorne effect).[26 27] However, based on our data, PDR is as good a marker for PCCRC as ADR. Since the ADR and PDR in the Danish colorectal screening programme are almost identical, the effect of a 'resect and discard' approach is unlikely to lead to incorrectly assigned surveillance intervals even without specialised endoscopist optical training. In other screening programmes with a vastly different PDR/ADR ratio validation, studies should likely be conducted to ensure that correct surveillance intervals are assigned if small polyps are discarded.

Few studies have examined the inverse relationship between sessile serrated lesions and PCCRC. Toledo *et al* found that 'proximal serrated polyp detection rate' was inversely correlated with PCCRC while Anderson *et al* found the same association with 'clinically significant serrated polyp' detection rates.[28 29] The nomenclature can be somewhat confusing. Toledo *et al* limited the study to proximal serrated polyps likely to avoid the sometimes difficult distinction between a hyperplastic polyp (commonly found in the distal colon) and a sessile serrated lesion.[28] The 'clinically significant' serrated polyp defined by Anderson *et al* used a more generous definition of flat polyps including hyperplastic polyps >5 mm in the proximal colon or >10 mm in the distal colon.[29] Hyperplastic polyps are not believed to be precursors for CRC but the definition by Anderson *et al* could make clinical sense nonetheless. It is generally believed that

ADR should be seen as a marker for a thorough endoscopic examination (and thus less risk of PCCRC) rather than the effect of the polypectomy itself. SSL and hyperplastic polyps are flat and can be difficult to differentiate from the normal mucosa. Continuing in that framework of understanding, it seems logical that SDR provides a similar or even better marker than ADR. However, the use of SDR has some challenges. First, because the distinction between hyperplastic polyps and SSLs can be difficult for pathologist.[30] The WHO updated their classification of SSLs in 2019 and it is likely to provide a clearer differentiation (and thus SDR becoming a more precise marker) in the future.[31] Second, the use of SDR does suffer from a statistical floor effect. SSLs are relatively rare (average SDR 6.0% in our study), causing small numerical numbers to differentiate tertiles and thus introduce statistical uncertainty when assigning them. The mean SDR has since risen to 9.5% (95% CI 9.1 to 9.9%) in the latest report from 2023, with some endoscopy units reaching an SDR of 18%.[6] Based on our data, SDR is as good a performance marker for PCCRC as ADR even with the above-described challenges. Challenges that are likely to be of less concern in the future. The ratio between hyperplastic polyps and SSLs is tracked in the annual Danish colorectal cancer screening reports (at an endoscopy unit level) and indicates fairly consistent SSL diagnosis.[6] A validation study could be performed to reduce/identify interdepartmental variability in diagnosing SSLs. The potential savings on histopathology by combining SDR with 'a resect and discard' approach are considerable. Around 90% of polyps are expected to be <10 mm.[32]

Our study did have some limitations. It would have been preferable to group endoscopist based on their individual performance data rather than their endoscopy unit data. However, data on individual endoscopist performance is not directly accessible through the Danish nationwide registries. The intervariability in detection rates among endoscopists is much higher than among endoscopy units. The consequence is presumably a reduced inverse relationship with PCCRC caused by the less optimal grouping of endoscopist (type-2 error). Corley *et al* stated that a 1% point increase in ADR resulted in a 3% decrease in PCCRC rate in a mixed colonoscopy indication setting.[2] Although the underlying statistical assumptions have been questioned, a similar approach in our FIT screening setting results in 1.8% decrease in PCCRC for every 1% point increase in ADR.[33] The less optimal grouping of endoscopist is likely a contributing factor.

CONCLUSION

ADR, PDR and SDR are all effective in predicting the risk of PCCRC. SDR as the primary key performance indicator combined with a 'resect and discard' approach are a likely cost-effective solution to colonoscopy quality performance monitoring in FIT-based screening programmes.

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