**Evidence Summary 15-5 Version 3**

## A Quality Initiative of the Program in Evidence-Based Care (PEBC), Ontario Health (Cancer Care Ontario)

# Quality Assurance for Colonoscopy in Ontario Evidence Summary

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**PUBLICATIONS RELATED TO THIS REPORT**

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## Abbreviations and Definitions List

**Adj:** Adjusted
**ADR:** Adenoma detection rate
**ADR-plus:** Additional adenomas found after the first adenoma per colonoscopy
**AGREE:** Appraisal of Guidelines for Research and Evaluation
**AMR:** Adenoma miss rate
**APC:** Adenomas per colonoscopy
**APP:** Adenomas per positive participant
**ASCO:** American Society of Clinical Oncology
**BBPS:** Boston bowel preparation scale
**CCO:** Cancer Care Ontario
**CI:** Confidence interval
**CIR:** Cecal intubation rate
**CRC:** Colorectal cancer
**CRC ADR:** ADR in individuals with prior colorectal cancer
**CSSDR:** Clinically significant serrated polyp detection rate
**CSSP:** Clinically relevant serrated polyp
**CSSQP:** Colonoscopy Satisfaction and Safety Questionnaire
**DCRC:** Detected colorectal cancer
**ECRI:** Emergency Care Research Institute
**EMBASE:** Excerpta Medica Database
**EMR:** Endoscopic mucosal resection
**EORTC-OLO-C30:** European Organization for Research and Treatment of Cancer Quality of Life Scale
**ER:** Endoscopic resection
**ESD:** Endoscopic submucosal dissection
**ESGE:** European Society of Gastrointestinal Endoscopy
**FIT:** Fecal immunochemical test
**FOBT:** Fecal occult blood test
**GESQ:** Gastrointestinal Endoscopy Satisfaction Questionnaire
**GI:** Gastrointestinal
**GRADE:** Grading of Recommendations, Assessment, Development, and Evaluations
**HR:** Hazard ratio
**HRADR:** High risk adenoma detection rate
**ICC:** Intraclass correlation coefficient
**ICU:** Intensive care unit
**ISFU:** Importance, Scientific Acceptability, Feasibility, Usability, and Comparison to Related/Competing Measures
**JBI:** Joanna Briggs Institute
**MA:** Meta-analysis
**MEDLINE:** Medical Literature Analysis and Retrieval System Online
**MGCS:** Modified Gloucester Comfort Score
**N/A:** Not applicable
**NAADR:** Nonadvanced adenoma detection rate
**NAPCOMS:** Nurse-assisted Patient Comfort Score
**NBI:** Narrow band imaging
**NLP:** Natural language processing
**OH:** Ontario Health
**OMH:** Ontario Ministry of Health

**OR:** Odds ratio
**PCCRC:** Post-colonoscopy colorectal cancer
**PDR:** Polyp detection rate
**PEBC:** Program in Evidence-Based Care
**PICI:** Performance indicator of colonic intubation
**PRISMA:** Preferred Reporting Items for Systematic Reviews and Meta-Analyzes
**PRO-STEP:** Patient-reported Scale for Tolerability of Endoscopic Procedures
**PSPDR:** proximal serrated polyp detection rate
**QI:** Quality indicator
**R0:** Resection
**R-ADR:** Right-sided adenoma detection rate
**RCR:** Right colon retroflexion
**RCT:** Randomized controlled trial
**RF:** Retroflexion
**RoB:** Risk of Bias
**ROBINS:** Risk of Bias in Non-Randomized Studies
**ROBIS:** Risk of Bias in Systematic Reviews
**SDR:** Serrated polyp detection rate
**SFV:** Second forward view
**SMAR-IR:** Segmental metachronous adenoma rate attributable to incomplete resection
**SPECS:** St. Paul's Endoscopy Comfort Scale
**SR:** Systematic review
**SSP:** Sessile serrated polyps
**SSPDR:** Sessile serrated polyp detection rate
**TA:** Tubular adenoma
**TI:** Terminal ileum
**TIIR:** Terminal ileum intubation rate
**UK:** United Kingdom
**USA:** United States of America
**VAS:** Visual analogue scale
**Vs:** versus
**WEO:** World Endoscopy Organization
**WT:** Withdrawal time
**y:** year

## Glossary

**Adverse events:** The term used for all complications including perforations, post-colonoscopy bleeds, mortality and unplanned admissions.

**High Risk Adenoma Detection Rate (HRADR):** Calculated by dividing the total number of patients with at least one of the following three criteria: (1) any sized tubulovillous adenoma or villous adenoma or adenoma with high-grade dysplasia, (2) adenoma ≥ 10 mm in size or (3) presence of three or more adenomas of any size, by the total number of patients undergoing screening colonoscopy**;** also includes advanced adenoma detection rate.

**Polypectomy**: The snare resection of non-complex lesions (usually <10 mm) usually using cold snare resection (usually without submucosal injection).

**EMR:** The removal of complex polyps (usually >10 mm) using submucosal injection followed by hot or cold snare resection.

**ESD:** En-bloc (singular piece) resection of target lesions through the use of an electrosurgical knife. Knife is used to both cut through the mucosa and dissect the submucosal layer.

# Quality Assurance for Colonoscopy in Ontario Evidence Summary

## Evidence Summary

**THE PROGRAM IN EVIDENCE-BASED CARE**

The Program in Evidence-Based Care (PEBC) is an initiative of the Ontario provincial cancer system, Ontario Health (Cancer Care Ontario). The PEBC mandate is to improve the lives of Ontarians affected by cancer through the development, dissemination, and evaluation of evidence-based products designed to facilitate clinical, planning, and policy decisions about cancer control.

The PEBC is a provincial initiative of OH (CCO) supported by the Ontario Ministry of Health (OMH). All work produced by the PEBC, and any associated Programs is editorially independent from the OMH.

**INTRODUCTION**

Colorectal cancer (CRC) is the most common cancer after prostate cancer for men and after lung and breast cancer for women (1). In 2022, it is estimated that 5000 new cases of CRC for men and 4000 new cases for women will be diagnosed in Ontario (1). CRC accounts for 10.3% of cancer deaths in Ontario (1).

Colonoscopy is a common medical procedure. In Ontario, fecal immunochemical testing (FIT) is recommended for average-risk CRC screening and for surveillance after diagnosis of low-risk adenomas (2). After an abnormal FIT, colonoscopy is recommended to diagnose CRC and to diagnose and remove precancerous polyps (2). Colonoscopy is also used for surveillance in persons with high-risk adenomas and CRC as well as to diagnose other digestive diseases such as inflammatory bowel disease. Poor-quality colonoscopy is associated with post-colonoscopy colorectal cancer (PCCRC) (3) and adverse events related to the procedure (4), which carry negative consequences for the patient. To improve the quality of these procedures, colonoscopy quality improvement and assurance initiatives have been developed worldwide, including in Ontario, and rely on quantifiable, evidence-based quality measures and strategies.

This evidence summary updates the evidence summarized in the 2013 CCO-PEBC "Guideline for Colonoscopy Quality Assurance in Ontario" with new information, including topic areas for which evidence was limited in the original review. The ColonCancerCheck and the GI Endoscopy Programs at OH (CCO) will be informed by this work. The project was led by a Working Group comprised of endoscopists, surgeons, program planners, patient representatives and research methodologists, which was responsible for developing the scope of the project and reviewing and summarizing the evidence base.

This systematic review has been registered on the PROSPERO website (International prospective register of systematic reviews) with the following registration number CRD42021225619.

**OBJECTIVE AND RESEARCH QUESTION**

The purpose of this report is to evaluate the existing evidence concerning colonoscopy quality indicators. Future work will address questions related to facility standards, acquiring, and maintaining competence and equipment. The current research question was developed to direct the search for available evidence to support quality improvement and assurance for colonoscopy in Ontario:

- What evidence is available for colonoscopy quality indicators, and is there any evidence to support benchmarks for these indicators to improve patient outcomes?

**In-scope Quality Indicators**

The Working Group considered the following colonoscopy quality indicators in scope (Table 1.0). They were chosen via consensus of the group, based on previous 2013 PEBC guidelines (5) and the 2016 UK Performance Standards (6). They were organized into categories of outcome and process indicators in accordance with Donabedian's health care framework, which is based on three pillars: structure, process and outcomes (7). Structural indicators, as described by Donabedian, will be addressed in subsequent evidence summaries. Outcome indicators examine the direct effect of health care on patients or populations while process measures address the actions that occur during the delivery of health care. Outcome indicators are often characterized as the most important indicators of quality; however, they are also often challenging to measure. Process measures are easier to assess, and they are valued as they are felt to be associated with important outcomes. The Working Group categorized the process indicators as those pertaining to the quality of inspection, polyp management/other interventions as well as appropriateness of procedural indication.

**Table 1.0. List of Indicators for Quality Colonoscopy.**

| **Outcome Indicators** |
|---|
| Post-colonoscopy CRC<br>CRC detection rate<br>Rates of surgical resection for large/complex polyps<br>Adverse events<br>• perforations<br>  ○ overall colonoscopy perforation rate<br>  ○ post-polypectomy perforation rate<br>  ○ colonoscopy perforation rate where dilation performed<br>  ○ colorectal stenting perforation rate<br>• post-polypectomy bleeding rate<br>• mortality<br>• unplanned admissions<br>Patient outcomes<br>• comfort level<br>• satisfaction/experience |
| **Process Indicators** |
| Quality of Inspection<br>• adenoma detection rate (thresholds may vary by indication)<br>• polypectomy rate (thresholds may vary by indication)<br>• colonoscope withdrawal time<br>• cecal intubation rate<br>• bowel preparation<br>• retroflexion rate |
| Polyp Management and Other Interventions<br>• polyp retrieval rate<br>• incomplete polyp resection<br>• indicators of appropriate management (e.g., polyp adjudication)<br>• endoscopic resection technique (e.g., tattooing) for large/complex polyps<br>• advanced visualization techniques<br>• diagnostic biopsies for unexplained diarrhea |
| Extra Procedural<br>• appropriate indication for colonoscopy (including need and timing of surveillance) |

**Abbreviations:** CRC, colorectal cancer

## TARGET POPULATION

Adult patients undergoing colonoscopy in Ontario.

## INTENDED PURPOSE

To summarize evidence available regarding quality indicators for colonoscopy including definition and validation of indicators, benchmarking and targets.

## INTENDED USERS

This document is intended for healthcare professionals involved in the delivery of colonoscopy to patients in Ontario and for policy makers and program planners involved in quality assurance at OH (CCO), as well as at hospitals and out-of-hospital premises where colonoscopies are performed. Colonoscopy may be performed for a variety of indications, specifically: follow-up to an abnormal FIT result, screening for those who have a family history of CRC, investigation of symptomatic patients, surveillance of those with a history of advanced adenomatous or serrated polyps, inflammatory bowel disease or CRC, and other screening.

## METHODS

This evidence summary was developed by a Working Group consisting of endoscopists (including both gastroenterologists and surgeons), nurses, program planners, patient representatives and health research methodologists, at the request of the Prevention and Cancer Control, Ontario Health (Cancer Care Ontario).

The Working Group was responsible for reviewing the identified evidence and drafting the summary. Conflict of interest declarations for all authors are summarized in Appendix 1, and were managed in accordance with the *PEBC Conflict of Interest Policy*.

This evidence review was conducted in two planned stages, including a search for guidelines and systematic reviews followed by a search for primary literature. These stages are described in subsequent sections.

### Search for Guidelines

As a first step in developing this review, a search for existing guidelines and systematic reviews was undertaken to determine whether existing guideline(s) could be used as a basis for this evidence summary. Existing guidelines were considered if they were evidence-based guidelines with systematic reviews that addressed the research question. In addition, guidelines older than three years (published before 2018) and guidelines based on consensus/expert opinion were excluded.

The following sources were searched for guidelines on November 25, 2021: Canadian Medical Association Journal Infobase, Scottish Intercollegiate Guidelines Network, American Society of Clinical Oncology (ASCO), National Health and Medical Research Council – Australia Clinical Practice Guidelines Portal, and Cancer Council Australia, National Institute for Health and Care Excellence, ECRI database, and Canadian Partnership Against Cancer, MEDLINE, EMBASE and gastrointestinal society websites. The search strategy and list of websites can be found in Appendix 2.

Guidelines that were considered relevant to the objectives and the research question were then evaluated for quality using the AGREE II instrument (8). The guideline endorsement criterion was that the AGREE II rigour of development domain, which assesses the methodological quality of the guideline, was above 50%.

**Search for Systematic Reviews**

An overall search strategy was developed and implemented that captured existing systematic reviews in the following databases: MEDLINE, EMBASE, and the Cochrane Database of Systematic Reviews for the years 2015-January 2021. Then an individual search was conducted for systematic reviews for each indicator between January 2021-November 2022.

Identified systematic reviews were evaluated based on their clinical content and relevance. Systematic reviews that were found to be directly relevant to this evidence summary were assessed using the Risk of Bias in Systematic Reviews (ROBIS) tool (9) to determine whether existing systematic review had sound methodological quality and could be considered for inclusion in the evidence base. If more than one systematic review met the inclusion criteria, then the Working Group reviewed the systematic review based on its age, quality, and the best match with the study selection criteria. Search terms and selection criteria can be found in Appendix 2.

**Search for Primary Literature**

For each indicator, a search for primary literature was conducted. For indicators where one or more relevant, high-quality systematic reviews were identified, an updated search for primary literature was performed from the point in time that the existing systematic review search ended. If no systematic reviews were found for an indicator, then a search for primary literature was conducted.

***Literature Search Strategy***

MEDLINE and EMBASE were searched for primary studies beginning from January 2015. When a systematic review was included, the search for primary studies started at the end of the search timeframe described in the included systematic review. Reference lists of papers and review articles were scanned for additional citations. Please see Appendix 2 for the full search strategy. Due to the large number of indicators, search strategies were conducted in a step-by-step manner.

***Study Selection Criteria and Process***

Inclusion Criteria:

- Standards, guidelines, systematic reviews, randomized controlled trials (RCTs) or observational studies relevant to the research question
- Minimum study size of 20 participants
- Adults over the age of 18 years
- Provided evidence to support using the indicator
- Provided evidence to define and measure the indicator and provide data to support a target or benchmark
- Only studies that validated patient outcomes were retained
- Provided data on rates for those indicators quantifying adverse events such as perforations, post-colonoscopy bleeds, mortality and unplanned admissions.

Exclusion Criteria:

Letters, editorials, abstract reports, papers published in a language other than English (because of lack of funds for translation), and studies limited to the assessment of special populations, e.g., high-risk populations, studies that assessed flexible sigmoidoscopy only, studies in which the results for colonoscopy could not be separated from the results for flexible sigmoidoscopy.

A review of the titles and abstracts was conducted by one reviewer (CZ) independently. If uncertainty existed for a given abstract, a second reviewer (JT) would review the paper in question.

For studies that warranted full-text review, one reviewer (CZ) independently reviewed each study. If uncertainty existed for a given study a second reviewer (JT) would review the paper in question.

***Data Extraction and Assessment of Risk of Bias***

All included primary studies underwent data extraction by CZ, TD, MD, with all extracted data and information audited subsequently by an independent auditor. The Risk of Bias Tool 2.0 (RoB-2 tool) (10) for RCTs, the Risk of Bias in Non-randomized Studies Quality Assessment Tool (ROBINS) tool (11) for cohort studies and case-control studies and the Joanna Briggs Institute (JBI) Critical Checklists for cross-sectional studies (12).

**Synthesizing the Evidence**

Meta-analysis was not planned due to the heterogeneity of the data for any of the outcomes. Weighted means were calculated for perforation rates, post-colonoscopy bleeding rates and mortality rates. For correlational data, a correlation coefficient of r=0.7 and higher was considered a strong correlation; a correlation coefficient between r=0.4 and r=0.7 was considered moderate correlation; and a correlation coefficient of r=0.4 or less was considered weak.

An accepted interpretation of intraclass coefficient (ICC) includes the following: values ≤0.4 demonstrate poor correlation, 0.41–0.59 is fair, 0.60–0.74 is good, and ≥0.75 is excellent reliability (13). The internal consistency was determined by calculating Cronbach's alpha and item-total correlations for verifying the reliability. A Cronbach's alpha between 0.7 and 0.95 was accepted for internal consistency (14).

**Evidence Assessment for Individual Indicators**

The Working Group applied the ISFU system (Importance to measure and report, Scientific Acceptability, Feasibility, Usability, and Comparison to related/competing measures), which results in a table that summarizes those criteria for each indicator (15). The ISFU system has been used by the European Society of Gastrointestinal Endoscopy (ESGE) for their colonoscopy quality improvement initiative (16). (See Appendix 7 for full description of the ISFU framework). The ISFU system also considers implementation and other relevant dimensions allowing for targets and benchmarks to be more meaningful and operational. ISFU was used because GRADE was believed to be sub optimally structured to assess the certainty of the evidence for quality indicators. For the importance category in the ISFU framework, the Working Group used three categories: high importance, important and less important. High importance was related to the indicators that were shown to have a direct impact on colonoscopy care and quality, where the supporting evidence was methodologically sound, significant, and precise (i.e., does not vary across studies). A ranking of important was used when the indicator had been shown indirectly to have an impact on patient care and/or measured a unique aspect of colonoscopy quality, and where the supporting evidence was methodologically sound, significant, and precise (i.e., does not vary across studies). A less important ranking was used when indicator had been shown indirectly to have an impact on patient care and if the evidence supporting had important methodological issues.

We also added a summary judgement using elements from the GRADE process for quality assessment. The components used from GRADE (Grading of Recommendations, Assessment, Development, and Evaluation) incudes assessments of the risk of bias, inconsistency, indirectness, and imprecision (17).

GRADE rating of evidence quality: High quality = very confident that the true effect lies close to that of the estimate of effect; Moderate quality = moderately confident in the effect estimate so the true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different; Low quality = confidence in the effect estimate is limited, therefore the true effect may be substantially different from the estimate of the effect. Very low quality = very little confidence in the effect estimates and the true effect is likely to be substantially different from the estimate of effect.

For each indicator, the available evidence is summarized under headings related to its definition, validation (compared to important patient outcomes or other established colonoscopy quality indicators), and targets/benchmarking. In select cases, where data on definitions and targets were not available, rates are reported.

## RESULTS

### Search for Guidelines

There were 13 guidelines identified in the search, of which nine met the inclusion criteria and, therefore, underwent a full-text review, and one was retained. The UK guideline and supporting systemic review by Rees et al. (6) was selected as the source document from which to update the evidence by the Working Group because of its comprehensive approach to colonoscopy quality.

### Guideline Assessment

Two reviewers evaluated this guideline independently using the AGREE II tool. The rigour of development domain was 52%, which met the a priori endorsement criterion noted above. The guideline scored well for all other domains, except the applicability domain. The guideline received a lower score for the applicability domain because the potential resource implications of applying the recommendations was not discussed. Overall, both reviewers (CZ and TD) recommended this guideline for use (See Appendix 5).

### Literature Search Results

In total, 2430 articles were found through the literature search. Two hundred and eighty articles were selected for full-text review and 127 were retained. Of 143 systematic reviews identified, 51 were considered for full-text review and 14 met the inclusion criteria. The others were excluded as they were not relevant to the scope of the summary. Table 2.0 summarizes the included studies by indicator and type. See Appendix 3 for the PRISMA diagram of search results and Appendix 5 for quality assessment results.

**Table 2.0. Studies Selected for Inclusion.**

| Indicator | Studies |
|---|---|
| Post-colonoscopy colorectal cancer | 1 SR, 1 case-control, 16 cohort |
| Rate of surgical resection | 3 SR, 18 cohort, 2 guidelines |
| Adverse events | 4 SR, 20 cohort studies |
| • overall | 12 cohort |
| • perforations | 2 SR, 18 cohort |
| • post-colonoscopy bleeds | 3 SR, 17 cohort |
| • mortality | 2 SR, 13 cohort |
| • unplanned admissions | 7 cohort |
| Patient outcomes | |
| • pain and comfort | 3 validation studies |
| • satisfaction | 6 validation studies |
| Adenoma detection rate | 1 SR, 31 cohort studies |
| Withdrawal time | 4 RCT, 9 cohort |
| Cecal intubation rate | 1 SR, 1 cohort |
| Bowel preparation | 2 SR, 1 review, 8 cohort, 1 cross sectional |
| Retroflexion | 3 SR, 2 RCT, 1 cohort |
| Performance Indicator of Colonic Intubation | 3 cohort |
| Terminal ileum intubation rate | 1 cohort |
| Polyp management | |
| • incomplete resection | 1 cross sectional |

**Abbreviations:** RCT, randomized controlled trial; SR, systematic review.

**Outcome Indicators**

The Working Group considered the evidence for five colonoscopy outcome indicators: PCCRC, CRC detection rate, the rate of surgical resection for large/complex polyps, adverse events, and patient outcomes.

***PCCRC***

PCCRC is a CRC diagnosed after a colonoscopy where a cancer is not detected (a 'negative' colonoscopy). PCCRCs may be due to a missed cancer, a cancer arising in a missed or incompletely resected adenoma, or a cancer that started to develop after the colonoscopy (6). PCCRCs are important markers of colonoscopy quality but as they are relatively uncommon and because of the delay from the initial colonoscopy to eventual diagnosis, PCCRC rates are difficult to measure and interpret (6).

The evidence to support PCCRC as a quality indicator comes from one guideline on performance indicators, one World Endoscopy Organization (WEO) statement paper on PCCRC definition and calculation (18), one systematic review (19) and 17 studies (5, 20-35) (Appendix 4, Table 4.1 and 4.2). The UK performance indicator guideline recommended that PCCRC should be a quality indicator for colonoscopy but noted variation in the reported rates of PCCRCs, likely in part because of different methodologies used (6). Recommendations included measuring PCCRC at the facility level and that there should be a system to capture data and review of each case of PCCRC to determine its root causes. The WEO developed consensus statements to standardize the calculation of PCCRC rates and the approach to the root cause analysis (18). The systematic review and meta-analysis from Kang et al. identified 15 population-based or multicentre studies from 2013-2021 reporting on PCCRC rates; rates were reviewed considering their alignment with WEO methodology (19). Seventeen studies were identified from the primary literature that examined the rates, root cause, risk factors of PCCRC

and its association with important outcomes and other quality indicators (5, 20-35). These studies used data sources that ranged from single-centre databases to national databases. Some studies were limited to PCCRCs in CRC screening programs while other studies examined PCCRCs related to all colonoscopy indications including diagnostic and surveillance.

*Definition*

In 2018, the WEO gathered a 20-member international team to develop consensus recommendations to standardize the definition of PCCRC and the calculation of PCCRC rates (18). They defined PCCRC as cancers appearing after a colonoscopy in which no cancer is diagnosed, up to 10 years after the colonoscopy. Quantitative and qualitative approaches were considered. For the former, the team recommended that the unadjusted PCCRC rate be calculated at the endoscopy unit level or higher, based on the date of the colonoscopy, with the term "detected cancer" being used to describe cancers diagnosed by the colonoscopy or within six months of the date of the colonoscopy; and PCCRC be used to describe those cancers identified from six months to three years from the date of the colonoscopy. The recommended approach for calculating the PCCRC rate is shown in Box 1.0. For the qualitative assessment, they recommended a formal process to identify and register PCCRC cases as well as using root cause analysis to determine the most plausible explanation(s). For this assessment, a four-year window (rather than three years) from the last colonoscopy is suggested when assigning the most plausible etiology.

The systematic review by Kang et al, and nine of the 17 studies examining PCCRC, used a definition of PCCRC that was consistent with the WEO's (5, 19, 22, 24, 26-28, 30, 32, 35), and four of those studies calculated the rate of PCCRC consistent with the WEO's recommendation for calculating this rate (24, 26, 30, 35). The other eight studies did not meet the WEO definition or calculation as they used other end dates and times to cancer diagnosis (21, 23, 25, 29, 31, 33, 34) (Appendix 4, Table 4.3).

**Box 1.0 WEO PCCRC Rate Calculation.**

| WEO methodology for PCCRC 3-year rate calculation |
|---|
| Identify all people undergoing a colonoscopy in a certain year<br><br>Each colonoscopy is labeled according to the outcome of the test:<br>• True-positive colonoscopy (where a CRC was detected at that procedure, or within 6 months—a "detected CRC")<br>• False-negative colonoscopy (where a CRC was detected between 6 and 36 months after the procedure—a "PCCRC")<br>• True-negative colonoscopy (no CRC detected within 36 months after the procedure)<br><br>The PCCRC 3-year rate is then calculated as: false negatives / (true positives + false negatives) % |

*Rates*

The UK performance standards state that endoscopy units should aspire to a target of <5% PCCRC (using a 3-year window from the initial colonoscopy). They reported a wide variation in the PCCRC rate in the studies they reviewed (from 0%-9%; studies had a mean window of 5 years from the initial colonoscopy) likely due differing study designs and calculations (6). They justified their target rate using a UK study that compared PCCRC rates from 2001 and 2008 using National Cancer Data Repository information and found that the rate fell over time from 10.6% to 6.8% (36).

Kang found four studies where the PCCRC rates ranged from 4.7 to 8.6% when measured using the WEO rate methodology (19). The three-year pooled rate for these four studies was 8.2% (95% confidence interval [CI], 6.9% to 9.4%, $I^2$=98.2%) (19).

Two studies reported PCCRC rates in different subpopulations (30, 35). Although the precise estimates varied across the two studies, PCCRC rates were notably higher in those with a history of inflammatory bowel disease and with a history of CRC compared to other subgroups (Appendix 4, Table 4.3).

*Validation: association with comparator and important outcomes*

Eight studies provided data to validate PCCRC (5, 22, 24, 27-29, 33, 35) (Appendix 4, Table 4.4). Six studies compared outcomes in patients with PCCRC to patients with detected CRC (DCRC) (5, 22, 28, 29, 33, 35). Dossa et al. found the adjusted five-year overall survival was not significantly different in patients with PCCRC than in patients with DCRC (hazard ratio [HR], 1.12; 95% CI, 0.92 to 1.32) (22). Cheung et al. found that the PCCRC-3yr had a worse cancer-specific survival than DCRC (log–rank p<0.001) (28). Macken et al. did a conditional survival analysis for all patients alive three years after their colonoscopy and compared those with and without PCCRC (27). Eighty percent of patient with PCCRC survived 1.6 years (95% CI, 1.2 to 2.0) while for those with DCRC 80% survived 2.8 years (95% CI, 2.6 to 2.9) (27). Govindarajan et al. found the five-year overall survival was significantly different among DCRC: 68.3%; PCCRC: 60.8%; and those who did not have a colonoscopy prior to the diagnosis date: 38.9%, p<0.001 (5). Multivariable analysis examining PCCRC vs. DCRC found significant differences in overall 5-year survival (adj HR, 1.25; 95% CI, 1.17 to 1.32, p<0.0001) and other important outcomes including surgical resection (adj odds ratio [OR], 0.65; 95% CI, 0.59 to 0.72, p<0.001), and emergency room presentation (adj OR, 2.86; 95% CI, 2.56 to 3.13, p<0.001). Stoffel et al. found that patients with PCCRC had less metastatic cancer (compared to localized and regional) at presentation (OR, 0.66; 95% CI, 0.48 to 0.90, p<0.001), than patients with DCRC (33).

*Root Cause Analysis*

Two studies of single centres (23, 24) used root cause analysis to classify PCCRC cases into the four categories of most plausible explanation as described by the WEO: possible missed lesion, prior examination adequate; possible missed lesion, prior examination negative but inadequate; detected lesion, not resected; or likely incomplete resection of previously identified lesion (Appendix 4, Table 4.5).

Aerts et al. found when excluding likely new CRCs, that 52.2% of PCCRCs were due to a possible missed lesion with a prior adequate examination and 17.4% due to the examination being inadequate; and 30.4% due to a likely incomplete resection of previously identified lesion (23). Anderson et al. found that 27% of PCCRCs were due to a possible missed lesion with a prior examination adequate and 58% due to the examination being inadequate; and 8% were categorized as detected lesion, not resected, 7% were categorized as likely incomplete resection of previously identified lesion, 7% could not be categorized and detected lesions not resected was 0% (24).

*Certainty of the Evidence*

The systematic review by Kang et al. was assessed using the ROBIS tool to assess the risk of bias and was found to have a low risk of bias for each domain and overall (19). The assessment of the systematic review found the quality of evidence of the included studies to be moderate overall, with five being high-quality studies. Sixteen of the studies found in the primary literature search were cohort studies and were assessed using the ROBINS tool for risk of bias in non-randomized studies (11). Overall, they were found to be at moderate risk of bias.

Tollivoro et al. was assessed using the ROBINS tool for risk of bias in case-control studies and was found to have a moderate risk of bias (25). See Appendix 6 for Quality Assessment Scores.

*Discussion and Implementation Considerations*

Based on the evidence outlined above, the Working Group considered PCCRC to be a quality indicator of high importance given its association with worse patient and cancer outcomes. PCCRC was felt to be an important measure to the patient.

There was agreement that the WEO definition was the preferred method to measure PCCRCs, as the standardized approach would facilitate comparison across and within jurisdictions. The Working Group felt that it should be applied to the facility level and above (i.e., region, province) and that facilities should be encouraged to perform a root cause analysis as a quality improvement initiative. Potential issues with measuring PCCRCs in high-risk groups were noted. Specifically, persons with inflammatory bowel disease or recent CRC are often recommended surveillance colonoscopies at short intervals. In these individuals, cancers may be identified as PCCRCs when adherent to recommended surveillance intervals and as 'DCRCs' when poorly adherent. The Working Group did not feel the evidence supported defining a target, future work could include target setting as the evidence emerges. Table 3.0 summarizes the evidence quality and ISFU criteria for PCCRC.

**Table 3.0. Summary Table: PCCRC.**

| Indicator | Number of studies | GRADE evaluation | ISFU Criteria | | | | |
|---|---|---|---|---|---|---|---|
| | | | **Importance to measure and report** | **Scientific acceptability of measure properties** | **Feasibility** | **Usability and use** | **Comparison to related or competing measures** |
| PCCRC | 1 SR<br>1 case-control<br>16 cohort studies | Moderate | High importance | PCCRC is well defined and precisely specified so it can be implemented consistently<br><br>Monitoring allows for identification of clinically meaningful differences in performance in specific circumstances (e.g., sufficiently large sample to measure rates) | May be feasible to report as a performance measure at the provincial, regional, facility and individual level<br><br>Required linkages (e.g., to cancer registries and across facilities) may limit feasibility<br><br>Measurement and interpretation in high-risk populations pose challenges | Likely useful for performance improvement<br><br>Data lags may limit usability<br><br>Used to calculate rates if sample size is sufficiently large, otherwise can be used for practice audit<br><br>It may be confusing to users if different time periods for practice audit and rate calculations are used | Key measure of the ability of colonoscopy to detect and prevent colorectal cancer<br><br>Important to the patient |

**Abbreviations:** GRADE, Grading of Recommendations, Assessment, Development and Evaluation; ISFU, importance, scientific acceptability, feasibility, usability, and comparison to related/competing measures; PCCRC, post-colonoscopy colorectal cancer; SR, systematic review.

### *CRC Detection Rate*

CRC detection rate measures the proportion of colonoscopies in which a CRC is diagnosed. We did not find any studies that supported the use of CRC detection rate as a colonoscopy quality indicator, either by validating a definition/target or by validating it against comparator indicators or important patient outcomes. We did note that CRC detection rates are reported in some circumstances. For example, the Dutch CRC screening program recommends monitoring abnormal FIT colonoscopy CRC detection rate (37) and in Ontario, the CRC detection rate for colonoscopy is reported for all indications in persons over age 50 (38). One of the key concerns of using CRC detection rate as a quality indicator is it is susceptible to case mix (by indication, age or setting, for example). Therefore, the Working Group advised against using CRC detection rate as a quality indicator given the lack of evidence and the concerns around case mix.

### *Rates of Surgical Resection for Large/Complex Polyps*

*Definition*

Large colorectal polyps can be challenging to remove due to their large size, shape, or position. Despite these challenges, the majority of large polyps can be resected endoscopically with low complication rates. Endoscopic resection (ER) techniques include endoscopic mucosal resection (EMR) and endoscopic submucosal dissection (ESD). EMR is the removal of complex polyps (usually >10 mm) using submucosal injection followed by hot or cold snare resection. ESD is en-bloc (singular piece) resection of target lesions through the use of an electrosurgical knife that is used to both cut through the mucosa and dissect the submucosal layer. However, if complex polyps are not amenable to ER, then surgical resection may be more appropriate, although the associated risks are higher compared to endoscopy. Given the advantages of endoscopic management of these polyps, low rates of surgical resection of large/complex polyps are desirable (39, 40).

A search of studies concerning rates of surgical resection for large/complex polyps as a quality indictor found three systematic reviews with meta-analysis (40-42). Endoscopic techniques for the assessment of large polyps (e.g., use of NBI) were not included and will be included in subsequent reviews. In total, three systematic reviews (40-42) and 18 studies were retained (43-60) (Appendix 4, Tables 4.6 and 4.7). The literature was classified into three groups: outcomes for endoscopic vs. surgical resection, outcomes for ER only, and rates and trends for complex polyps at the population level.

The UK guideline stipulates that all units should have a policy for the management of polyps, including large and large sessile polyps, and that the use of a multidisciplinary team to discuss complex polyps would be beneficial (6). The ESGE 2017 guideline recommends that large (≥20 mm) sessile and laterally spreading or complex polyps should be removed by an appropriately trained and experienced endoscopist, in an appropriately resourced endoscopy centre (61). (Moderate quality evidence, strong recommendation.)

*Endoscopic vs. Surgical Resection*

Eight studies compared ER and surgical resection of large polyps, examining outcomes such as the difference in adverse events (such as post-colonoscopy bleeds and perforations) and quality of life scores (44, 49, 51, 53, 54, 58). Patients who underwent ER to remove their polyps were at lower risk of post-procedure adverse events compared to those who had surgery in Parker et al., (5.5% vs. 31.7%, $p<0.001$) (50), Wickham et al. (4.2% vs. 33.9%, $p<0.001$) (58), Patel et al. (0.6% vs. 22%, $p=0.0001$) (51), Bosch et al. (16.3% vs. 44.3%, $p=0.001$) (44), and Moon et al. (5.9% vs. 22.8%; $p<0.001$) (49). The definition and severity of adverse events varied widely across these studies.

Parker et al., Wickham et al., Patel et al., Bosch et al., and Moon et al., reported that the hospital lengths of stay for endoscopic resection were significantly shorter than those for surgical resection (44, 49, 51, 53, 54, 58).

Wickham et al., (58) found a significant increase n the rate of hospital readmissions for colonic resection compared to ER, while Parker et al., (50) and Bosch et al., (44) did not.

Using the European Organization for Research and Treatment of Cancer Quality of Life Scale (EORTC-OLO-C30), one paper studied patients who had ESD (53). Qu et al. found that two years postoperative, patients who had ESD had statistically significant higher scores in general quality of life, emotional functioning, fatigue, constipation, and diarrhea than patients who had surgery (53). They also found that the ESD group had shorter operation time (45.6 vs. 88.4 min, p=0.001) and shorter mean hospital stay (6.8 vs. 10.4 days, p=0.001) than the surgery group (53).

*Endoscopic Resection Only*

The success rate for ER of large polyps is high and complication rates are low. Thorlacuis et al. conducted a systematic review of 15 studies to summarize ESD in Europe (42). They found an en bloc rate of 83% (range: 67-93%) and complete histologic resection (R0) rate of 70% (range:35-91%). Hassan et al. to assess the efficacy and safety of ER, conducted an meta-analysis of over 50 studies with patients with at least one polyp 20mm or larger (41). They found that ER was successful in 90.3% of patients (95% CI 88.2% to 92.5%), with perforation in 1.5% of cases, bleeding in 6.5% of cases and that ER prevented surgery in 92% of cases.

For the seven retrospective studies investigating outcomes associated with ER, three focused on EMR (43, 45, 48) and the other four examined ESD (43, 46, 47, 55, 56). The success rate reported for two studies using EMR was 95% (43, 45) and for the studies using ESD, the range reported for success rate was from 83-95% (47, 55, 56). ESD related perforations were reported in three studies and were in 5.3%, 5.8% and 7.3% of patients (47, 55, 56). Only one EMR study reported any perforation rate which was 0.6% (45). Recurrence rates were reported in two EMR studies. Chaoui et al., found recurrent adenomas in 16.2% of patients after a median time of 6.2 months (IQR 5-9.9) (45) and Azevedo et al., had a recurrent rate of 25.8% (43). ESD was successful in removing very large polyps of 10 cm or more in two studies (46, 55). One of those studies found that adverse events were comparable between large ≥10 cm and smaller 5–10 cm polyps (16 vs. 7, p=0.115) (46). In two studies examining ESD use in polyps over 20 mm, the en bloc success rate was 93.9% (study limited to polyps without deep invasion) and 61% (study not limited in terms of risk of deep invasion) (48, 56). Spychalski et al., had an 88.0% en bloc success rate with ESD in polyps over 10 cm (55).

*Rates and Trends of Surgical and Endoscopic Resection at the Population Level*

Quantifying rates of surgical resection allows jurisdictions to track trends over time and to compare their performance with other jurisdictions. In a systematic review of 26 studies examining postoperative outcomes by de Neree Tot Babberich et al. five studies reported on surgical referral rates, ranging from 4.1-21.7%, with polyp location in the right-sided colon, non-pedunculated morphology, and large polyp size comprising the most common reasons for surgical resection referral (40). They also pooled data from these 26 studies to calculate a surgical complication rate of 17% (95%CI, 10% to 29%) and a nonsurgical complication (post operative adverse events not related to the surgical technique itself) rate of 9% (95%CI 6-13%). Peery et al. reported a significant increase in the incidence of surgery over time in the USA for non-malignant polyps ranging from 5.9 in 2000 to 9.4 in 2014 per 10000 adults in the USA (52). Yu et al. examining trends in the USA, found a significant increase in the rate of EMR use from 1.62% in 2011 to 2.48% in 2015 (p<0.001) (59). Rodrigues et al. compared surgery rates before and after a regional referral network was implemented in their screening program in 2015 (54).

Among the 1571 patients who underwent colonoscopy, the trend in surgery rates for benign lesions decreased from 14.6% in 2012 to 7.7% in 2016 and 5% in 2017 (p=0.017). However, for lesions 20mm or larger (105 patients), the surgery rate trended towards less surgery but was not significantly different (62.5% in 2012 to 53.62% in 2016 and 40% in 2017; p=0.38). They also found that reasons for surgery referral for lesions ≥ 20 mm included the large size and location of the lesion, endoscopic suspicion of malignancy and ER failure (Appendix 4, Table 4.8).

*Certainty of the Evidence*

The three systematic reviews were assessed using the ROBIS tool and all had a low risk of bias (9). The 18 cohort studies were assessed using the ROBINS tool for non-randomized studies and had an overall moderate risk of bias (11). See Appendix 6 for all quality assessments.

*Discussion*

Based on the evidence, the Working Group felt that that low rates of surgical resection for large complex polyps were desirable. However, they also felt that the evidence in this area was emerging and consisted largely of descriptive studies. No validated and relevant quality indicators were identified in the literature. As such, the Working Group felt that an ISFU table could not be generated. For example, the Working Group felt that while rates of surgical resection could be measured using health administrative data, but it would be challenging to ascertain whether the decision to manage the polyp surgically was correct. The Working Group recommended further study in this area to support indicator development. In light of the complexity involved with the management of these large complex polyps and the data from Rodrigues et al., the Working Group supported the UK guideline recommendations for adjudication by multidisciplinary teams (54).

***Adverse events***

Adverse events can occur as a result of the colonoscopy; these include perforation, post-colonoscopy bleeding, hospital admission and death. Typically, adverse events are reported as rates (per 100 or 1000 colonoscopies). The risk of adverse events increases when therapeutic procedures, such as polypectomy or dilation, are performed. Polypectomy is more common, and polyps tend to be more complex when the colonoscopy is performed for an abnormal FIT result. It is important that endoscopy units develop quality assurance approaches to investigate adverse events and to monitor the frequency and conditions of these events (6).

The evidence to support complication rates as a quality indicator is derived from four systematic reviews (4, 62-64) and 20 studies from the primary literature (65-84) (Appendix 4, Tables 4.9 and 4.10). We did not find studies that validated definitions/targets for complication rates or by validating them against comparator indicators or important patient outcomes. The literature largely comprises reports of rates from different jurisdictions; given the potential for adverse events to vary by procedure complexity and because of the relevance to CRC screening programs, studies were stratified into those that only included abnormal FIT colonoscopies, only abnormal fecal occult blood test (FOBT) colonoscopies and those studies that included all colonoscopies across for all indications.

***Overall adverse events***

*Definition*

The UK performance standard did not provide any guidance on overall adverse events rates. The overall adverse events rate is the number of colonoscopies per 1000 that results in an individual being admitted to the hospital within 14 or 30 days (depending on the study) post-procedure for any complication or adverse event (6).

*Rates*

There were 12 cohort studies that provided overall complication rates (66, 70, 72, 73, 76-79, 81-84) (Appendix 4, Table 4.11. Two studies using data for colonoscopies completed across all indications, found overall complication rates of 17/1000 and 34/1000 (72, 79). For colonoscopies after an abnormal FIT, overall complication rates ranged from 0.8-11.2/1000 (66, 70, 76-78); while for colonoscopies after an abnormal FOBT, the rates ranged from 3.3-14.2/1000 (73, 81-84). For colonoscopies after an abnormal FOBT where polypectomy was performed, two studies found overall complication rates of 17.1/1000 and 18.4/1000 (83, 84).

*Discussion and Implementation Considerations*

The Working Group rated an overall measure of adverse events as important. They noted that from the patient perspective, overall complication rate is an important summary measure of risk and in particular, would be useful information to add to consent forms. Limitations were noted however, including a lack of consensus in the literature regarding what specific adverse events should be included in this composite measure and that as a composite measure, it is less well suited for targeted performance improvement. Table 4.0 summarizes the evidence quality and ISFU criteria for overall adverse events.

**Table 4.0. Summary Table: Overall Adverse Events.**

| Indicator | Number of studies | GRADE evaluation | ISFU Criteria | | | | |
|---|---|---|---|---|---|---|---|
| | | | Importance to measure and report | Scientific acceptability of measure properties | Feasibility | Usability and use | Comparison to related or competing measures |
| Overall adverse events | 12 cohort studies | Low | Important (Especially for patients)<br><br>Higher | There is face validity to this indicator. However, there is little comparison in studies to a gold standard (e.g., chart review)<br><br>Lack of consensus as to what adverse events ought to be included for this composite measure | Required linkages (i.e., to track adverse events presenting to another facility) may limit feasibility<br><br>Systematically measuring this indicator at the provincial, regional, or facility level is likely possible | Not suitable for targeted performance improvement<br><br>Data lags may limit usability | Important to the patient |

**Abbreviations:** GRADE, Grading of Recommendations, Assessment, Development and Evaluation; ISFU, importance, scientific acceptability, feasibility, usability, and comparison to related/competing measures; QI, quality indicator.

## *Perforations*

*Definition*

Perforations occur when the wall of the bowel is punctured during a colonoscopy, typically occurring during polypectomy (especially complex polyps) or as a result of shear injury to the bowel wall. A facility or jurisdiction's perforation rate may be influenced by case mix

(the ratio of screening or diagnostic colonoscopies to the therapeutic procedures performed) (6). Typically, the perforation rate is the number of colonoscopies per 1000 that result in an individual being admitted to the hospital post-procedure (generally within 1-2 weeks) for a perforation (6).

*Rates*

There were two systematic reviews and 18 cohort studies that reported perforation rates (65-67, 69, 70, 72-84). Of these, five studies reported rates for colonoscopies done for abnormal FIT indication (66, 70, 76-78) and five studies reported rates for colonoscopies done for abnormal FOBT indication (67, 73, 80-82) (Appendix 4, Table 4.12). Ten studies calculated perforation rates for colonoscopies where polypectomy was performed (65-67, 69, 70, 75, 77, 81-83).

The UK guidance recommends that the target for the overall colonoscopy perforation rate be <1/1000 as a minimal standard with an aspirational standard of <0.33/1000. This guidance also provides perforation targets for diagnostic perforation rate, (minimal:<1/2000; aspirational:<1/4000), perforation rate where polypectomy is performed (minimal:<1/500; aspirational:<1/1500), perforation rate where dilation is performed (minimal:<1/33; aspirational:<1/100) and colorectal stenting perforation rate (minimal:<1/10; aspirational:<1/20) (6).

The risk of a perforation increases with the complexity of the procedure. For colonoscopies completed across all indications, two systematic reviews with meta-analyzes, Kothari et al. and Reumkens et al. calculated perforation rates of 0.58/1000 and 0.5/1000 (4, 63). There were five studies that examined perforation rate in all colonoscopies, reporting a range of 0.08-0.73/1000 (65, 69, 72, 74, 79).

For patients with a polypectomy, the meta-analysis by Reumkens et al. calculated a post-polypectomy perforation rate of 0.8/1000 whereas the two cohort studies observing post-polypectomy perforation rates reported rates of 0.08/1000 and 0.33/1000 colonoscopies (4).

Kothari et al. pooled EMR and ESD studies and calculated a perforation rate of 19/1000 (63) and a cohort study that examined EMR/ESD found a rate of 10/1000 (75).

Twelve studies examined perforation rate in colonoscopies after an abnormal FIT/FOBT (66, 67, 70, 76, 77, 82-88). The five studies that reported perforation rates on abnormal FIT colonoscopies had a range of 0.5-2.7/1000 (66, 70, 76-78). The weighted mean of the perforation rate in abnormal FIT colonoscopies was 0.7/1000 (standard deviation [SD]=0.9) The seven studies that examined abnormal FOBT colonoscopy perforation rates reported a range of 0.5-2.0/1000 for all abnormal FOBT colonoscopies (67, 73, 80-84) and 0.7-2.5/1000 for those where polypectomy was performed (67, 81-83, 89). The weighted mean of the perforation rate in abnormal FOBT colonoscopies was 0.7/1000 (SD=0.5).

*Discussion and Implementation Considerations*

The Working Group rated the measure of perforations as highly important given its potential to cause harm to the patient and therefore, the importance to the patient. The Working Group discussed its challenges in defining a target for perforations and the importance of reviewing outlier endoscopists with high perforation rates. The lack of a standardized method to measure perforations (i.e., different time frames, indications for colonoscopy, and procedure complexity) was identified as an important limitation that might have contributed to the heterogeneity in reported rates. The similarity in the rates reported in the systematic reviews for standard colonoscopies was noted as well as the relatively higher rates for higher risk procedures (i.e., abnormal fecal test, those where ESD/EMR was performed). These findings would appear to support different targets for standard and higher-risk procedures; however, the evidence base was not felt to be sufficient to determine what these specific

targets should be. Future work should focus on establishing targets, including by indication. Table 5.0 summarizes the evidence quality and ISFU criteria for perforation rate.

**Table 5.0. Summary Table: Perforations.**

| Indicator | Number of studies | GRADE evaluation | ISFU Criteria | | | | |
|---|---|---|---|---|---|---|---|
| | | | Importance to measure and report | Scientific acceptability of measure properties | Feasibility | Usability and use | Comparison to related or competing measures |
| Perforation rate | 2 SRs<br>18 cohort studies | Low | High<br>Important to have a measure to monitor intraprocedural care and endoscopist technical skills | There is face validity to this indicator. However, studies do not often compare to a gold standard (e.g., chart review)<br><br>Lack of consensus about the appropriate time frame to measure after colonoscopy<br><br>Lack of consensus about whether there should be a separate target for FIT vs. other indications<br><br>Lack of consensus about whether there should be a separate target by type of therapeutic procedure (e.g., ESD) | Required linkages (i.e., to track adverse events presenting to another facility) may limit feasibility<br><br>Systematically measuring this indicator at the provincial, regional, or facility level is likely possible | Likely useful for performance improvement | Important to the patient |

**Abbreviations:** EMR, endoscopic mucosal resection; ESD, endoscopic submucosal dissection; FIT, fecal immunochemical test; GRADE, Grading of Recommendations, Assessment, Development and Evaluation; ISFU, importance, scientific acceptability, feasibility, usability, and comparison to related/competing measures; SR, systematic review; vs, versus.

### *Post-colonoscopy Bleeding*

*Definition*

Post-colonoscopy bleeding typically occurs in procedures where polypectomy has been performed. Post-polypectomy bleeding may occur immediately, or it may be delayed for up to four weeks (63). The two main risk factors are the size and proximal location of polyps (6). Typically, the post-colonoscopy bleeding rate is the number of colonoscopies per 1000 that

result in an individual being admitted to the hospital (generally within 14 or 30 days) post-procedure for bleeding (6).

*Rates*

There were three systematic reviews and 17 cohort studies that calculated post-colonoscopy bleeding rates for all colonoscopies, and either with or without polypectomy (65-67, 69, 70, 72-79, 81-84) (Appendix 4, Table 4.13). Where studies report only on colonoscopies where polypectomy is performed, we refer to "post-polypectomy" bleeding, otherwise we use the term "post-colonoscopy" bleeding for studies that pool across indications or present stratified results (with and without polypectomy).

The UK guidance recommends a target for overall post-polypectomy target bleeding rate of <5/1000 as a minimal standard with an aspirational standard of <1/1000 (6).

Two recent meta-analyzes have been conducted; Kothari et al. pooled 15 studies for an overall post-colonoscopy bleeding rate of 2.4/1000 (63) and Reumkens et al. calculated post-colonoscopy bleeding rates of 2.6/1000 for procedures completed across all indications (16 studies), and 0.6/1000 for 11 studies of colonoscopies without polypectomy (4). Four studies reporting on colonoscopies completed across all indications had a post-colonoscopy bleeding rate range of 0.51-4/1000 (65, 69, 72, 74, 79). Yoshida et al. calculated a post-colonoscopy bleeding rate of 0.059/1000 for colonoscopies completed without polypectomy and a post-polypectomy bleeding rate of 1.36/1000 with polypectomy (65). Kim et al. reported a post-polypectomy bleeding rate of 0.73/1000 (69).

Reumkens et al. calculated post-polypectomy bleeding rates of 9.8/1000 for 14 pooled studies (4). Jaruvongvanich et al. reported a post-polypectomy bleeding rate of 15/1000 from pooled 12 studies (62). Two studies found a post-colonoscopy with polypectomy bleeding rate of 0.73 and 1.36/1000 (65, 69).

The five studies that reported on colonoscopies after an abnormal FIT had a post-colonoscopy bleed rate range of 0.3-6.2/1000 (66, 70, 76-78) with one study reporting a post-polypectomy rate of 3.69/1000 (70). The weighted mean of the post-colonoscopy bleeding rate in abnormal FIT colonoscopies was 2.2/1000 (SD=0.2).

The six studies that reported on colonoscopies after an abnormal FOBT had a post-colonoscopy bleed rate range of 1.3-6.6/1000 (67, 73, 81-84) and a post-polypectomy range of 4.3-14.0/1000 (67, 81-84). Two studies calculated the rates for no polypectomy with the post-colonoscopy bleeding rates of 0/1000 and 1/1000 (82, 83). The weighted mean of the post-colonoscopy bleeding rate in abnormal FOBT colonoscopies was 4.8/1000 (SD=2.7).

Given the increased use of advanced endoscopic techniques for removal of colorectal polyps such as EMR and ESD, it is important to report on their adverse events after these procedures (63). Kothari et al. pooled 27 EMR and ESD studies and computed a post-colonoscopy bleeding rate of 37/1000 (63). Amato et al. found an EMR/ESD bleeding rate of 112/1000 (75).

*Discussion and Implementation Considerations*

The Working Group rated the measure of post-colonoscopy bleeding rate as highly important given its potential to cause harm to the patient. As with perforations, the Working Group identified the lack of a standardized measure as an important limitation to interpreting data for this indicator. While the Working Group felt that overall post-colonoscopy bleeding rate could be used for patient consent, they felt the post-polypectomy rate was most pertinent for endoscopist performance measurement. As for perforation, different targets may be appropriate depending on the level of risk of the procedure. Future work should focus on establishing targets, including by indication. When doing so, targets should be based on studies using current polypectomy techniques (i.e., majority of polyps managed with cold snare). Table 6.0 summarizes the evidence quality and ISFU criteria for post-polypectomy bleeding rate.

**Table 6.0. Summary Table: Post-colonoscopy Bleeding.**

| Indicator | Number of studies | GRADE evaluation | ISFU Criteria | | | | |
|---|---|---|---|---|---|---|---|
| | | | Importance to measure and report | Scientific acceptability of measure properties | Feasibility | Usability and use | Comparison to related or competing measures |
| Post polypectomy bleeding rate | 3 SRs<br>17 cohort studies | Low | High<br>Important to have a measure to monitor intraprocedural care and endoscopist technical skills | There is face validity to this indicator. However, studies do not often compare to a gold standard (e.g., chart review)<br><br>Lack of consensus about the appropriate time frame to measure after colonoscopy<br><br>Lack of consensus about which indicator should be used to measure overall bleeding rate vs. post-polypectomy<br><br>Lack of consensus about whether there should be a separate target for FIT vs. other indications | Required linkages (i.e., to track adverse events presenting to another facility) may limit feasibility<br><br>Systematically measuring this indicator at the provincial, regional, or facility level is possible | Likely useful for performance improvement | Important to the patient |

**Abbreviations:** FIT, fecal immunochemical test; GRADE, Grading of Recommendations, Assessment, Development and Evaluation; ISFU, importance, scientific acceptability, feasibility, usability, and comparison to related/competing measures; SR, systematic review; vs, versus.

### *Mortality*

*Definition*

Death is a very rare complication of colonoscopy. Typically, the mortality rate is the number of individuals dying within a specified period of time (generally 14 or 30 days) of colonoscopy per 1000. Some report all-cause mortality while others report colonoscopy-specific (i.e., where the death can be attributed to the colonoscopy itself) mortality. There were two systematic reviews and 13 cohort studies that reported mortality rates for colonoscopy (65, 66, 68-72, 74, 76, 77, 80, 81, 83, 84) (Appendix 4, Table 4.14). Most studies used 30 days post-procedure to calculate the mortality rate (68-72, 74, 80, 81, 83, 84). Tomaszewski et al.,

Mikkelsen et al., and Yoshida et al., used a variety of days post-procedure to measure mortality calculations: 14-, 90- and 7-days respectively (65, 66, 76). The UK guidance did not have mortality rate as a quality indicator.

*Rates*

For colonoscopies completed across all indications, Kothari et al. pooled nine studies and reported a colonoscopy-specific mortality rate of 0.03/1000 (63) and Reumkens et al. pooled 19 studies reporting a colonoscopy-specific mortality rate of 0.029/1000 (4). As well, five cohort studies that reported on all-cause mortality rate for colonoscopies completed across indications had a range of 0.0029-1/1000 (65, 69, 71, 72, 74) and colonoscopies with polypectomy had a range of 0.0081-0.11/1000 (65, 89).

Ten studies reported on colonoscopies after abnormal FIT/FOBT (66, 68, 70, 76, 77, 80, 81, 83, 84). In four of the studies that reported on colonoscopies after an abnormal FIT, the range of all-cause mortality rate was 0-0.23/1000 (80, 81, 83, 84). Kooyker et al., Tomaszewski et al., and Mikkelsen et al. reported abnormal FIT colonoscopy-specific mortality rates of 0.089/1000 (95% CI, 0.048–0.163), 0.013/1000 and 0.07/100 respectively (66, 68, 76). The weighted mean of the mortality rate in abnormal FIT colonoscopies was 0.07/1000 (SD=0.07). In the four studies that examined colonoscopies after an abnormal FOBT, two reported no deaths, and two reported 30-day post-procedure mortality rates of 0.87/1000 and 0.3/1000 (80, 81, 83, 84).

*Discussion and Implementation Considerations*

The Working Group rated the measure of colonoscopy-related mortality as very rare but important. The Working Group discussed the difficulty in distinguishing the mortality resulting from colonoscopy from all-cause mortality using available data sources. The data suggest an increased mortality rate after fecal testing, which could be important to patients and CRC screening programs. Table 7.0 summarizes the evidence quality and ISFU criteria for mortality rate.

**Table 7.0. Summary Table: Mortality Rate.**

| Indicator | Number of studies | GRADE evaluation | ISFU Criteria | | | | |
|---|---|---|---|---|---|---|---|
| | | | Importance to measure and report | Scientific acceptability of measure properties | Feasibility | Usability and use | Comparison to related or competing measures |
| Mortality | 2 SRs<br>13 cohort studies | Low | Important | There is face validity to this indicator. However, studies do not often compare to a gold standard (e.g., chart review)<br><br>Lack of consensus about the best way to measure mortality: 30 day all-cause; excess mortality (e.g., abnormal FIT vs. normal FIT); colonoscopy specific death | Required linkages (i.e., to track adverse events presenting to another facility) may limit feasibility<br><br>Excess mortality or colonoscopy-related death might be less feasible to measure due to data lags, effort, chart review, phoning people. | Likely useful for performance improvement, however feasibility issues limit its use. | Important to the patient |

**Abbreviations:** FIT, fecal immunochemical test; GRADE, Grading of Recommendations, Assessment, Development and Evaluation; ISFU, importance, scientific acceptability, feasibility, usability, and comparison to related/competing measures; SR, systematic review; vs, versus.

### *Unplanned admission rate*

*Definition*

Unplanned admissions refer to unanticipated hospital admissions or emergency department visits after an outpatient colonoscopy or procedure. Typically, this rate is calculated as the number of individuals having colonoscopy per 1000 that have an unplanned admission within a certain number of days after an outpatient colonoscopy. There were seven cohort studies that reported on unplanned admission rates (70-73, 79, 81, 83) (Appendix 4, Table 4.15). Six studies used 30 days after the procedure to calculate the rate (70-73, 81, 83) and one used one day after the procedure (79). The UK guidance recommends the unplanned admission rates be an auditable outcome and that every case should be reviewed (6).

*Rates*

Three studies reported on patients with colonoscopies completed across all indications (71, 72, 79). Two found unplanned admission rates ranging from 0.10 to 0.3 for all colonoscopies (71, 79). Causada-Calo et al., calculated a rate for all ED visits and admissions of 34/1000 for all colonoscopies (72).

Benazzato et al. reported on individuals having colonoscopies after an abnormal FIT and found an unplanned admission rate of 0.5/1000 for all colonoscopies, 0.87/1000 in those who had polypectomy and 0.02/1000 in those who did not (70).

Of the three studies that examined colonoscopies based on abnormal FOBT, unplanned admission rates were 3.3/1000, 3.6/100 and 9.5/1000 (73, 81, 83).

*Discussion and Implementation Considerations*

The Working Group rated the measure of unplanned admission rate to be of low importance. The Working Group felt that limitations of this indictor include the heterogeneity of the data and the lack of specificity in the reasons for admission (i.e., the admission may not be due to colonoscopy at all). Table 8.0 summarizes the evidence quality and ISFU criteria for unplanned admissions.

**Table 8.0. Summary Table: Unplanned Admissions.**

| Indicator | Number of studies | GRADE evaluation | ISFU Criteria | | | | |
|---|---|---|---|---|---|---|---|
| | | | Importance to measure and report | Scientific acceptability of measure properties | Feasibility | Usability and use | Comparison to related or competing measures |
| Unplanned admissions | 7 cohort studies | Low | Low | Not all unplanned admissions will be directly related to the colonoscopy | Required linkages (e.g., to track adverse events presenting to another facility) may limit feasibility | Could be useful for performance improvement | May be important to the patient |

**Abbreviations:** GRADE, Grading of Recommendations, Assessment, Development and Evaluation; ISFU, importance, scientific acceptability, feasibility, usability, and comparison to related/competing measures.

*Certainty of the Evidence*

The four systematic reviews for adverse events were assessed using the ROBIS tool. Kothari et al. and Takamaru et al. were deemed to have a high risk of bias whereas Jaruvongvanic et al. and Reumkens et al. had a low risk of bias (9). The 20 cohort studies from the primary literature were assessed using the ROBINS tool for non-randomized studies and were found to be moderate risk of bias (11). See Appendix 6 for all quality assessments.

***Patient Outcomes***

Patient experience of colonoscopy is important, and patients should have as comfortable a procedure as possible. Patient satisfaction, pain, and comfort levels are affected by many factors including technique and there is some evidence to suggest that high performing endoscopists (based on results from other quality indicators) provide a more comfortable patient experience with less sedation (6). A UK national audit demonstrated that 10% of patients experienced moderate or severe discomfort (6). Patient comfort during colonoscopy is associated with improved patient satisfaction and compliance with future procedures for the patient and others through word-of-mouth communication (13, 90). Colonoscopy may be perceived to be a painful and embarrassing procedure and this perception hampers patient participation in screening programs. Therefore, patient experience should be assessed using a validated scale to allow for feedback and improvement (90).

The literature search found 26 studies that underwent a full-text review. Most of the studies examined and validated scales on either patient satisfaction with the whole procedure or pain and comfort during the procedure. Ten studies were kept for the evidence summary.

The UK guideline states that all units should audit comfort and <10% of patients should have moderate or severe discomfort and all units should consistently record patient comfort

via validated measures of patient comfort (6). The UK systematic review referenced two patient comfort scales: the Nurse-assisted Patient Comfort Score (NAPCOMS) and the Modified Gloucester Comfort Score (MGCS). The UK guideline did not provide guidance for patient satisfaction (6).

*Patient Pain and Comfort*

Definition and validation

Three studies developed and validated their own scales (13, 91-93) (Appendix 4, Table 4.16). The Patient-Reported Scale for Tolerability of Endoscopic Procedures (PRO-STEP) has six questions that are completed by the patient prior to discharge from the endoscopy unit. There are two domains (intraprocedural, 2 questions and post-procedural, 4 questions). The scale was found to have poor to acceptable reliability (internal consistency): Domain 1 (intraprocedural): acceptable, Cronbach's α=0.71 (95% CI, 0.62 to 0.78); Domain 2 (post-procedural): poor, Cronbach's α=0.29 (95% CI, 0.04 to 0.55); intra- vs. post-procedure pain: poor, Cronbach's α=0.18 (95% CI, 0.01 to 0.34) (91).

St. Paul's Endoscopy Comfort Scale (SPECS) is completed by an observer (generally the nurse) and assesses the patients in three areas: vocalization, positioning/body language and anxiety/emotion. In the validation study, it was completed by a physician, a nurse and a research assistant and found to have strong inter-rater reliability (ICC, 0.81; 95% CI, 0.78 to 0.84). The SPECS (ρ=0.53) correlated moderately with a patient self-reported post-procedure visual analogue scale (VAS) using the observers' scores for each subject (13).

The NAPCOMS is also completed by an observer (generally the nurse). The three domains are pain, sedation and global (tolerability) (93). The inter-rater reliability for the NAPCOMS score between two nurses was very good (ICC, 0.84; 95% CI, 0.80 to 0.87) and criterion validity was good: NAPCOMS and endoscopist ratings of comfort: ICC, 0.77 (95% CI, 0.72 to 0.81) and NAPCOMS and patient ratings of comfort: ICC, 0.61 (95% CI, 0.53 to 0.67) (93).

There were no studies validating the use of the MGCS. However, this scale was referenced in the UK systematic review.

Discussion and Implementation Considerations

The Working Group rated the measure of patient pain and comfort as highly important. The Working Group discussed that a simple and practical patient pain/comfort scale would promote better response rates. They also felt that completing a pain/comfort score for every procedure would be challenging and that the type of sedation and sedation levels (which are known to vary across centres and endoscopists) may affect the assessment of pain and comfort. The Working Group discussed that receiving feedback from patients regarding their comfort levels is important to improve endoscopist skills but noted that an unintended consequence of using this indicator could be oversedation. They also felt that the SPECS and the NAPCOMS were best supported by the evidence, with the important limitation that the scale was developed without patient input. Table 9.0 summarizes the ISFU criteria for patient pain and comfort.

**Table 9.0. Summary Table: Patient Pain and Comfort.**

| Indicator and Number of studies | GRADE evaluation | ISFU Criteria | | | | |
|---|---|---|---|---|---|---|
| | | **Importance to measure and report** | **Scientific acceptability of measure properties** | **Feasibility** | **Usability and use** | **Comparison to related or competing measures** |
| Comfort and pain with the procedure<br><br>3 studies<br>3 questionnaires, see below for study specific detail | N/A | High<br>Important to have a measure to monitor intraprocedural care and endoscopist technical skills | Patient comfort and pain may be correlated with other quality indicators.<br><br>Sedation practices vary across endoscopy units and patient comfort is impacted by the degree of sedation. | Systematically measuring this indicator at the provincial or regional level would be challenging at a unit level for every procedure<br>However, short audits of this indicator are feasible at the facility level. Some units may be able to report this on a consistent basis given the appropriate IT/infrastructure | Could be used to improve patient care<br>Sedation may impair a patient's ability to recall discomfort or affect experience of discomfort. Variation in sedation practice across endoscopy units and/or providers may limit ability to compare scores. Interpretation of scores should take variation in sedation practice into account<br>Measuring pain and comfort is only appropriate for cases using conscious sedation<br>An unintended consequence of measuring pain and comfort using this indicator might be to promote over sedation | Important to the patient, to ensure procedure completeness and to optimize attendance at colonoscopy<br>Best assessment tools based on the ISFU criteria:<br>• SPECS<br>• NAPCOMs<br>• Both are nurse reported, limited patient input into development |
| PRO-STEP | | | Only measured reliability; Had poor to acceptable reliability but no validity measures.<br>Patients involved in development<br>Results are for all endoscopies; no stratification by procedure type. | | • 6 questions<br>• Patient reported | |
| SPECS | | | Had excellent reliability and acceptable validity.<br>Results are specific to colonoscopy.<br>Measured against patient self-reported VAS. | | • 3 questions<br>• Nurse reported | |
| NAPCOMS | | | Had excellent reliability and acceptable validity.<br>Results are specific to colonoscopy.<br>Measured against patient rating of comfort. | | • 3 domains; 5 questions<br>• Nurse reported<br>• Accounts for level of consciousness and tolerability | |

**Abbreviations:** GRADE, Grading of Recommendations, Assessment, Development and Evaluation; ISFU, importance, scientific acceptability, feasibility, usability, and comparison to related/competing measures; IT, information technology; NAPCOMs, Nurse-assisted Patient Comfort Score; PRO-STEP, Patient-reported scale for tolerability of endoscopic procedures; SPECS, St. Paul's Endoscopy Comfort Scale; VAS, visual analogue scale.

*Patient Satisfaction*

Definition and Validation

Six studies reported on four satisfaction scales (14, 94-98) (Appendix 4, Table 4.17). The Comprehensive Endoscopy Satisfaction Tool (CEST) has 30 questions across four domains plus demographic questions and an open comment section that can be completed via their smartphone. (96). The four domains are preprocedural, periprocedural, facilities and post procedure. The questions are on a scale from 1 to 7, with 1 being "very poor" and 7 being "excellent". The CEST was found to have acceptable internal consistency with a Cronbach alpha greater than 0.80 (96).

The Newcastle ENDOPREM scale was developed with interviews with patients, question development, patient feedback, refinement and reduction. Psychometric properties were investigated and found to be robust. It consists of 10 demographic/patient characteristic questions, 54 patient experience questions (5 levels from strongly agree-strongly disagree) and four explanatory questions for comments (97).

One study developed and validated the Colonoscopy Satisfaction and Safety Questionnaire (CSSQP), which patients complete at home one day after the colonoscopy (90). Patients were involved in the development of the scale. The final version has three sections: 1) a satisfaction scale, with 13 items on satisfaction regarding: information, care and service environment and facilities (scale 1-5), 2) a perceived safety scale, with two items (yes/no) and 3) a space to include additional comments. The CSSQP was found to have acceptable internal consistency and reliability: the Cronbach's α was 0.86 and the split-half readability Spearman-Brown coefficient was 0.85 (90). Construct validity was evaluated with eigenvalues of greater than 0.40 and factor loading greater than 0.5. A principal components analysis revealed three factors that explained 64% of the variance, with element saturation over 0.51 in looking at selected questions from the satisfaction scale. In looking at the safety scale, the Kendall coefficient of concordance assessing agreements among raters was 0.71, reflecting coherent differences between patients who had safety incidents with those without safety incidents (94).

Three studies examined the Gastrointestinal Endoscopy Satisfaction Questionnaire (GESQ), which is completed by the patients after the colonoscopy (14, 95, 98). Patients were involved in the development of the scale. Each of the three studies used a different time frame: in the endoscopy centre (98), one day after the colonoscopy (95) or 30 days after the colonoscopy (14). One study translated the scale to Dutch (14) and one to Korean (98). There are 21 items from four subscales asking about skills and hospital, pain and discomfort, and information before and after the endoscopy. All the studies showed high internal consistency with the Dutch study reporting a Cronbach alpha of 0.88, and the Korean study had a Cronbach alpha of 0.89 (14). In regard to criterion validity, Yoon et al. found a correlation coefficient between the K-GESQ and five-point Likert satisfaction scale was 0.513 ($p<0.001$) (98). The Pearson correlation coefficients between domains were all comparatively low (<0.70) and revealed that the four subscales consisting of 21 items were not collinear, suggesting that they were measuring separate satisfaction domains (98).

Discussion and Implementation Considerations

The Working Group rated the measure of patient satisfaction as highly important, and it is important to the patient. Patient satisfaction may affect attendance at subsequent colonoscopies. The Working Group discussed that the timing of questionnaire administration can affect the nature of the responses and the response rate from patients. However, while even if the yield is low, the Working Group felt that insight into the patient experiences is valuable and important. It is both low cost and low effort to institute with the technology available to most centres. The Working Group felt that the data to support the CSSQP was the

most robust based on its reliability and validity, specificity to the whole colonoscopy experience and patient input in its development. Table 10.0 summarizes the ISFU criteria for patient satisfaction.

**Table 10.0. Summary Table: Patient Satisfaction.**

| Indicator and Number of studies | GRADE evaluation | ISFU Criteria | | | | |
|---|---|---|---|---|---|---|
| | | **Importance to measure and report** | **Scientific acceptability of measure properties** | **Feasibility** | **Usability and use** | **Comparison to related or competing measures** |
| Satisfaction with the process<br><br>6 studies<br>4 questionnaires see below for study specific details | N/A | High | Patient satisfaction may be correlated with other quality indicators.<br>Sedation practices vary across endoscopy units and patient satisfaction is impacted by the degree of sedation. | Systematically measuring patient satisfaction would be challenging at the provincial and regional level. However, short audits of this indicator could be feasible.<br><br>Response rates from patients may be a challenge.<br><br>It can be a low cost and low effort to institute with the appropriate technology available. | Could be used to improve patient care<br><br>Variation in sedation practices across units of analysis may limit comparisons. However, within an institution, conducting surveys and acting on the results is expected to be valuable | Important to the patient<br><br>Best assessment tools based on the ISFU criteria: CSSQP |
| CEST | | | Had good reliability.<br>Results specific to colonoscopy.<br>Patients involved in development. | | • 30 questions<br>• Patient reported<br>• Has an open-ended comment section | |
| ENDOPREM | | | Results specific to colonoscopy.<br>Patients involved in development. | | • 68 questions<br>• Patient reported<br>• Has an open-comment section | |
| CSSQP | | | Had strong reliability and good validity.<br>Results specific to colonoscopy.<br>Patients involved in development. | | • 15 questions<br>• Patient reported<br>• Has an open-ended comment section to generate new areas for improvement<br>• Fewer items than GESQ | |
| GESQ | | | Had strong reliability measured, but not much data on validity.<br>Results are for all endoscopy<br>Reported on in three studies. Mostly assessing translations into different languages<br>Patients involved in development | | • 21 questions<br>• Patient reported<br>• Used in different contexts | |

**Abbreviations:** CSSQP, Colonoscopy Satisfaction and Safety Questionnaire based on patients' experiences; GESQ, gastrointestinal endoscopy satisfaction questionnaire; GRADE, Grading of Recommendations, Assessment, Development and Evaluation; ISFU, importance, scientific acceptability, feasibility, usability, and comparison to related/competing measures.

Certainty of the Evidence

The studies for the quality indicator of patient outcomes were all cross-sectional/validation studies. The eight studies were appraised using the JBI Critical Appraisal Checklist for Analytical Cross-Sectional Studies, and the studies used appropriate validation and reliability methodology to evaluate the questionnaires and scales (12).

***Process indicators***

According to Donabedian, process indicators address the actions that occur during the delivery of health care (7). While they are easier to measure than outcome indicators typically, they may be perceived as less important by patients. Process indicators derive their importance because of evidence or the perception that they are associated with outcome indicators. The Working Group divided process indicators into two groups: those related to the quality of inspection, and polyp management.

***Quality of Inspection***

Under quality of inspection, the following process indicators were evaluated: adenoma detection rate (ADR) and similar indicators, withdrawal time, cecal intubation rate, bowel preparation, retroflexion, performance indicator of colonic intubation (PICI) and terminal ileum intubation rate (TIIR). Where the data permitted, the validation of the definition and target were reviewed for each indicator. Where definitions and targets were not available, rates are reported. The gold standard or the indicators used as comparators for validation varied by indicator and are listed in each section below.

*ADR*

ADR is a proxy measure for how well the lining of the colon is inspected. This commonly used measure is generally defined as the proportion of colonoscopies where one or more adenomas is identified (6). It is generally reported at the endoscopist level (99).

The literature search for ADR as a quality indicator resulted in 32 articles being kept after full-text review.

There was one systematic review (39) and 31 studies that investigated ADR as a quality indicator (3, 99-124) (Appendix 4, Table 4.18). The UK guidelines recommend that the minimal ADR should be 15% and the aspirational ADR should be 20% among colonoscopies performed in all adults for all indications (6). The UK guidelines differs from the US Multi-Society Task Force, which recommends measuring ADR only in those having screening colonoscopy. As well, the UK guidance states that where polyp detection rate (PDR) can be shown to be accurate, it may be used as a marker of ADR (6).

Definition and Validation

The UK guideline found studies that showed that ADR is inversely correlated with PCCRC (6). As well, it has been shown that interventions can lead to improvement in ADR (125) and that improving ADR is associated with lower PCCRC rates (3). More recently, Zessner-Spitzenberg et al., found the a 1% increase in ADR was associated with 2% decrease in PCCRC (111), Zorzi et al., found that the adjusted HR for PCCRC associated with 1% increase in ADR was 0.96 (CI, 0.95 to 0.98) (112), Schottinger et al., found that ADR was significantly associated with lower risks of PCCRC: HR=0.97 per 1% absolute ADR increase (95% CI, 0.96-0.98) (126) and Wisse et al., found that ADR is associated with interval PCCRC in patients having colonoscopy after abnormal FIT: adjusted HR, 0.95 (95% CI, 0.92 to 0.97, $p<0.001$) per 1% increase in ADR (110).

PDR and SSPDR (includes CSSDR and PSPDR) have also been found to be inversely associated with PCCRC. Schwartz et al., found that physicians with a PDR less than or equal to

21.8% had significantly higher cumulative CRC death that those physicians with a PDR higher than 21.8% (108). Zessner-Spitzenberg et al., found that a 1% increase in PSPDR was associated with 3% lower PCCRC death (111). Van Toledo et al., found that a 1% increase in PSPDR was associated with 7%-point decrease of PCCRC: HR= 0.93 (95% CI, 0.90–0.95; p<0·0001) (109). See Appendix 4, Table 4.19.

Rates

There was a wide variation in ADR means (range 22-50%) and medians (28-67%) across the identified studies (3, 99-124). These findings are likely due to variation in the underlying risk of neoplasia in the populations across the studies, due to differences in age, indication for procedure, and baseline population risk of CRC (Appendix 4, Table 4.19).

ADR appears to vary by the indication for colonoscopy. Fourteen studies reported ADR means for screening colonoscopies ranging from 22-58% (3, 100-102, 107, 111, 113, 116-120, 124, 126). Seven studies reported on abnormal FIT ADR, resulting in a range from 38-67% (where hemoglobin concentrations ranging from 15 ug/g to 47 ug/g were used to define abnormal FIT, when reported) (99, 103, 109, 110, 112, 115, 121) (103). Wisse et al. made the argument that the median ADR in their study of colonoscopies for abnormal FIT (67%) should be considered "equivalent" to the ADR thresholds reported in studies of primary screening colonoscopy (i.e., 15% in Kaminski and 25% in Corley) (110). Cubiella et al. reported that the median ADR in the group with abnormal FIT indication was ADR: 55% (range, 21% to 83%) vs. ADR: 31% (range, 14% to 51%) in those performing primary screening colonoscopy (115). Using multivariable regression analysis, they estimated that an ADR of 20% in primary screening colonoscopy correlates with an ADR of 45% (95% CI, 35% to 57%) in abnormal FIT colonoscopy (115). van Toledo et al., reported a similar median ADR as Wisse of 66% using a similar abnormal FIT threshold with a 47 µg Hb/g faeces (109). Hilsden et al. proposed that the minimally acceptable abnormal FIT ADR should be 55%, the standard of care abnormal FIT ADR should be 60% and the aspirational abnormal FIT ADR should be 65% (99).

Indicators similar to ADR

While ADR is one of the most common and well validated measures, it does have some important limitations, including that it is challenging to measure as pathology data linked to colonoscopy may not be available and that it may be susceptible to a "one and done" phenomenon where if an adenoma is found, then the endoscopist might not search as intensely for more. As a result, indicators with a similar purpose that address some of these limitations have been developed.

There were 17 studies that examined indictors with a similar purpose as ADR, typically by reporting their correlation with ADR or adenoma miss rate (AMR) (100, 102, 105-107, 109-111, 113, 114, 116, 119-122, 127, 128). These indicators included PDR (102, 105, 121, 128), high risk ADR (HRADR) (107, 110, 113, 119, 122), nonadvanced ADR (NAADR) (107, 113), adenomas per positive participant (APP) (100, 102, 110, 113, 114, 116), adenomas per colonoscopy (APC) (102, 110, 113, 114, 116, 119), ADR-plus (102, 113), CRC ADR (120), clinically relevant serrated polyp detection rate (CSSDR) and proximal serrated polyp detection rate (PSPDR) (106, 127).

Four studies calculated as adenoma to polyp detection rate quotient (APDRQ) which is calculated as the weighted average of ADR/PDR of individual endoscopists (105, 118, 121, 129). The APDRQ was similar in all four studies: in Gingold-Belfer et al., the APDRQ=0.71; in Murphy et al., APDRQ=0.72; in Vojtechova et al., APDRQ=0.72 and in Murchie et al., the APDRQ=0.67 (Appendix 4, Table 4.20).

Definition and Validation

Four studies compared PDR with ADR and found that they were strongly correlated (r=0.70-0.93) (102, 105, 121, 128). CSSDR and ADR were found to be moderately correlated in two studies (r=0.47 (p<0.01), r=0.69 (p<0.0001)) (106, 127) PSPDR and ADR were found to be strongly correlated in one study (r=0.70 95% CI, 0.70-0.71) (111) and moderately correlated in the other, (r=0.59; p<0·0001) (109). Five studies compared high risk HRADR with ADR and altogether were moderately to strongly correlated (r=0.51 to r=0.82) (107, 110, 113, 119, 122). Nonadvanced ADR (NAADR) was correlated with ADR in two studies and found to be moderately correlated in one (r=0.49 [p<0.001], and strongly correlated in the other, (r=0.99 [p=0.0001]) (107, 113). Six studies found that the correlation between APP and ADR was inconsistent and variable in strength (r=0.05 to 0.66) (100, 102, 110, 113, 114, 116). APC and ADR were found to be moderately to strongly correlated in six studies (r=0.57 to 0.99) (102, 110, 113, 114, 116, 119). APC was not correlated to AMR in two studies (r=-0.82, p=0.18, r=-0.095, p=0.84) (102, 114). Two studies found the correlations between ADR plus (additional adenomas found after the first adenoma per colonoscopy) and ADR to be inconsistent and variable in strength and significance (r=0.238 (p=0.582), r=0.85 (p=0.047)) (102, 113). One study found ADR plus was not significantly inversely correlated to AMR (r=-0.93, p=0.07) (114). One study compared CRC ADR to ADR and found a strong correlation of r=0.74 (p=0.002) (120). (Appendix 4, Table 4.20).

Discussion and Implementation Considerations

The Working Group rated the measure of ADR as an indicator of high importance given its association with PCCRC and PCCRC-related death, making it one of the few process indicators that provides direct evidence of an association of colonoscopy quality. Challenges related to measuring ADR may be addressed in part with the use of newer approaches such as natural language processing. The Working Group felt that the evidence supported using different ADR benchmarks for abnormal FIT results and for other colonoscopy indications. The use of distinct benchmarks for abnormal FIT colonoscopies is relevant for CRC screening programs. There was also discussion around the importance of examining outliers or focusing on low performers, defined using ADR, to improve quality. Table 11.0 summarizes the evidence quality and ISFU criteria for adenoma detection rate.

The Working Group discussed the use of PDR, SSPDR, HRADR, NAADR, APP, APC, ADR-plus, and CRC ADR. These indicators were felt to have similar properties as ADR but may confer certain advantages. Most indicators were validated using ADR as the gold standard, which limits interpretation (i.e., cannot assess if they perform better than ADR). PDR and SSPDR were felt to be of high importance as they had direct evidence of an association with colonoscopy quality (validated against PCCRC). However, there are no head-to-head comparisons to determine if PDR performs better than ADR and the Working Group felt that the susceptibility to manipulation and observed variation in its correlation with ADR were potential issues. The remaining indicators were indirectly related to colonoscopy quality as the data to support them was based on their correlation with ADR or in a few instances, adenoma miss rate (AMR). Of these, the Working Group felt that HRADR and APC were important (others considered less important) because respectively, they measured the most clinically significant precancerous lesions, addressed the “one and done” phenomenon and were complementary as they captured a distinct type of precancerous lesion. Table 11.1 summarizes the evidence quality and ISFU criteria for these additional indicators.

Certainty of the Evidence

There were 31 cohort studies assessed using the ROBINS tool (11) for non-randomized studies: two had a serious risk of bias, 27 had a moderate risk of bias and one has a low risk of bias.

**Table 11.0. Summary Table: Adenoma Detection Rate.**

| Indicator | Number of studies | GRADE evaluation | ISFU Criteria | | | | |
|---|---|---|---|---|---|---|---|
| | | | Importance to measure and report | Scientific acceptability of measure properties | Feasibility | Usability and use | Comparison to related or competing measures |
| ADR | 1 SR<br>23 cohort studies | Low | High importance | Strong validation against PCCRC and PCCRC related death.<br><br>Benchmarks exist relative to PCCRC.<br><br>Some evidence to suggest different ADR benchmarks are warranted for abnormal FIT vs. other colonoscopy indications.<br><br>At the jurisdictional level (i.e., many endoscopists across multiple facilities), quartiles/ quintiles can be considered for benchmarking rather than absolute thresholds, given wide variation in the literature and that ADR is population specific.<br><br>May be a ceiling effect. | Challenges related to linking pathology to colonoscopy may pose feasibility issues.<br><br>Measurement at facility level may be more feasible than regional and higher levels because of the lack of jurisdictional pathology databases.<br><br>Natural language processing may make this easier to measure in the future. | Direct evidence of an association with colonoscopy quality.<br><br>Evidence suggests that improving ADR is possible with endoscopy education initiatives.<br><br>Improvement in ADR is associated with reduction in PCCRC. | Often used as a gold standard that other measures are compared against.<br><br>No studies comparing ADR to other indicators against another gold standard to determine which performs better i.e., PCCRC. |

**Abbreviations:** ADR, adenoma detection rate; FIT, fecal immunochemical test; GRADE, Grading of Recommendations, Assessment, Development and Evaluation; i.e., in other words; ISFU, importance, scientific acceptability, feasibility, usability, and comparison to related/competing measures; PCCRC, post-colonoscopy colorectal cancers; SR, systematic review

**Table 11.1. Summary Table: Other Additional Indicators Related to Adenoma Detection Rate.**

| Indicator | Number of studies | GRADE evaluation | ISFU Criteria | | | | |
|---|---|---|---|---|---|---|---|
| | | | Importance to measure and report | Scientific acceptability of measure properties | Feasibility | Usability and use | Comparison to related or competing measures |
| PDR | 4 cohort studies | Low | High importance | Validated against PCCRC and ADR.<br><br>Strongly correlated with ADR. | No need for pathology data in order to measure.<br><br>Feasible to measure at facility, regional and provincial levels. | Direct evidence of an association with colonoscopy quality.<br><br>No data to indicate that improving PDR is possible or that improvement leads to a change in colonoscopy quality.<br><br>PDR can be used as a proxy for ADR assuming a ratio of approximately two-thirds.<br><br>Concerns about the potential for manipulation. | Easier to measure than ADR.<br><br>Potential for manipulation and variation in relationship to ADR limits usefulness. |
| SSPDR (includes CSSDR and PSPDR) | 4 cohort studies | Low | High importance | Validated against PCCRC and ADR.<br><br>Moderate-strongly correlated to ADR. | Challenges related to linking pathology to colonoscopy may pose feasibility issues.<br><br>Measurement at facility level may be more feasible than regional and higher levels because of the lack of jurisdictional pathology databases.<br><br>Natural language processing may make this easier to measure in the future. | Direct evidence of an association with colonoscopy quality.<br><br>No data to indicate that improving SSPDR is possible or that improvement leads to a change in colonoscopy quality. | Possible complementary measure to ADR as it targets a separate precancerous lesion. |
| HRADR | 5 cohort studies | Low | Important | Validated against ADR.<br><br>Moderately-strongly correlated with ADR. | Challenges related to linking pathology to colonoscopy may pose feasibility issues.<br><br>Measurement at facility level may be more feasible than regional and higher levels because of the lack of jurisdictional pathology databases. | Indirect evidence of an association with colonoscopy quality. | Measures most clinically significant precancerous lesions. |

| Indicator | Number of studies | GRADE evaluation | ISFU Criteria | | | | |
|---|---|---|---|---|---|---|---|
| | | | Importance to measure and report | Scientific acceptability of measure properties | Feasibility | Usability and use | Comparison to related or competing measures |
| | | | | | Natural language processing is less able to capture number of adenomas.<br><br>Requires additional effort to distinguish from ADR. | | |
| NAADR | 2 cohort studies | Low | Less Important | Validated against ADR.<br><br>Moderate-strongly correlated with ADR. | Challenges related to linking pathology to colonoscopy may pose feasibility issues.<br><br>Measurement at facility level may be more feasible than regional and higher levels because of the lack of jurisdictional pathology databases.<br><br>Natural language processing is less able to capture number of adenomas.<br><br>Requires additional effort to distinguish from ADR. | Indirect evidence of an association with colonoscopy quality. | Unclear if there is additional benefit over ADR given the additional effort required to compute. |
| APP | 6 cohort studies | Low | Less Important | Validated against ADR and AMR.<br><br>The correlations are not consistent (variable strength of association and not always significant) | Challenges related to linking pathology to colonoscopy may pose feasibility issues.<br><br>Measurement at facility level may be more feasible than regional and higher levels because of the lack of jurisdictional pathology databases.<br><br>Natural language processing is less able to capture number of adenomas. | Limited evidence of an association with colonoscopy quality. | Addresses a “one and done” phenomenon, a concern with ADR. |
| APC | 6 cohort studies | Low | Important | Validated against ADR and AMR.<br><br>Moderate-strongly correlated to ADR. Correlations to AMR not significant. | Challenges related to linking pathology to colonoscopy may pose feasibility issues.<br><br>Measurement at facility level may be more feasible than regional and higher levels because of the lack of jurisdictional pathology databases. | Indirect evidence of an association with colonoscopy quality. | Addresses a “one and done” phenomenon, a concern with ADR. |

| Indicator | Number of studies | GRADE evaluation | ISFU Criteria | | | | |
|---|---|---|---|---|---|---|---|
| | | | Importance to measure and report | Scientific acceptability of measure properties | Feasibility | Usability and use | Comparison to related or competing measures |
| | | | | | Natural language processing is less able to capture number of adenomas. | | |
| ADR plus | 3 cohort studies | Low | Less Important | Validated against ADR and AMR.<br><br>The correlations are not consistent (variable strength of association and not always significant) | Challenges related to linking pathology to colonoscopy may pose feasibility issues.<br><br>Measurement at facility level may be more feasible than regional and higher levels because of the lack of jurisdictional pathology databases.<br><br>Natural language processing is less able to capture number of adenomas. | Indirect evidence of an association with colonoscopy quality. | Addresses a "one and done" phenomenon, a concern with ADR. |
| CRC ADR | 1 cohort study | Low | Less Important | Validated against ADR.<br><br>Strongly correlated to ADR. | Applies to a small sub population of patients having colonoscopy.<br><br>Challenges related to linking pathology to colonoscopy may pose feasibility issues.<br><br>Measurement at facility level may be more feasible than regional and higher levels because of the lack of jurisdictional pathology databases.<br><br>Natural language processing may make this easier to measure in the future. | Indirect evidence of an association with colonoscopy quality. | Of limited use compared to ADR |

**Abbreviations:** ADR, adenoma detection rate; AMR, adenoma miss rate; APC, adenomas per colonoscopy; APP, adenomas per positive participant; CRC ADR, colorectal cancer adenoma detection rate; GRADE, Grading of Recommendations, Assessment, Development and Evaluation; HRADR, high-risk adenoma detection rate; ISFU, importance, scientific acceptability, feasibility, usability, and comparison to related/competing measures; NAADR, nonadvanced adenoma detection rate; PCCRC, post-colonoscopy colorectal cancers; PDR, polyp detection rate; SSSDR, clinically significant serrated polyp detection rate.

*Withdrawal Time*

Withdrawal time (WT) is defined as the length of time taken to withdraw the colonoscope from the cecum to the rectum. It is felt that a longer WT optimizes the inspection of the lining of the colon, which takes place during withdrawal of the colonoscope. The WT is calculated for each endoscopist using cases where the investigation was normal or excluding time spent removing polyps (6).

The literature search for WT as a quality indicator resulted in four RCTs (130-133) and nine cohort studies (134-142) that were kept after full-text review (Appendix 4, Tables 4.21). The UK guideline recommends that for all colonoscopies, there should be a minimum mean withdrawal time of six minutes for negative procedures with an aspirational target of a mean withdrawal time of 10 minutes. The guideline also recommended that withdrawal times should be routinely recorded and audited (6).

Definition and Validation

Shaukat et al. compared withdrawal times to PCCRC over 10 years and found a relationship between WT and ADR: a 3.6% increase in ADR per minute increase in WT (95% CI,2.4-4.8; p<0.0001) (141). However, for interval CRC, it was noted that below a WT of eight minutes, PCCRC rate increased as WT decreased; the PCCRC rate appeared to plateau after eight minutes. Desai et al., also found that for each one-minute increase in WT, there was 6% higher odds of detecting an additional patient with an adenoma (OR, 1.06; 95% CI, 1.02-1.10; p=0.004) up to 13 minutes but not after (131). In general, other studies found that longer withdrawal times were associated with higher ADR, AMR, PDR, APC or serrated polyp detection rate (SPDR), leading to recommendations that WT target should be longer than the commonly used six-minute target. These recommended WTs ranged from 8-11 minutes (130, 133-137, 139, 141, 142) (Appendix 4, Table 4.22).

Discussion and Implementation Considerations

The Working Group rated the measure of WT as highly important. Despite the Working Group's concern about gaming, there is a consistent relationship between longer WT and a lower PCCRC rate as well as a higher yield in detected precancerous lesions; further, there are data to suggest a WT benchmark relative to a key outcome indicator, PCCRC. While WT is not routinely available in administrative data, the Working Group felt it could be measured at the facility level. Table 12.0 summarizes the evidence quality and ISFU criteria for withdrawal time.

**Table 12.0. Summary Table: Withdrawal Time.**

| Indicator | Number of studies | GRADE evaluation | ISFU Criteria | | | | |
|---|---|---|---|---|---|---|---|
| | | | Importance to measure and report | Scientific acceptability of measure properties | Feasibility | Usability and use | Comparison to related or competing measures |
| Withdrawal Time | 4 RCT<br>9 cohort studies | Low | High importance | Validated in a single study against PCCRC. Remainder of studies compared to ADR.<br><br>Using ADR as the reference is less desirable than PCCRC as mostly low-risk lesions may be detected as WT increases.<br><br>Data support a benchmark of eight minutes relative to PCCRC. | Not possible to measure at the jurisdictional level but could be measured at the facility level.<br><br>Unclear if routinely reported in endoscopy reports, making use of NLP less feasible. | Direct evidence of an association with colonoscopy quality.<br><br>Lacking evidence that an increase in withdrawal time leads to an improvement in quality.<br><br>Susceptible to manipulation.<br><br>Not routinely available in administrative data. | Unclear if there is additional benefit over ADR, especially given potential for manipulation and limitations in data availability.<br><br>However, ADR and WT, interpreted together, may provide important complementary information. |

**Abbreviations:** ADR, adenoma detection rate; GRADE, Grading of Recommendations, Assessment, Development and Evaluation; ISFU, importance, scientific acceptability, feasibility, usability, and comparison to related/competing measures; NLP, natural language processing; PCCRC, post-colonoscopy colorectal cancer; WT, withdrawal time.

*Cecal Intubation Rate*

Cecal intubation is defined as the passage of the scope beyond the ileocecal valve to the cecal pole. Failure to reach the cecum or incomplete colonoscopy can lead to missed diagnoses and an increase in PCCRC (6). A lower cecal intubation rate (CIR) or completion rate has been significantly associated with greater risk of a PCCRC in a study using a large administrative database in Ontario (143).

The literature search for CIR as a quality indictor resulted in one article being kept after full-text review (Appendix 4, Table 4.25). The UK guidance recommends a minimal unadjusted (rate is not adjusted for bowel preparation or impassable strictures) CIR of 90% and that endoscopists should aspire to achieve 95% CIR. As well, photographic documentation of cecal intubation should be obtained with images taken of clear cecal landmarks or of the terminal ileum (6).

Rates

One retrospective study that investigated the stability of CIR over 16 years found an overall mean of CIR of 99.4%, an unadjusted CIR of 98% and that none of the included 16 physicians had a CIR <96.6% in any given year. These data were felt to support a CIR target of over 95% (144) (Appendix 4, Table 4.26).

Discussion and Implementation Considerations

The Working Group rated the measure of CIR highly important. The Working Group discussed whether the finding that CIR is consistently high may make this quality indicator less useful. However, they were reluctant to stop measuring and reporting CIR in case people stopped making the effort to reach the cecum. Lastly, the group discussed whether a higher benchmark than currently recommended may be more useful. Table 13.0 summarizes the evidence quality and ISFU criteria for CIR.

**Table 13.0. Summary Table: Cecal Intubation Rate.**

| Indicator | Number of studies | GRADE evaluation | ISFU Criteria | | | | |
|---|---|---|---|---|---|---|---|
| | | | Importance to measure and report | Scientific acceptability of measure properties | Feasibility | Usability and use | Comparison to related or competing measures |
| Cecal Intubation Rate | 1 SR<br>1 cohort | Low | High importance | Validated against PCCRC and ADR. | May be feasible to report as a performance measure at the regional, provincial, facility and individual level.<br><br>Unadjusted CIR is more feasible to report. | High reported rates of cecal intubation in multiple jurisdictions may limit usefulness for performance improvement.<br><br>Some data to suggest use of a higher benchmark than is currently recommended. | Important validated measure but high endoscopist performance may make less relevant. |

**Abbreviations:** ADR, adenoma detection rate; CIR, cecal intubation rate; GRADE, Grading of Recommendations, Assessment, Development and Evaluation; ISFU, importance, scientific acceptability, feasibility, usability, and comparison to related/competing measures; PCCRC, post-colonoscopy colorectal cancers.

*Bowel Preparation*

Good bowel preparation is important because it is associated with higher colonoscopy completion rates and ADRs (145). Evidence in the UK from the national colonoscopy audit showed that 22% of failed colonoscopies were due to poor bowel preparation (6).

The literature search for bowel preparation as a quality indictor resulted in 11 studies being kept after full-text review (Appendix 4, Table 4.27). There were two systematic reviews (39, 146), one narrative review (147), eight cohort studies focussed on lesion detection (134, 148-154) and one cross-sectional study examining patient experience (155). The UK guidance recommended that 90% of patients having colonoscopy should have bowel preparation of at least adequate quality with an aspirational goal that 95% of patients have bowel preparation of at least adequate quality. Further, they recommend that an easy to use, validated national bowel preparation scale should be developed (6).

Definition and Validation

The scoping review by Kastenburg et al. compared various current bowel preparation scales and recommended the Boston Bowel Preparation Scale (BBPS) for use in clinical practice. The authors state that a colonoscopy with a total BBPS score of ≥6 and/or all segment scores ≥2 supports the recommendation of a 10-year follow-up (147).

A systematic review by Sulz et al. converted 27 studies into the Aronchick scale of categories of bowel preparation being (either inadequate or adequate) and found that fewer adenomas and advanced adenomas were detected with inadequate vs. adequate bowel preparation (OR, 0.52; 95% CI, 0.46 to 0.63, p<0.001 and OR, 0.74; 95% CI, 0.62 to 0.87, p<0.001) (146). The cohort studies compared the quality of bowel preparation for outcomes such as ADR, PDR, HRADR and APC and found that there are larger differences in ADR in those with poor vs. adequate bowel preparation than those with adequate vs. excellent preparation (134, 148, 152-154). Four studies found significant increases in HRADR when comparing lower quality to higher quality bowel preparations (148, 149, 151, 152). Two studies found significant increases in PDR in excellent vs. adequate preparation (134, 153), and Clark et al. found that excellent vs. adequate bowel preparation detects more SSPDR on the right side of the colon (154). Kimpel et al. examined patients' experiences and found that patients with inadequate bowel preparation experienced significantly more anxiety than those with adequate bowel preparation (p=0.03) (155). Through online surveys and telephone interviews, they found that bowel preparation depends on personal experience, context, instruction clarity and staff support. Pantelon Sanchez et al., found that the BBPS score was much higher in repeat colonoscopy after inadequate bowel preparation and the ADR rate in the repeat colonoscopy was 45.3% (95% CI, 40.5–50.1%) compared to 22% (95% CI, 18.1-26.3%) (150). See Appendix 4, Table 4.28.

Zhou et al. investigated the automatic BBPS (e-BBPS), a deep learning-based bowel preparation system, to determine the threshold of a e-BBPS score for adequate bowel preparation (153). They evaluated 616 screening colonoscopies, calculated the ADR of each e-BBPS score and found a significant inverse relationship between the e-BBPS and ADR of r=0.967, p<0.01. An e-BPPS score of 1 had a corresponding ADR of 28.57%, whereas an e-BBPS score of 8 had an ADR of 0%. Using 25% ADR as a standard for screening colonoscopy, they found a score of 3 on the e-BBPS could be set as a threshold in order to ensure an ADR of more than 25% (153).

Discussion and Implementation Considerations

The Working Group rated the measure of quality of bowel preparation highly important. Bowel preparation was felt to be an important measure to the patient as poor bowel preparation can cause patient stress and anxiety. The Working Group felt that bowel preparation is associated with lesion detection and felt that in general, a threshold of inadequate vs. adequate was appropriate, but that a more stringent threshold for right side, in order to detect sessile lesions, should be considered. Table 14.0 summarizes the evidence quality and ISFU criteria for bowel preparation.

**Table 14.0. Summary Table: Bowel Preparation.**

| Indicator | Number of studies | GRADE evaluation | ISFU Criteria | | | | |
|---|---|---|---|---|---|---|---|
| | | | Importance to measure and report | Scientific acceptability of measure properties | Feasibility | Usability and use | Comparison to related or competing measures |
| Bowel Preparation | 2 SR<br>1 review<br>8 cohort<br>1 cross-sectional | Low | High importance | Validated against ADR, HRADR, SSP and CIR and important patient outcomes.<br><br>BBSP is reliable, validated and has established benchmarks. Other reasonably validated scales include the Aronchick and Ottawa scale. Some evidence to support threshold of poor/inadequate bowel preparation vs. other for detection of adenomas. Some evidence to support more stringent right colon bowel preparation scores to detect SSPs. | Measurement at facility level may be more feasible than at regional and higher levels.<br><br>Use of validated scales in usual clinical practice may be cumbersome.<br><br>Unlikely to be used in a standardized fashion in routine reporting, making use of NLP less feasible. | Indirect evidence of an association with colonoscopy quality.<br><br>Lack of endoscopist "ownership" for bowel preparation quality may make it less actionable. | Key measure for colonoscopy quality.<br><br>Important to the patient.<br><br>No other similar measures. |

**Abbreviations:** HRADR, high-risk adenoma detection rate; ADR, adenoma detection rate; BBSP, Boston Bowel Preparation Scale; CIR, cecal intubation rate; GRADE, Grading of Recommendations, Assessment, Development and Evaluation; ISFU, importance, scientific acceptability, feasibility, usability, and comparison to related/competing measures; NLP, natural language processing; SSP, sessile serrated polyps; vs., versus.

*Retroflexion and second forward view of right side of colon*

Retroflexion refers to sharply turning the distal end of the colonoscope so as to see backwards. Typically, this maneuver is performed in the rectum; however, more recently, it has also been used to improve detection of lesions on the right side of the colon, which are often missed during standard colonoscopy (156).

The literature search for retroflexion as a quality indicator resulted in six articles being kept after full-text review (Appendix 4, Table 4.29). There were three systematic reviews (39, 156, 157) and three studies that explored retroflexion (158-160). The UK guidance recommends that rectal retroflexion should be performed in 90% of cases, based on small, reported increases in the detection of adenomas, but did not make recommendations about right colon retroflexion (RCR) (6).

Definition and Validation

Two systematic reviews with meta-analyzes compared the yield of RCR, second forward view (SFV) examinations and standard colonoscopy for detection of right-sided adenomas and other lesions and found that any second examination significantly improved detection of right-sided lesions (156, 157). The systematic review by Rees et al., discussed the improvement in ADR with retroflexion and the importance of careful attention paid to good technique to avoid harms (39). An RCT by Yang et al., found that a second examination of the proximal colon had a statistically significantly higher ADR and PDR for the proximal colon and statistically significantly higher ADR for the whole colon (160). The RCT by Nunez Rodriguez et al. randomized patients to RCR or SFV in a FIT screening program and did not find a statistically significant difference in ADR between the two procedures (9% proximal retroflexion vs. 12% second forward view, p=0.21) (159)(Appendix 4, Table 4.30).

Discussion and Implementation Considerations

The Working Group rated the indicator of re-examination of the right colon (whether as SFV or RCR) as important. When comparing SFV and RCR, it seems that any second examination of the right-sided colon increases the yield of lesions found over a standard colonoscopy. The Working Group did not feel that there was sufficient evidence to set a target for rectal retroflexion or re-examination of the right side of the colon. They also acknowledged the possible increase in the risk for adverse events such as perforations. Table 15.0 summarizes the evidence quality and ISFU criteria for right sided retroflexion.

**Table 15.0. Summary Table: Retroflexion and Second Forward View**

| Indicator | Number of studies | GRADE evaluation | ISFU Criteria | | | | |
|---|---|---|---|---|---|---|---|
| | | | Importance to measure and report | Scientific acceptability of measure properties | Feasibility | Usability and use | Comparison to related or competing measures |
| Re-examination of the right colon (either RCR or SFV) | 3 SR<br>2 RCT<br>1 cohort study | Moderate | Important | Re-examination of right-sided colon validated against AMR and R-ADR.<br><br>Method of re-examination not important. | Not possible to measure at the jurisdictional level but could be measured at the facility level.<br><br>Unclear if routinely reported in endoscopy reports, making use of NLP less feasible. | Indirect evidence of an association with colonoscopy quality. | Addresses the issue of missed right sided neoplasia. |
| Rectal retroflexion | 1 SR<br>1 RCT | Low | Important | Rectal retroflexion has been shown to lead to small improvements in adenoma detection | Not possible to measure at the jurisdictional level but could be measured at the facility level.<br><br>Unclear if routinely reported in endoscopy reports, making use of NLP less feasible. | Indirect evidence of an association with colonoscopy quality. | |

**Abbreviations:** AMR, adenoma miss rate; GRADE, Grading of Recommendations, Assessment, Development and Evaluation; ISFU, importance, scientific acceptability, feasibility, usability, and comparison to related/competing measures; NLP, natural language processing; R-ADR, right-sided ADR; RCR, right colon retroflexion; SFV, second forward view.

The literature search for colonoscopy quality indicators resulted in two new indicators: Performance Indicator of Colonic Intubation (PICI) and Intubation of the terminal ileum (TIIR) (Appendix 4, Table 4.31).

*PICI*

There were three studies that investigated the use and validity of PICI, defined as the proportion or percentage of all colonoscopies where the cecum was intubated, a nurse assessed comfort score of 1–3 ("comfortable" to "mild discomfort") on the Gloucester comfort scale AND

≤2 mg of midazolam (or ≤2.5 mg in the Nass study) (161-163). Adequate PICI was defined as cecal intubation without significant discomfort and use of minimal sedation (Nass). Achievement of PICI was defined as the proportion of all procedures in the audit that achieved cecal intubation AND less than or equal to the median dose of midazolam (2 mg) AND a nurse-assessed comfort score of 1–3 ("comfortable" to "mild discomfort") (163).

Definition and Validation

PICI varied across studies (46.1% vs. 78.7% vs. 54.1%) (161-163) and across endoscopists (40-91.9% in the Lund et al. study (161)). Nass et al. found that ADR was marginally higher for colonoscopies during which adequate PICI was achieved compared with colonoscopies without adequate PICI (64.8% vs. 63.6%; p<0.001), (OR, 1.16; 95% CI, 1.12 to 1.20), but there was no difference in advanced adenoma detection (OR, 1.03; 95% CI, 1.00 to 1.06; p=0.65) or detection of proximal serrated polyp (OR, 1.04; 95% CI, 0.99 to 1.10; p=0.14) detection (162). Lund et al. found no clear pattern for improvement in ADR, PDR, polyp retrieval rate and WT over increasing PICI quartiles. Valori et al. found that PICI was associated with a significantly higher likelihood of detecting one or more polyps, compared with procedures with no achievement of PICI (where one of the three procedure were not met) (OR, 1.44; 95% CI, 1.35 to 1.53). PICI was also associated statistically with detecting two or more polyps (OR, 1.45; 95% CI, 1.34 to 1.57) but not significantly associated with finding cancer (OR, 1.14; 95% CI, 0.98 to 1.32) (163).

*TIIR*

Intubation of the terminal ileum determines a complete colonoscopy, but it is unknown whether terminal ileum intubation during screening colonoscopy is associated with other colonoscopy quality measures.

Definition and Validation

One retrospective cohort study investigated whether terminal ileum intubation during screening colonoscopy was associated with various quality measures. However, there were no statistically significant differences in the PDR, ADR, or SSPDR in cases with or without terminal ileum intubation (164).

Discussion and Implementation Considerations

The Working Group rated the measures of PICI and TIIR as having low importance. The Working Group felt that PICI, although associated with ADR and other indicators and though it addresses a key safety concern with CIR, was too complicated to measure (especially across endoscopy units where sedation practices may differ) and not reproducible. The Working Group felt that TIIR was not associated with other indicators such as ADR and did not add anything beyond CIR measures. Table 16.0 summarizes the evidence quality and ISFU criteria for PICI and Table 17.0 summarizes the evidence quality and ISFU criteria for TIIR.

**Table 16.0. Summary Table: PICI.**

| Indicator | Number of studies | GRADE evaluation | ISFU Criteria | | | | |
|---|---|---|---|---|---|---|---|
| | | | Importance to measure and report | Scientific acceptability of measure properties | Feasibility | Usability and use | Comparison to related or competing measures |
| PICI | 3 cohort studies | Low | Addresses concern with CIR, with respect to safety and patient comfort<br><br>New colonoscopy quality construct | Associated with ADR in most studies<br><br>PICI correlated with:<br>-unit accreditation,<br>-the presence of magnetic imagers in the unit,<br>-greater annual volume,<br>-fewer years' experience,<br>-higher training/trainer status<br><br>No data on risk adjustment, clinically important difference, issues with data sources or missing data. | CIR, sedation level, and comfort should be measured regardless<br><br>PICI cannot be measured in units where propofol is routinely used<br><br>PICI varies on sedation level and may not be comparable across or within endoscopy units with different sedation practices<br><br>May be feasible to report at the unit level but it may challenge across a region or provincially as their patient comfort or sedation measure is not in the health administrative data | Takes into consideration of safety and comfort<br><br>Could be used to improve patient care | Is CIR enough?<br><br>It adds another dimension to CIR |

**Abbreviations:** ADR, adenoma detection rate; CIR, cecal intubation rate; GRADE, Grading of Recommendations, Assessment, Development and Evaluation; ISFU, importance, scientific acceptability, feasibility, usability, and comparison to related/competing measures; PICI, Performance Indicator of Colonic Intubation.

**Table 17.0. Summary Table: TIIR.**

| Indicator | Number of studies | GRADE evaluation | ISFU Criteria | | | | |
|---|---|---|---|---|---|---|---|
| | | | Importance to measure and report | Scientific acceptability of measure properties | Feasibility | Usability and use | Comparison to related or competing measures |
| TIIR | 1 cohort study | Low | Low importance (Not associated with quality indicators or indication of additional pathology) | No significant differences in the PDR, ADR, or SSPDR in cases with or without TI intubation.<br><br>No additional pathology. | Quite feasible | Unlikely to change quality of patient care | Does not appear to add anything beyond CIR |

**Abbreviations:** ADR, adenoma detection rate; CIR, cecal intubation rate; GRADE, Grading of Recommendations, Assessment, Development and Evaluation; ISFU, importance, scientific acceptability, feasibility, usability, and comparison to related/competing measures; PDR, polyp detection rate; PICI, Performance Indicator of Colonic Intubation; SSPDR, sessile serrated polyp detection rates; TI, terminal ileum; TIIR, terminal ileum intubation rate.

Certainty of the Evidence

There were three systematic reviews (two for retroflexion and one for bowel preparation) that were found to have a low risk of bias using the ROBIS (9). Three RCTs were assessed using the RoB 2.0 tool (10). The four for WT were found to have a low risk of bias and for retroflexion, Yang et al., has a low risk of bias and Nunez Rodriguez et al., had a moderate-low risk of bias. Nineteen cohort studies were assessed using the ROBINS tool (11) for non-randomized studies: five had a serious risk of bias, 10 had a moderate risk of bias and one has a low risk of bias. For PICI, three studies were found to be of a moderate risk of bias. For TIIR, the study by Leiman et al. had a moderate risk of bias.

***Polyp Management***

The literature search for polyp management topics as a quality indicator resulted in 60 articles. However, only one study was deemed appropriate for this review. Other topics (polyp retrieval rate, indicators of appropriate management (e.g., polyp adjudication) and ER technique (e.g., tattooing) for large/complex polyps, advanced visualization techniques and diagnostic biopsies for unexplained diarrhea) would be more appropriately addressed by other questions that are planned for the future.

*Incomplete Resection*

One retrospective cohort study was found that compared the rate of metachronous adenoma attributable to incomplete resection in polyps 6 to 9 mm versus polyps 10 to 20 mm using an indicator called the segmental metachronous adenoma rate attributable to incomplete resection (SMAR-IR). The SMAR-IR was calculated at a second colonoscopy by subtracting the rate of metachronous adenoma in segments without adenoma at the index examination from the rate of metachronous adenoma in segments with adenoma at the index examination (165) (Appendix 4, Table 4.32).

Definition and Validation

For the 146 patients in which a 10-20 mm tubular adenoma was resected at the index colonoscopy, the SMAR-IR was 11.4% (95% CI, 4.5 to 18.3). For 191 cases in which an index 6-9 mm tubular adenoma was resected at the index colonoscopy, the SMAR-IR was 13.2% (95% CI, 7.2 to 19.4) (165) (Appendix 4, Table 4.33).

Certainty of the Evidence

One cross-sectional study was assessed using the JBI Critical Appraisal Checklist for Analytical Cross-Sectional Studies (12) and was found to be methodologically sound.

Discussion and Implementation Considerations

Incomplete polypectomy is an important cause of PCCRC. SMAR-IR is intended to capture this construct; as such, it may be valuable. Incomplete resection of neoplasia appears to be a significant risk factor for metachronous neoplasia in 6-9 mm lesions as well as larger polyps (10 to 20 mm). The Working Group rated it as less important because of the lack of validation with other indicators. Monitoring of incomplete resections lesions could be considered at the facility level. Table 18.0 summarizes the evidence quality and ISFU criteria for SMAR-IR.

**Table 18.0. Summary Table: Incomplete Resection.**

| Indicator | Number of studies | GRADE evaluation | ISFU Criteria | | | | |
|---|---|---|---|---|---|---|---|
| | | | Importance to measure and report | Scientific acceptability of measure properties | Feasibility | Usability and use | Comparison to related or competing measures |
| SMAR-IR | 1 cross-sectional study | Low | Less important | Not validated.<br><br>An approach to measuring incomplete resection has been reported. | Potentially feasible at the facility level more than at regional and higher levels. | No association with colonoscopy quality reported.<br><br>Has face validity as incomplete resection is a cited cause for PCCRCs. | No other similar measures. |

**Abbreviations:** GRADE, Grading of Recommendations, Assessment, Development and Evaluation; ISFU, importance, scientific acceptability, feasibility, usability, and comparison to related/competing measures; PCCRC, post-colonoscopy colorectal cancers; SMAR-IR, segmental metachronous adenoma rate attributable to incomplete resection

**Ongoing, Unpublished, or Incomplete Studies**

A search for ongoing, unpublished, or incomplete phase II, III or IV trials was conducted on January 27, 2023, at clinicaltrials.gov using the terms “colonoscopy” AND “quality indicator”. No studies were found that were applicable to this evidence summary.

**DISCUSSION**

CRC screening has been shown to be reduce CRC morbidity and mortality. Colonoscopy is key to CRC screening because of its role in detecting CRC after an abnormal fecal test and because it is used to detect and resect precancerous polyps. Therefore, high-quality colonoscopy for all indications is critical. In order to measure quality, valid indicators with

minimally acceptable and aspirational targets are necessary but not sufficient to improve colonoscopy quality. Simply reporting indicators to endoscopists is likely not sufficient (37); supplementing with additional interventions including facilitated feedback that helps to minimize cognitive dissonance and access to evidence-based training programs may be required.

In 2013, OH (CCO)'s PEBC updated the 2007 Colonoscopy Standards with a Guideline for Colonoscopy Quality Assurance in Ontario. In the past decade, more evidence on existing indicators and on new indicators has been published. In this document, the Working Group reviewed and reassessed the evidence for the existing indicators and considered evidence for new indicators to inform OH (CCO)'s colonoscopy quality program. This evidence summary is intended to provide the basis for a quality framework for colonoscopy, regardless of indication and to provide evidence, where available, for benchmarks or targets for those indicators.

The Working Group categorized indicators in this review as either outcome indicators or process indicators, noting that structural indicators will be considered separately in the future. Outcome indicators are those that measure a direct effect of health care on patients or populations while process measures measure the actions that occur during the delivery of health care and are typically correlated with outcome indicators.

The Working Group decided to use the UK Performance standards as an evidence base to start because of its comprehensive approach to colonoscopy quality, but many other guidelines have overlapping indicators (166, 167). Evidence is summarized to inform or to support the use of each indicator, and where possible, to provide evidence to define and measure the indicator as well as providing data to support a benchmark or target. The Working Group also completed an ISFU table for each indicator to help clarify the importance, scientific acceptability, feasibility and usefulness of each indicator to help indicate where benchmarking and target setting can be used by the program. Additionally, the Working Group ranked the importance (high, important, or low) of each indicator based on the direct impact on patient care and the methodologically soundness of the evidence through the discussion among the Working Group members.

This summary only examined the quality indicators and provided implementation guidance. How these quality indicators can be used to develop benchmarks and targets at the endoscopist, unit or regional level will be considered by the ColonCancerCheck and the GI Endoscopy Programs at OH (CCO).

## CONCLUSIONS

This evidence summary document will form the basis or a quality assurance system for colonoscopy in Ontario. As noted above, measuring these indicators alone is likely not sufficient, additional supplementary interventions will likely be required with the ultimate goal of encouraging a culture of lifelong learning and upskilling among endoscopists. In so doing, it is hoped that optimizing the quality of colonoscopies will lead to an improvement in patient outcomes such as comfort and satisfaction, a reduction in PCCRCs and adverse events and ultimately, a reduction in CRC incidence and mortality.

## INTERNAL REVIEW

The evidence summary was reviewed by Jonathan Sussman. The Working Group was responsible for ensuring any necessary changes were made.

### Acceptance by Prevention and Cancer Control, Ontario Health (Cancer Care Ontario)

After internal review, the report was presented to the Prevention and Cancer Control, Ontario Health (Cancer Care Ontario). Prevention and Cancer Control, Ontario Health (Cancer

Care Ontario) reviewed the document in November 2023 via email, and formally accepted the document.

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## Appendix 1: Affiliations and Conflict of Interest Declarations

In accordance with the PEBC Conflict of Interest (COI) Policy, the evidence summary authors and internal reviewers were asked to disclose potential conflicts of interest.

Colonoscopy Quality Assurance Evidence Summary Working Group

| Name | Affiliation | Declarations of Interest |
|---|---|---|
| **Jill Tinmouth** | Sunnybrook Hospital<br>Toronto, ON | None |
| **Catherine Dubé** | The Ottawa Hospital<br>Ottawa, ON | None |
| **Sunil Patel** | Kingston Health Sciences Centre<br>Kingston, ON | None |
| **David Baron** | North York General Hospital<br>North York, ON | None |
| **Stan Feinberg** | North York General Hospital<br>North York, ON | None |
| **Jeff Mosko** | Unity Health Toronto<br>Toronto, ON | Received grant from the Canadian Association of Gastroenterology |
| **Catharine Walsh** | Sick Kids Hospital<br>Toronto, ON | None |
| **Joni Ettinger** | The Ottawa Hospital<br>Ottawa, ON | None |
| **Caroline Zwaal** | Program in Evidence-based Care, McMaster University | None |

## Appendix 2: Literature Search Strategy

Guideline Search
ECRI Database: https://guidelines.ecri.org/
NICE Evidence Search: http://www.evidence.nhs.uk/
CPAC Database: https://www.partnershipagainstcancer.ca/tools/cancer-guidelines-database/
CMA Infobase: https://www.cma.ca/En/Pages/clinical-practice-guidelines.aspx

International Guideline Developers:
NICE (UK) – NICE Guidance
SIGN (UK) – SIGN Guidelines
ASCO (US) – ASCO Guidelines
National Health and Medical Research Council – Australia Clinical Practice Guidelines Portal
Cancer Council Australia – Cancer Guidelines Wiki
Geneva Foundation for Medical Education and Research - https://www.gfmer.ch/

Other sources (to be refined with input from the working group):

Canadian Association of Gastroenterology
Society of American Gastrointestinal Endoscopic Surgeons
American Society for Gastrointestinal Endoscopy
American Society of Colon and Rectal Surgeons
Joint Advisory Group on Gastrointestinal Endoscopy
Canadian Society of Gastroenterology Nurses and Associates
American Gastroenterological Association
American College of Gastroenterology
Society of Gastrointestinal Endoscopic Surgery

Full Search
Date: August 2021
Databases: OVID EMBASE and Medline
Results: 1445 found: Full text: 157: Kept: 47

1. exp colonoscopy/ or colonoscopy.mp. or colonoscopies.mp. or colonoscopy.tw. or exp Colonoscopes/ or colonoscope.mp.
2. exp Quality Indicators, Health Care/ or quality indicator.mp. or exp Quality Assurance, Health Care/ or quality assurance.mp.
3. 1 and 2
4. (comment or letter or editorial or note or erratum or short survey or news or newspaper article or patient education handout or case reports or historical article). pt.
5. animal/ not human/
6. 4 or 5
7. 3 not 6

Additional Searches
Database: Medline

Post-colonoscopy CRC -September 2021
1. post colonoscopy colorectal cancer.ti

2. colonoscopy.mp. or Colonoscopy/
3. 1 and 2
4. (comment or letter or editorial or note or erratum or short survey or news or newspaper article or patient education handout or case report or historical article).pt.
5. 3 not 4
6. limit 5 to English language
7. exp animal/ not (exp human/ or humans/)
8. 6 not 7
9. limit 8 to yr="2015 -Current"

Rates of Surgical Resection -January 2022

1. Colonic Neoplasms/ or Colonic Polyps/ or large polyps.mp. or Colorectal Neoplasms/
2. ("colon" or "colon" or "rectum" or "rectum" or "colorectal").mp.
3. ("polypectomy" or "removal" or "EMR" or "removal" or "ESD" or "endoscopic resection" or "mucosectomy" or "endoscopic submucosal resection" or "Colonoscopy/therapeutic use OR Colonoscopy/therapy").mp.
4. ("colonic polyps" or ("colonic" and "polyps") or "colonic polyps" or ("colon" and "polyp") or "colon polyp" or "polyps" or "polyps" or "polyp" or "lesion" or "Adenoma" or "adenoma" or "adenomatous" or "neoplasia" or "Neoplasms").mp.
5. 1 and 2 and 3 and 4
6. limit 5 to (english language and yr="2014 -Current")
7. (comment or letter or editorial or note or erratum or short survey or news or newspaper article or patient education handout or case report or historical article or conference abstract).pt.
8. 6 not 7
9. exp animal/ not (exp human/ or humans/)
10. 8 not 9
11. children.mp. or Child/
12. 10 not 11
13. rate.mp.
14. 12 and 13
15. surgery.mp. or General Surgery/
16. 14 and 15
17. snare.mp.
18. 16 not 17
19. 12 and 15
20. 19 not 17
21. 20 and 13

Adverse events -May 2022

1. complication:.ti
2. complication.mp.
3. perforation:.ti.
4. perforation.mp.
5. bleed:.ti
6. bleed.mp
7. death:,ti
8. death.mp
9. adverse event:.ti
10. adverse event.mp

11. 1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10
12. colonoscopy.mp. or Colonoscopy/
13. 11 and 12
14. (comment or letter or editorial or note or erratum or short survey or news or newspaper article or patient education handout or case report or historical article).pt.
15. 13 not 14
16. limit 15 to English language
17. exp animal/ not (exp human/ or humans/)
18. 16 not 17
19. limit 18 to yr="2015 -Current"

Patient Outcomes -November 2021

1. patient satisfaction.ti
2. patient satisfaction.mp.
3. patient comfort.ti.
4. patient comfort.mp.
5. patient pain.ti
6. patient pain.mp
7. 1 or 2 or 3 or 4 or 5 or 6
8. colonoscopy.mp. or Colonoscopy/
9. 7 and 8
10. (comment or letter or editorial or note or erratum or short survey or news or newspaper article or patient education handout or case report or historical article).pt.
11. 9 not 10
12. limit 11 to English language
13. exp animal/ not (exp human/ or humans/)
14. 12 not 13
15. limit 14 to yr="2015 -Current"

Adenoma Detection Rate -August 2022

1. adenoma detection rate.ti
2. adenoma detection rate.mp.
3. polyp detection rate.ti.
4. polyp detection rate.mp.
5. 1 or 2 or 3 or 4
6. colonoscopy.mp. or Colonoscopy/
7. 5 and 6
8. (comment or letter or editorial or note or erratum or short survey or news or newspaper article or patient education handout or case report or historical article).pt.
9. 7 not 8
10. limit 9 to English language
11. exp animal/ not (exp human/ or humans/)
12. 10 not 11
13. limit 12 to yr="2015 -Current"

CIR, Retroflexion, Withdrawal Time, Bowel Preparation -October 2022

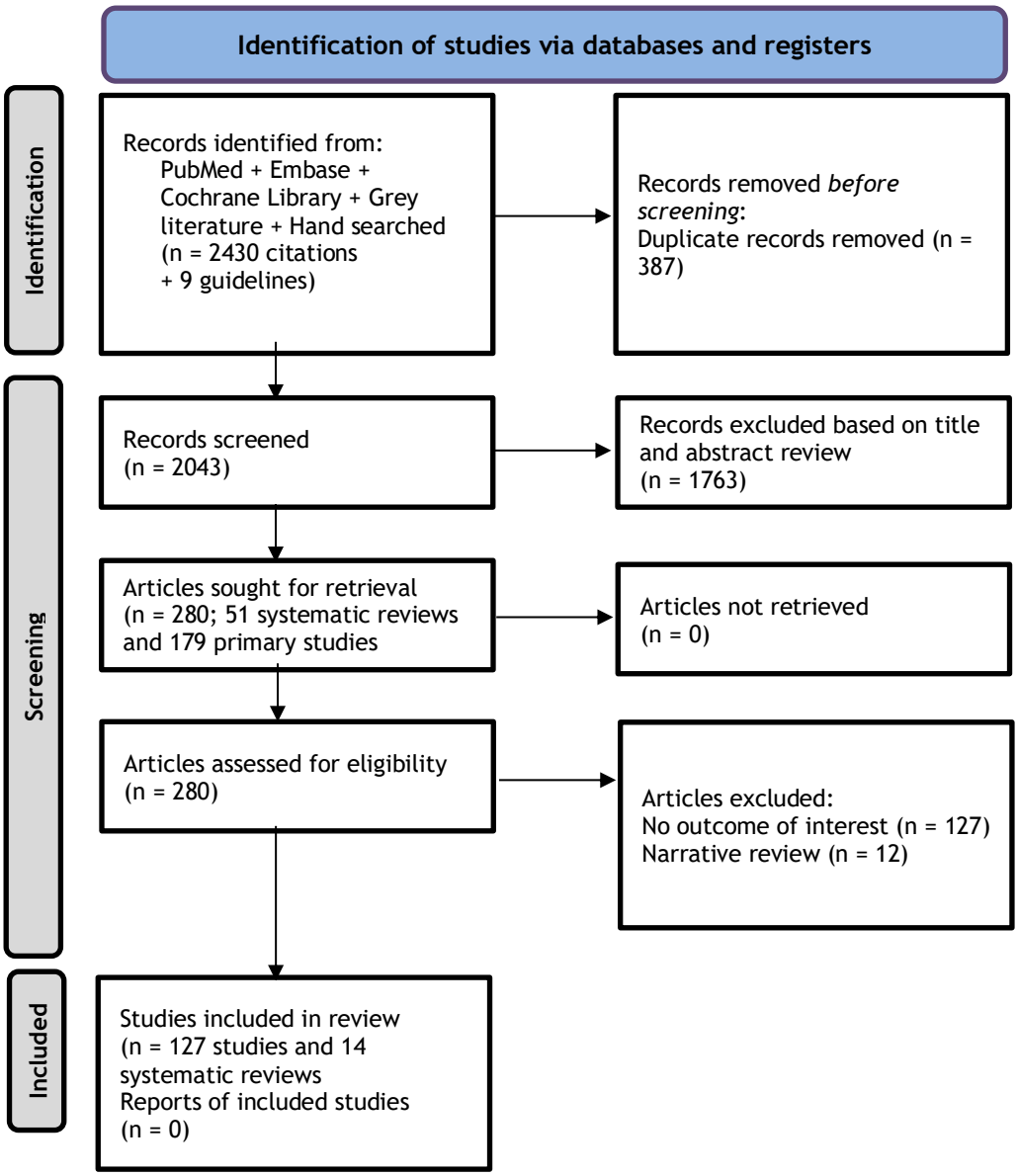
1. cecal intubation rate.ti
2. cecal intubation rate.mp.
3. caecal intubation rate.mp.
4. caecal intubation rate.ti.

5. 1 or 2 or 3 or 4
6. bowel preparation.mp
7. bowel preparation.ti.
8. 6 or 7
9. rectal retroflexion.mp.
10. rectal retroflexion.ti.
11. 8 or 9
12. withdrawal time.mp
13. withdrawal time.ti.
14. 11 or 12
15. colonoscopy.mp. or Colonoscopy/
16. (5 or 8 or 11 or 14) and 15
17. (comment or letter or editorial or note or erratum or short survey or news or newspaper article or patient education handout or case report or historical article).pt.
18. 16 not 17
19. limit 18 to English language
20. exp animal/ not (exp human/ or humans/)
21. 19 not 20
20. limit 21 to yr="2015 -Current"

Polyp management -October 2022

1. Colonoscopy/ or colonoscopy.mp.
2. colonic polyp.mp. or Colonic Polyps/
3. rate.mp.
4. polyp retrieval rate.mp.
5. polyp retrieval.ti.
6. polyp retrieval.mp.
7. Diarrhea/ or diarrhea.mp.
8. diarrhoea.mp.
9. 7 or 8
10. Biopsy/ or biopsy.mp.
11. 10 and 9 and 1
12. (comment or letter or editorial or note or erratum or short survey or news or newspaper article or patient education handout or case report or historical article).pt.
13. 11 not 12
14. exp animal/ not (exp human/ or humans/)
15. 13 not 14
16. limit 15 to yr="2015 -Current"
17. Case Reports/
18. 16 not 17
19. 4 or 5 or 6
20. incomplete polyp resection.mp.
21. incomplete resection.ti.
22. incomplete resection.mp.
23. 22 or 21 or 20
24. 23 and 1 and 2
25. 23 and 1

## Appendix 3: PRISMA Flow Diagram



## Appendix 4: Data tables

### Table 4.1. PCCRC Clinical Outcomes Study Characteristics.

| Study | Location | Design | Number of Participants or procedures | Data Source | Data Collection | Purpose of Study | Reason for Colonoscopy |
|---|---|---|---|---|---|---|---|
| Shanahan, 2022 (20) | Canada | Retrospective Cohort | 508 PCCRC | Two health authorities database and chart review | 1996-2018 | To estimate the PCCRC rate in NL, and compare the features to other Canadian rates | All colonoscopies<br>Used pts with CRC for data |
| Waldmann, 2022 (21) | Austria | Prospective cohort | 352,685 screening COL<br>241 PCCRC | Nationwide quality assurance program | 2008-2019 | To examine PCCRC with endoscopist performance and ADR | Screening colonoscopy |
| Aerts, 2021 (23) | Belgium | Prospective cohort | 807 CRC<br>47 PCCRC | Single centre<br>Chart review | 2014-2020 | To classify PCCRC into categories by WEO and calculate unadjusted PCCRC rate | Not stated<br>Used pts with CRC for data |
| Dossa, 2021 (22) | Canada | Retrospective cohort | 779 pts<br>412 CRC<br>367 PCCRC | Random sample from 49 institutions<br>Chart review | 2000-2005 | To assess the association of patient, tumour and endoscopist characteristics | Not stated<br>Used pts with CRC for data |
| Anderson, 2020 (24) | England | Retrospective cohort | 107 PCCRCs | Single centre<br>Chart review | 2010-2017 | To perform a root-cause analysis for each PCCRC case | Symptoms, surveillance<br>Index colonoscopies |
| Forsberg, 2020 (35) | Sweden | Retrospective cohort | 458,937 colonoscopies performed on 352,176 individuals | Swedish Cancer Registry<br>No chart review | 2003-2012 | To analyze survival, identify and evaluate the risk factors associated with developing PCCRC | Not stated |
| Burr, 2019 (30) | England | Retrospective cohort | 126,152 COL in 121,402 people | English National Health Service<br>No chart review | 2005 -2013 | To quantify PCCRC rates in England by using recent WEO guidelines | Screening program, all procedures |
| Chen, 2019 (29) | Taiwan | Prospective cohort | 1653 patients with PCCRC and 22,169 patients with DCRC | Taiwan National Cancer Registry<br>No chart review | 2002-2009 | To quantify if there was a shorter life expectancy with PCCRC and explore risk factors | Not stated. Used pts with CRC for data |
| Cheung, 2019 (28) | Hong Kong | Retrospective cohort | 197,902<br>10,005 FN COLs<br>854 TP COLs | Hong Kong Hospital Authority data base (CDARS)<br>No chart Review | 2005-2016 | To determine the epidemiology, characteristics, risk factors, and mortality of PCCRC as compared with detected CRC | Screening colonoscopies |

| Study | Location | Design | Number of Participants or procedures | Data Source | Data Collection | Purpose of Study | Reason for Colonoscopy |
|---|---|---|---|---|---|---|---|
| Macken, 2019 (27) | Belgium | Retrospective cohort | 2126 FN COLs | Belgian Cancer Registry<br>No chart review | 2002-2010 | To quantify the incidence of PCCRC in Belgium and describe influencing factors | All colonoscopies |
| Pedersen, 2019 (26) | Denmark | Retrospective Cohort | 15,007 TN COL<br>1746 FN COL | No chart review | 2001-2015 | To compare Danish PCCRC rates internationally and evaluate the Danish PCCRC-3yr using WEO guidelines | Not stated |
| Tollivoro, 2019 (25) | USA | Case-control | Cases (n=1206)<br>Controls (n=634) | Health Plan members<br>Chart review | 2002-2012 | To examine the index colonoscopy predictors of PCCRC diagnosed >1 year and up to 10 years after examination | Not stated |
| Murthy, 2018 (32) | Canada | Retrospective Cohort | 1,093,658 low-to moderate risk screen eligible people | No chart review | 1996-2010 | Explore temporal trends | Screening colonoscopy |
| Nakada, 2017 (31) | Japan | Retrospective cohort | 2544 patients with 2 colonoscopies | No chart review | September 1995 -January 2012 | To estimate the incidence of and identify risk factors associated with PCCRC | Not stated |
| Govindarajan, 2016 (5) | Canada | Retrospective cohort | 45,104 patients<br>2804 PCCRC<br>27,671 DCRC<br>14 629 NOSCOPE | No chart review | 2003-2009 | To assess the outcomes of patients diagnosed with PCCRC | Not stated |
| Stoffel, 2016 (33) | Denmark | Cross-sectional | 10,365 CRC cases<br>9640 DCRC<br>725 PCCRC | Danish medical registries<br>Chart review | 2007-2011 | To examine the clinical and molecular features of PCCRC | Not stated |
| Hilsden, 2015 (34) | Canada | Retrospective cohort | 18,456 asymptomatic people | Chart review | 2008-2010 | To explore the association of COL quality indicators and detection of SRLs, AE and PCCRC | Screening colonoscopy |

**Abbreviations:** ADR, adenoma detection rate; AE, adverse events; CDARS, Clinical Data Analysis and Reporting System; COL, colonoscopy; CRC, colorectal cancer; DCRC, detected colorectal cancer; FN, false negative; NOSCOPE, no colonoscopy within 36 months of diagnosis; PCCRC, post-colonoscopy colorectal cancers; PCRC, pts, patients; SRL, screen-relevant lesions; TN, true negative; TP, true positive; WEO, World Endoscopy Organization; yr, year.

**Table 4.2. PCCRC: Characteristics and Risk Factors -13 studies.**

| Study | Participants | Results |
|---|---|---|
| Shanahan, 2022 (20) | 508 CRC<br>median age of 67.1 years | • Estimated PCCRC rate to be between 8.1% to 9.3%<br>• 57% of PCCRCs occur proximal to the splenic flexure, and 47.6% proximal to the hepatic flexure<br>• median interval time from index colonoscopy to PCCRC diagnosis: 2.9 years, range: 0.3–5.0 years<br>• median age of diagnosis: 69.6 years |
| Waldmann, 2022 (21) | 352685 screening COL<br>241 PCCRC, prospective cohort 2008-2019 | • PCCRC and high-risk group of patients (HR compared with negative colonoscopy 3.27, 95% CI 2.36 to 4.53, p<0.001).<br>• PCCRC and increased patient age was also highly significant (HR per 10 years increase 1.79, 95% CI 1.54 to 2.08, p<0.001) |
| Aerts, 2021 (23) | 2014-2020<br>6 years of data collection in prospective registration of patients with CRC and COL | PCCRCs were more located in the right colon with a higher percentage of MSI-positive and B-RAF mutated tumours |
| Dossa, 2021 (22) | 367 patients with PCCRC (between 6 mo-3 yr post COL) and 412 with detected CRC (within 6 mo of COL); from random sample from 49 institutions; diagnosed with CRC from 1 January 2000 to 31 December 2005 | Compared to patients with detected CRC, patients with PCCRC<br>• older (71.58 ± 11.45 years vs. 67.31 ± 12.28 years, p<0.001)<br>• more likely to be women (48.0% vs. 38.8%, p=0.01)<br>• more likely to have proximal cancers (54.2% vs. 32.8%, p<0.001)<br><br>Factors independently associated with PCCRC<br>• patient age (OR, 1.01; 95% CI 1.00–1.03), p=0.05<br>• endoscopist specialty (general surgeon vs. gastroenterologist OR, 0.66; 95% CI 0.49–0.88), p<0.01<br>• proximal tumour location (distal vs. proximal OR, 0.36; 95% CI 0.25–0.53), p<0.01 |
| Anderson, 2020 (24) | 107 PCCRCs identified at a single medical centre in England from January 1, 2010, through December 31, 2017, using coding and endoscopy data.<br><br>Retrospective analysis | Factors associated with PCCRC:<br>• 43% were in high-risk patients (those with inflammatory bowel disease, previous CRC, previous multiple large polyps, or hereditary cancer syndromes, “hot” colon)<br>• 66% were located distal to the hepatic flexure.<br>• no correlation between post colonoscopy colorectal tumour size and time to diagnosis after index colonoscopy.<br>• 24.3% had more than 1 colonoscopy in the 4 years before<br><br>PCCRC diagnosis<br>• Development of 73% of PCCRCs was determined to be affected by technical endoscopic factors, 17% of PCCRCs by administrative factors (follow-up procedures delayed/not booked by administrative staff), and 27% of PCCRCs by decision-making factors. |

| Study | Participants | Results |
|---|---|---|
| Forsberg, 2020 (35) | Swedish Cancer Registry 2003-2012, individuals with at least 1 COL | Risk factor PCCRC vs. DCRC<br>• male vs. female RR=0.87, p=0.009 (95% CI, 0.79–0.86)<br>• ulcerative colitis, yes/no, RR=5.44, p<0.001 (95% CI, 4.75–6.23)<br>• Crohn's disease, yes/no, RR=3.81, p<0.001 (95% CI, 2.98–4.87)<br>• prior polypectomy, yes/no, RR=2.32, p<0.001 (95% CI, 1.97–2.72)<br>• prior CRC diagnosis, yes/no, RR=3.31, p<0.001 (95% CI, 2.71–4.04)<br>• COPD, yes/no, RR=2.42, p=0.001 (95% CI, 1.42–4.11)<br>• Ischemic heart disease, yes/no, RR=1.21, p=0.020 (95% CI, 1.03–1.42)<br>• polypectomy, yes/no RR=1.37, p=0.001 (95% CI, 1.38–1.77)<br>• location, CRC Left- vs. right-sided CRC, RR= 0.66, p<0.001 (95% CI, 0.59–0.73)<br>• location, not defined vs. right-sided CRC, RR=0.72, p<0.001 (95% CI, 0.59–0.87) |
| Burr, 2019 (30) | All people undergoing colonoscopy in NHS between 2005 -2013 and subsequently diagnosed as having CRC up to three years after (PCCRC-3yr)<br><br>126 152 COL in 121,402 people who were diagnosed with CRC within 3 years of COL | Odds of developing PCCRC -3 yr in comparison to the rest of the study population, adjusted via multivariable analysis:<br>• year of colonoscopy<br>  ○ 2008-10: adj OR=0.86 (0.82-0.91, p<0.01)<br>  ○ 2011-13: adj OR=0.70 (0.66-0.74, p<0.01)<br>• age at colonoscopy > 80 adjusted OR =1.17 (1.09-1.27, p<0.01)<br>• female: adj OR =1.15 (1.10-1.20, p<0.1)<br>• Charlson comorbidity score<br>• 1: adj OR, 1.36 (1.28 to 1.44) <0.01<br>• 2: adj OR, 1.62 (1.48 to 1.76) <0.01<br>• 3: adj OR, 2.17 (1.98 to 2.38) <0.01<br>• inflammatory bowel disease adj OR, 4.93 (4.50 to 5.40) <0.01<br>• diverticular disease adj OR, 1.88 (1.79 to 1.97) <0.01<br>• COL within BCSP adj OR, 0.68 (0.62 to 0.74) <0.01<br>• COL with independent provider adj OR, 1.63 (1.39 to 1.91) <0.01<br>• previous CRC adj OR, 2.24 (2.00 to 2.52) <0.01<br>• previous COL adj OR, 3.29 (3.13 to 3.46) <0.01 |
| Chen, 2019 (29) | All patients with CRC from 2002-2009 in Taiwan National Cancer Registry | In comparison with detected CRC (found between 6-60 months)<br>PCCRC vs. DCRC<br>• males, 60.5% vs. 57.6% p=0.021<br>• higher diagnostic age, 68.7 vs. 65.2 p<0.001<br>• cancer stage 0, p=0.005<br>• location, more proximal sites, p<0.001<br>• previous endoscopic polypectomy procedures, 25.3% vs. 16.3%, p<0.001<br><br>Rates/proportions of PCCRC were<br>• 11.0% in the cecum, ascending colon, and hepatic flexure segment,<br>• 9.4% in the transverse colon segment,<br>• 7.0% in the splenic flexure and descending colon segment,<br>• 5.6% in the distal colon segment. |

| Study | Participants | Results |
|---|---|---|
| Cheung, 2019 (28) | All patients aged 40 years or above, who had undergone colonoscopy between 2005 and 2013.<br><br>197,902<br>10,005 FN COLs<br>854 TP COLs | In comparison with detected CRC (PCCRC vs. DCRC)<br>• older at index colonoscopy (74.6 vs. 71.9 years, p<0.001)<br>• older at CRC diagnosis (75.9 vs. 72.0 years, p<0.001),<br>• more proximal (17.2% vs. 9.8%, p<0.001)<br>• more colonic polyps (35.8% vs. 25.4%, p<0.001)<br>• more comorbidities: atrial fibrillation (6.4% vs. 4.0%, p<0.001) and congestive heart failure (7.5% vs. 4.8%, p=0.003)<br>Rates/proportions of PCCRC were<br>• 17.2% in the proximal colon<br>• 82.8% in the distal colon<br>Multivariable logistic regression found the following predictive factors:<br>• Age (in yearly increments): OR, 1.07, 95% CI, 1.06–1.08, p<0.001<br>• Male sex: OR, 1.45, 95% CI, 1.26–1.67, p<0.001<br>• History of colonic polyps: OR, 1.31, 95% CI, 1.13–1.51, p<0.001<br>• Polypectomy/biopsy at index COL: OR, 3.97, 95% CI, 3.46–4.56, p<0.001 |
| Macken, 2019 (27) | 2126 false FN COL<br>28,100 FN+ TP COL<br>2002-2010 | Hazard ratios comparing those with PCCRC and those without: (comparing conditional observed survival of patients with or without PCCRC)<br>• male vs. female: HR=0.68, 95% CI, 0.64-0.73, p<0.0001<br>• in situ vs. invasive: HR=1.26, 95% CI, 1.07-1.47, p=0.0048<br>• others vs. right/middle: HR=1.14, 95% CI, 1.06-1.23, p=0.0003<br>• age:<br>  ○ < 45 years vs. 55-64: HR=1.72, 95% CI, 1.19-2.47, p=0.0042<br>  ○ < 45 years vs. 65-74: HR=2.57, 95% CI, 1.73-3.67, p<0.0001<br>  ○ < 45 years vs. 75-84: HR=5.12, 95% CI, 3.59-7.32, p<0.0001<br>  ○ < 45 years vs. >84: HR=10.5, 95% CI, 7.23-15.2, p<0.0001<br>• multiple metachronous no vs. yes: HR=1.47, 95% CI, 1.18-1.53, p<0.0001<br><br>Comparing FN to FN+ TP (PCCRC to DCRC)<br>• Location: compared to left side<br>  ○ Sigmoid colon/rectosigmoid junction, OR, 0.86, p=0.007 (95% CI 0.75 – 0.98)<br>  ○ Middle, OR, 1.79, p<0.0001 (95% CI, 1.44 – 2.21)<br>  ○ Right, OR, 1.61, p<0.0001 (95% CI, 1.42 – 1.82)<br>  ○ Overlapping, OR, 1.34, p<0.0001 (95% CI, 1.14 – 1.56)<br><br>• Tumour behaviour: in situ: OR, 2.17, p<0.0001 (95% CI, 1.91 – 2.45)<br>• Deep sedation: no: OR, 1.50, p<0.0001 (95% CI, 1.35 – 1.65)<br>• Specialty; compared to gastroenterologist<br>  ○ Surgeon, OR, 1.95, p=0.001 (95% CI, 1.28 – 2.88)<br>  ○ Intern, OR, 1.31, p<0.0001 (95% CI, 1.18 – 1.45) |
| Pedersen, 2019 (26) | From 2001 to 2010, 39 100 Danish individuals were diagnosed | The Multivariable Poisson regression model found PCCRC to be significantly associated with<br>• diverticulitis (RR=3.25, 95% CI, 2.88 – 3.66, p<0.001),<br>• ulcerative colitis (RR=3.44, 95% CI, 2.79 – 4.23, p<0.001), |

| Study | Participants | Results |
|---|---|---|
| | with first primary CRC, of whom 11 483 individuals had undergone colonoscopy within 3 years of the diagnosis.<br><br>15,007 TN COL<br>1746 FN COL | • hereditary cancer (age<60 years: RR=7.39, 95% CI, 5.77 – 9.47, p<0.001; age ≥ 60 years: RR=3.81, 95% CI, 2.74 – 5.31, p<0.001),<br>• location in the transverse (RR=1.57, 95% CI=1.28 – 1.94, p<0.001)<br>• ascending colon (RR=1.85, 95%CI=1.64 – 2.08, p<0.001)<br>• colon (not otherwise specified) (RR=2.08, 95% CI, 1.74-2.49, p<0.001)<br>• tumour size: T3/T4 (RR=0.70, 95% CI, 0.61-0.81, p<0.001)<br>• Charlson comorbidity index:<br>  ○ 1: (RR=1.20, 95% CI, 1.03-1.40, p<0.05)<br>  ○ 2: (RR=1.25, 95% CI, 1.06-1.48, p<0.01) |
| Tollivoro, 2019 (25) | PCCRC cases (n=1206) included health-plan members who had an index COL negative for CRC and were subsequently diagnosed with CRC with the diagnosis occurring >12 months and up<br>to 10 years after the COL between 1998 and 2010 for KPNC; between 2005 and 2012 for KPSC<br><br>Controls (n=634) were health-plan members who had an index COL negative for CRC and were without a CRC diagnosis at the time of their selection as cases between 2002 and 2012, which was >1 year and up to 10 years after their COL | Risk factors for early versus late cancers (12-36 months vs. >36 months to 10 years after examination) included<br>• incomplete polyp excision in the colonic segment of the subsequent cancer (OR, 4.76; 95% CI, 2.35-9.65)<br>• failure to examine the segment (OR, 2.42; 95% CI, 1.27-4.60)<br>• polyp ≥10 mm in the segment (OR, 2.38; 95% CI, 1.53-3.70).<br><br>In adjusted analyzes significantly associated with PCCRC,<br>• the detection of any polyp (OR, 2.68; 95% CI, 2.15-3.34)<br>• incomplete colonoscopy (OR, 5.52; 95% CI, 2.98-10.21)<br>• not inadequate bowel preparation (OR, 1.11; 95% CI, 0.78-1.57)<br><br>Associated with PCCRC -Comparing cases to controls:<br>• proximal polyp ≥10 mm (OR, 8.18; 95% CI, 4.59-14.60),<br>• distal polyp ≥10 mm (OR, 3.30; 95% CI, 1.65-6.58),<br>• adenoma with advanced histology (OR, 3.23; 95% CI, 1.83-5.68)<br>• adenoma without advanced histology (OR, 1.87; 95% CI, 1.37-2.55),<br>• incomplete colonoscopy (OR, 5.52; 95% CI, 2.98-10.21)<br><br>Among 1206 cases, 559 (46.4%) had 1 or more of the risk factors that were significant for PCCRC (incomplete examination, large polyp, or any adenoma); among 634 controls, 155 (24.5%) had 1 or more risk factors |
| Murthy, 2018 (32) | Retrospective cohort study of persons aged 50 to 74 years without advanced risk factors for CRC who underwent complete COL in Ontario, Canada between 1996 and 2010. | Risk factors using regression models for adjusted OR: (all PCCRC)<br>• female, OR, 1.35, p<0.0001 (95% CI, 1.21-1.50)<br>• age (per-year increase) OR, 1.01, p=0.0049 (95% CI, 1.00-1.02)<br>• Charlson-Deyo Index (per 1 point increase) 1: OR, 0.24, p<.000 (95% CI, 0.22-0.27)<br>• diverticular disease, OR, 1.55, p=0.027 (95% CI, 1.09-2.20)<br>• colonoscopy at community clinic decrease over time (1996-2010) OR, 0.47, p<0.0001 (95% CI, 0.36-0.60)<br>• colonoscopy performed by other than gastroenterologist OR, 0.86, p=0.040 (95% CI, 0.74-0.99) |

| Study | Participants | Results |
|---|---|---|
| Stoffel, 2016 (33) | Danish medical registries, population-based nationwide study of all CRCs diagnosed during 2007–2011.<br>Cross-sectional | PCCRC compared with DCRC<br>• more proximal (OR, 2.34; 95% CI, 1.90-2.89, p<0.001)<br>• more dMMR (OR, 1.26; 95% CI, 1.00-1.59)<br>• less likely to be metastatic at presentation (OR, 0.65, 95% CI, 0.48-0.89)<br>• older and higher proportion of individuals with inflammatory bowel disease (p<.001). |

**Abbreviations:** adj, adjusted; BCSP, bowel cancer screening program; B-RAF, serine/threonine-protein kinase B-Raf; CI, confidence interval; COL, colonoscopy; COPD, chronic obstructive pulmonary disease; CRC, colorectal cancer; DCRC, detected colorectal cancer; dMMR, DNA mismatch repair deficiency; FN, false negative; HR, hazard ratio; KPNC, Kaiser Permanente Northern California; KPSC, Kaiser Permanente Southern California; mo, months; MSI, microsatellite instable; NHS, National Health Service; OR, odds ratio; PCCRC, post-colonoscopy colorectal cancers; RR, risk ratio; TN, true negative; TP, true positive; yr, years.

### Table 4.3. PCCRC -definition and rates: 16 studies, 1 systematic review.

| Study | Participants | Results |
|---|---|---|
| Kang, 2021 (19)<br><br>Meta-analysis | 15 studies -12 population-based cohort, 1 case control +2 from previous SR that used in unadjusted PCCRC calc. | • Range of PCCRC prevalence: 1.7-10.4%<br>• PCCRC- 3yr pooled prevalence of 4 studies using WEO rate methodology 8.2% (95% CI, 6.9%-9.4%) with high levels of heterogeneity ($I^2$=98.2%) (Burr, Cheung, Pedersen, Forsberg)<br>• "Unadjusted" PCCRC -3yr pooled prevalence (9 studies): 7.4% (95% CI, 6.5%-8.4%) with high levels of heterogeneity ($I^2$=99.0%) |
| Shanahan, 2022 (20) | 508 CRC<br>median age of 67.1 years | PCCRC DEFINITION:<br>• Primary analysis not consistent with the WEO: colorectal cancer diagnosed after a screening or surveillance exam in which no cancer is detected, and before the date of the next recommended exam<br>PCCRC RATE CALCULATION:<br>• Not consistent with WEO. Estimated PCCRC rate to be between 8.1% to 9.3% taking into account missing data. |
| Waldmann, 2022 (21) | 2008-2019<br>352685 screening COL<br>241 PCCRC | PCCRC DEFINITION:<br>• Primary analysis not consistent with WEO (defined as colorectal cancer diagnosed at least 6 months after screening colonoscopy and before the date of an actual surveillance colonoscopy)<br>PCCRC RATE CALCULATION:<br>• Not consistent with WEO. Report cumulative incidence overall and by baseline colonoscopy findings and by endoscopist ADR.<br>• At 5 years overall: 0.08% (95% CI 0.07% to 0.09%)<br>• At 5 years by findings:<br>  ○ Negative colonoscopy: 0.068%; hyperplastic polyps – 0.067%<br>• At 5 years by endoscopist ADR with an ADR≥20%:<br>  ○ Negative colonoscopy: 0.045%; hyperplastic polyps – 0.065%<br>• At 5 years by endoscopist ADR with an ADR<20%:<br>  ○ Negative colonoscopy: 0.089%; hyperplastic polyps – 0.074% |
| Aerts, 2021 (23) | 2014-2020<br>6 years of data collection in prospective registration of patients with CRC and COL | PCCRC DEFINITION:<br>• Primary analysis not consistent with WEO (colonoscopy 6 mos to 120 mos prior to CRC dx)<br>• Additional analysis: PCCRC-3y was consistent with WEO (colonoscopy 6 mos to 36 mos prior to CRC dx) |

| Study | Participants | Results |
|---|---|---|
| | | PCCRC RATE CALCULATION:<br>• Not consistent with WEO (# persons w PCCRC / # persons w PCCRC + # persons w DCRC (DCRC))<br>• Primary: 47 (5.82%) were classified as PCCRC (47/807)<br>• Additional analysis unadjusted PCCRC-3y: 2.35% (19/807)<br>• Single centre, not linked to population-based data or cancer registry |
| Dossa, 2021 (22) | Patients from a random sample from 49 institutions in Ontario; diagnosed with CRC from 1 January 2000 to 31 December 2005 | PCCRC DEFINITION:<br>• Consistent with WEO (colonoscopy 6 mos to 36 mos prior to CRC dx)<br>• Restricted to complete colonoscopies<br>PCCRC RATE CALCULATION:<br>• Not consistent with WEO (# persons w PCCRC / # persons w PCCRC + # persons w DCRC)<br>• 8% of patients had PCCRC (1752/21692 for whole province) |
| Anderson, 2020 (24) | PCCRCs identified at a single medical centre in England from January 1, 2010, through December 31, 2017, using coding and endoscopy data. Participates in BCSP collected PCCRS -3 yr rates from UK colorectal intelligences Hub's CRC repository (CORECT-R) -a hub that links cancer registry and hospital data for England.<br><br>Retrospective analysis | PCCRC DEFINITION:<br>• Rate consistent with WEO (colonoscopy 6 mos to 36 mos prior to CRC dx)<br><br>PCCRC RATE CALCULATION:<br>• Consistent with WEO: false negative colonoscopies / (true positive colonoscopies + false negative colonoscopies) %<br>• Unadjusted PCCRC-3y rate of 4.7% (95% CI 3.15%-6.25%) |
| Forsberg, 2020 (35) | Swedish Cancer Registry 2003-2012, individuals with at least 1 COL | PCCRC DEFINITION:<br>• Consistent with WEO (colonoscopy 6 mos to 36 mos prior to CRC dx)<br>PCCRC RATE CALCULATION:<br>• Consistent with WEO: false negative colonoscopies / (true positive colonoscopies + false negative colonoscopies) %<br>• Overall unadjusted PCCRC-3yr rate: 7.2% (1384/19 849), 2003-2012<br>• Unadjusted PCCRC-3yr rate: 9.4% in 2003 to 6.1% in 2012<br>• Unadjusted PCCRC-3yr rates by subgroup (statistically significant):<br>  ○ Time period: 2003-2007: 7.4% vs. 2008-2012: 6.7%<br>Unadjusted PCCRC-3yr rates by subgroup (statistically significant):<br>• Sex<br>  ○ Female: 7.3% vs. Male: 6.7%<br>• Co-morbidity<br>  ○ Ulcerative colitis: Yes: 35.5% vs. No: 6.4% |

| Study | Participants | Results |
|---|---|---|
| | | ○ Crohn's disease: Yes: 24.7% vs. No: 6.8%<br>○ Diverticular disease: Yes: 10.5% vs. No: 6.8%<br>○ Prior polypectomy: Yes: 19.1% vs. No: 6.3%<br>○ Prior CRC: Yes: 23.0% vs. No: 6.7%<br>• Procedure -Polypectomy<br>○ Yes: 9.4% vs. No: 6.5%<br>• Location CRC<br>○ Left Side: 5.4% vs. Right side: 8.4% vs. Not Defined: 8.4%<br>• T-stage<br>○ T3/T4: 6.8% vs. T1/T2: 8.9% vs. Not Defined: 4.5%: |
| Burr, 2019 (30) | All people undergoing COL in NHS between 2005 -2013 and subsequently diagnosed as having CRC up to three years after (PCCRC-3yr) | PCCRC DEFINITION:<br>• Consistent with WEO (colonoscopy 6 mos to 36 mos prior to CRC dx)<br>PCCRC RATE CALCULATION:<br>• Consistent with WEO: false negative colonoscopies / (true positive colonoscopies + false negative colonoscopies) %<br>• Overall unadjusted PCCRC-3yr rate: 7.4% (9317/126 152), 2005-2013<br>• Unadjusted PCCRC-3yr rate: 2.7%in 2005 to 3.6% in 2013 (p=0.06)<br>SUGGESTED TARGETS:<br>Minimum standard of up to 5.5% and aspirational target of 3.6% based on 25th percentile of all endoscopists and of screening program endoscopists respectively<br><br>Unadjusted PCCRC-3yr rates by subgroup: (statistically significant)<br>• Screening program endoscopists: 3.6% vs. not: 8%<br>• Age at colonoscopy >80 yr: 9.5% vs. ≤ 60 yr: 6.6%<br>• Female: 8% vs. Male: 7%<br>• High comorbidity: 14.9% vs. no: 6.3%<br>• Inflammatory bowel disease: yes: 35.5% vs. no: 6.8%<br>• Diverticular disease: 11.6% vs. no: 6.0%<br>• Prior CRC: 31.2% vs. no: 7.1%<br>• Previous colonoscopy: 19.3% vs. not: 5.1%<br><br>Rates/proportions of PCCRC were<br>• 6.3% in rectum<br>• 5.7% in distal colon<br>• 8.2% in proximal colon<br>• 9.2% in cecum<br>• 15.0% not otherwise specified<br>• 8.7% Stage I<br>• 5.8% stage II<br>• 6.2% Stage III |

| Study | Participants | Results |
|---|---|---|
| | | • 9.7% Stage IV<br>• 8.9% Unknown |
| Chen, 2019 (29) | All patients with CRC from 2002-2009 in Taiwan National Cancer Registry | PCCRC DEFINITION:<br>• Not consistent with WEO (colonoscopy 6 mos to 60 mos prior to CRC dx)<br>PCCRC RATE CALCULATION:<br>• Not done overall |
| Cheung, 2019 (28) | All patients aged 40 years or above, who had undergone colonoscopy between 2005 and 2013.<br>197,902<br>10,005 FN COLs<br>854 TP COLs | PCCRC DEFINITION:<br>• Consistent with the WEO (colonoscopy 6 mos to 36 mos prior to CRC dx)<br>PCCRC RATE CALCULATION:<br>• Not consistent with WEO (# persons w PCCRC / # persons w PCCRC + # persons w DCRC)<br>• PCCRC-3y rate of 7.9%<br>• A significant increase in the PCCRC-3y rate from 4.1% to 9.7% (p<0.001) between 2005 and 2009 but a significant decrease in the PCCRC-3y rate from 9.7% to 7.7% (p=0.046) between 2009 and 2013. |
| Macken, 2019 (27) | The Belgian Cancer Registry (BCR) over a period covering 9 years (2002 – 2010).<br><br>FN=2126<br>TP=25 974 | PCCRC DEFINITION:<br>• Consistent with the WEO (colonoscopy 6 and 36 (721 – 1080 days) months prior to CRC dx)<br>PCCRC RATE CALCULATION:<br>• Not consistent with WEO: all false negative colonoscopies / (true positive colonoscopies + all false negative colonoscopies) %<br>• PCCRC rate of 7.6%.<br>• WEO rate calculation: 7.4% |
| Pedersen, 2019 (26) | From 2001 to 2010, 39,100 Danish individuals were diagnosed<br>with first primary CRC, of whom 11,483 individuals had undergone colonoscopy within 3 years of the diagnosis.<br><br>15,007 TN COL<br>1746 FN COL | PCCRC DEFINITION:<br>• Consistent with WEO (colonoscopy 6 mos to 36 mos prior to CRC dx)<br>PCCRC RATE CALCULATION:<br>• Consistent with WEO: false negative colonoscopies / (true positive colonoscopies + false negative colonoscopies) %<br>• Overall unadjusted PCCRC-3yr rate: 8.6% (992/11483), 2001-2010<br>• Unadjusted PCCRC-3yr rate: 22.5% in 2001 to 7.9% in 2012<br>• Unadjusted PCCRC-3yr rates by subgroup (statistically significant):<br>  ○ Time period: 2001-2006: 11.7% vs. 2007-2012: 7.5%<br>• Unadjusted PCCRC-3yr rates by subgroup (statistically significant):<br>  ○ Co-morbidity<br>  ▪ Ulcerative colitis: Yes: 32.5% vs. No: 8.6%<br>  ▪ Diverticular disease: Yes: 27.4% vs. No: 7.7%<br>  ▪ Hereditary cancer age<60: Yes: 64.3% vs. No: 8.8%<br>  ▪ Hereditary cancer age≥60: Yes:43.4% vs. No: 8.8%<br>  ▪ Solid Metastasis: No: 7.8% vs. Unknown: 13.4%<br>  ○ Charlson Comorbidity Index<br>  ▪ 0: 8.3% vs. 1: 10.8% vs. 2:11.7%<br>  ○ Location CRC |

| Study | Participants | Results |
|---|---|---|
| | | ▪ Rectum/sigmoid: 6.2% vs. Transverse: 10.3% vs. Cecum/ascending/hepatic flexure: 11.8% vs. Colon – not otherwise specified: 16.6%<br>○ T-stage<br>▪ T3/T4: 7.4% vs. T1/T2: 10.3%<br>○ Time period<br>▪ 2001-2006: 11.7% vs. 2007-2012:7.5% |
| Tollivoro, 2019 (25) | PCCRC cases (n=1206) who had an index COL negative for CRC and were subsequently diagnosed with CRC Controls (n=634) had an index COL negative for CRC and were without a CRC diagnosis at the time of their selection as cases | PCCRC DEFINITION:<br>• Not consistent with the WEO (CRC dx >12 mos to 120 mos after the colonoscopy)<br>• Secondary analyzes: early PCCRCs (arising >12 months and ≤ 36 months after colonoscopy) vs. late PCCRCs (arising >36 months to 10 years after)<br>PCCRC RATE CALCULATION:<br>• Not done |
| Murthy, 2018 (32) | 1,093,658 low-to-moderate risk screen-eligible people study of persons aged 50 to 74 years | PCCRC DEFINITION:<br>• Consistent with the WEO<br>• CRC diagnosed between 6- and 36-months following colonoscopy, based on estimates of the mean sojourn time for the transition from preclinical, screen-detectable CRC to symptomatic CRC<br>PCCRC RATE CALCULATION:<br>• Not consistent with the WEO (# persons w PCCRC / # persons w PCCRC + # persons w DCRC)<br>• PCCRC rate was about 8% throughout the study period. |
| Nakada, 2017 (31) | Colonoscopy database of the Department of Gastroenterology, the University of Tokyo Hospital, which is a referral centre in Tokyo. Data recorded between September 1995 and January 2012 | PCCRC DEFINITION:<br>• Not consistent with the WEO<br>PCCRC RATE CALCULATION:<br>• Not consistent with WEO<br>• PCCRC rate of 0.77 per 1000 person years |
| Govindarajan, 2016 (5) | Includes all patients diagnosed with colorectal cancer (CRC) in Ontario, Canada from 2003 to 2009.<br><br>45,104 patients<br>2804 PCCRC<br>27,671 DCRC<br>14,629 NOSCOPE | PCCRC DEFINITION:<br>• Consistent with the WEO (Patients whose index colonoscopy occurred 6–36 months prior to the date of cancer diagnosis)<br>PCCRC RATE CALCULATION:<br>• Not consistent with WEO (# persons w PCCRC / # persons w PCCRC + # persons w DCRC)<br>• 6.2% of patients had PCCRC (2804/45104)<br>• WEO rate calculation: 9.2% (2804/27671+2804) |

| Study | Participants | Results |
|---|---|---|
| Stoffel, 2016 (33) | Danish medical registries, population-based nationwide study of all CRCs diagnosed during 2007–2011. Categorized as post-colonoscopy or detected during diagnostic colonoscopy (in patients with no prior colonoscopy). Cross-sectional | PCCRC DEFINITION:<br>• Not consistent with the WEO (colonoscopy >6 mos prior to CRC dx – no end date specified)<br>• Classified PCCRCs as <1 year, 1–10 years, and >10 years after their index colonoscopy<br>PCCRC RATE CALCULATION:<br>• Not consistent with WEO (# persons w PCCRC / # persons w PCCRC + # persons w DCRC)<br>• 7% of patients had PCCRC (725/10,365) |
| Hilsden, 2015 (34) | 18,456 asymptomatic men and women ages 40 to 74, at either average risk or increased risk for colorectal cancer because of a family history, who underwent a screening colonoscopy from 2008 to 2010. | PCCRC DEFINITION:<br>• Not consistent with the WEO (colonoscopy >6 mos prior to CRC dx – no consistent end date specified)<br>• Colonoscopies 2008-2010 with linkage to CRC registry June 2014, therefore 4.5 to 6.5 yrs observation window.<br>• Average and increased (family hx of CRC/polyps) risk screening colonoscopies only, ages 40-74 yrs<br>• Excluded duplicate colonoscopies<br>PCCRC RATE CALCULATION:<br>• Not consistent with WEO (# persons w PCCRC / # persons having 1+ average or increased risk screening colonoscopy)<br>• 10 PCCRC were found: 0.54 per 1000 persons having average or increased risk screening colonoscopy |

**Abbreviations:** ADR, adenoma detection rate; BCR, Belgian Cancer Registry; BCSP, bowel cancer screening programme; calc, calculation; CI, confidence interval; COL, colonoscopy; CORECT-R, UK Colorectal Cancer Intelligence Hub's colorectal cancer data repository; CRC, colorectal cancer; DCRC, detected colorectal cancer; dx, diagnosis; FN, false negative; hx, history; mos, months; NHS, National Health Service; NOSCOPE, no colonoscopy within 36 months of diagnosis; PCCRC, post-colonoscopy colorectal cancers; SR, systematic review; TN, true negative; TP, true positive; WEO, World Endoscopy Organization; yr, year.

## Table 4.4. PCCRC: Associations with Important Clinical Outcomes: 8 studies.

| Study | Participants | Results |
|---|---|---|
| Dossa, 2021 (22) | 779 pts from random sample from 49 institutions in Ontario; diagnosed with CRC from January 2000 -December 2005 | • Unadjusted 5-year overall survival was worse in patients with PCCRC (49.7% in patients with PCCRC vs. 61.2% in patients with detected CRC, p=0.003)<br>• After adjusting for age, sex and tumour location, there was no significant difference in overall survival between groups (HR, 1.12; 95% CI, 0.92–1.32). |
| Anderson, 2020 (24) | 107 PCCRCs identified at a single medical centre in England from January 1, 2010, through December 31, 2017, using coding and endoscopy data. | No comparison to DCRC<br><br>Treatment intent was<br>• curative in 86 (80.4%)<br>• palliative in 21 (19.6%) |

| Study | Participants | Results |
|---|---|---|
| | Retrospective analysis | Immortal time bias and lead-time bias were accounted for by ignoring deaths within 3 and 4 years of the index colonoscopy:<br>• 1-year survival (within 3 years): 76 (80%) of 95<br>• 1 year survival (within 4 years): 59 (69.4%) of 85 |
| Forsberg, 2020 (35) | Swedish Cancer Registry 2003-2012, individuals with at least 1 COL | Stage of PCCRC<br>• T stage: T3/T4 vs. T1/T2, RR= 0.79, p<0.001 (95% CI, 0.71–0.88)<br>• T stage: Undefined vs. T1/T2, RR=0.59, p<0.001 (95% CI, 0.50–0.71)<br><br>Multivariate hazard (adj for T stage) ratios for conditional CRC specific survival (used individuals who were still alive at 3 years after index COL) from TP/FN colonoscopy for PCCRC compared with DCRC were:<br>• Males: HR, 2.00 (95% CI, 1.59–2.52, p<0.001)<br>• Females: HR, 2.75 (95% CI, 2.21–3.42, p<0.001)<br><br>The effect of PCCRC on survival was more pronounced in women than in men |
| Chen, 2019 (29) | All patients with CRC from 2002-2009 in Taiwan National Cancer Registry | • Within the same gender and tumour stage from 2 to 4, the life expectancy of PCCRC was always lower than that of DCRC (p<0.001). (No HR)<br>• However, after adjusting for age distribution or lead time bias, there was no consistent trend in the difference of expected years of life lost between PCCRC and DCRC after stratifications by gender and tumour stage. |
| Cheung, 2019 (28) | All patients aged 40 years or above, who had undergone colonoscopy between 2005 and 2013.<br><br>197 902<br>10 005 FN COLs<br>854 TP COLs | Survival analysis.<br>The follow up of this study cohort was up to 13 years, and 6011 (55.4%) of all CRC patients died, with 3413 (31.4%) being cancer related.<br>• 1-year cancer-specific survival: 83.2% (95% CI, 81.5–82.9%)<br>• 3-year cancer-specific survival: 70.6% (95% CI, 69.8–71.6%),<br>• 5- year cancer-specific survival: 66.1% (95% CI, 65.1–67.1%),<br>• 10-year cancer-specific survival: 63.4% (95% CI, 62.4–64.4%),<br><br>PCCRC-3y had a worse cancer-specific survival than detected CRC (log-rank p<0.001).<br>• 1-year cancer-specific survival: 74.3% (95% CI, 71.2–77.4%),<br>• 3-year cancer-specific survival: 60.8% (95% CI, 57.3–64.5%),<br>• 5- year cancer-specific survival: 57.7% (95% CI, 54.1–61.5%),<br>• 10-year cancer-specific survival: 55.3% (95% CI, 51.3–59.7%),<br><br>The corresponding cancer-specific survival probability for detected CRC was<br>• 1-year cancer-specific survival: 84.0% (95% CI, 83.2–84.7%),<br>• 3-year cancer-specific survival: 71.4% (95% CI, 70.5–72.4%),<br>• 5- year cancer-specific survival: 66.8% (95% CI, 65.8–67.8%),<br>• 10-year cancer-specific survival: 64.0% (95% CI, 63.0–65.1%). |

| Study | Participants | Results |
|---|---|---|
| Macken, 2019 (27) | 2126 FN colonoscopies<br>28,100 FN+ TP colonoscopies<br>2002-2010 | Conditional survival analysis for all patients still alive 3 years after colonoscopy: comparisons at higher quantiles showed:<br>80% patient survival for:<br>• PCCRC: 1.6 years (95% CI, 1.2–2.0)<br>• Non-PCCRC: 2.8 years (95% CI, 2.6–2.9)<br>60% patient survival for:<br>• PCCRC: 4.7 years (95% CI, 4.0–6.0)<br>• Non- PCCRC: 6.7 years (95% CI, 6.5–7.2)<br><br>Hazard ratios comparing those with PCCRC and those without:<br>• interval cancer:<br>o Adjusted: no vs. yes: HR=1.35, 95% CI, 1.18-1.53, p<0.0001<br>o Not Adjusted: no vs. yes: HR=1.38, 95% CI, 1.22-1.57, p<0.0001 |
| Govindarajan, 2016 (5) | Includes all patients diagnosed with colorectal cancer (CRC) in Ontario, Canada from 2003 to 2009.<br><br>45,104 patients<br>2804 PCCRC<br>27,671 DCRC<br>14,629 NOSCOPE | Five-year overall survival was significantly different among the three groups (DETECTED: 68.3%; PCCRC: 60.8%; NOSCOPE: 38.9%, p<0.001)<br>(During study period)<br><br>Multivariable analysis examining PCCRC vs. DCRC<br>• overall survival: adj HR: 1.25, 95% CI 1.17 to 1.32, p<0.001<br>• surgical resection: adj OR: 0.65, 95% CI 0.59 to 0.72, p<0.001<br>• emergency room presentation: adj OR: 2.86, 95% CI 2.56 to 3.13, p<0.001<br>• postoperative mortality rate: adj OR: 1.01, 95% CI 0.77 to 1.31, p=0.97 |
| Stoffel, 2016 (33) | Danish medical registries, population-based nationwide study of all CRCs diagnosed during 2007–2011.<br>Cross-sectional | PCCRC compared with DCRC<br>• less metastatic (compared to localized and regional) at presentation (OR, 0.66; 95% CI, 0.48-0.90). |

**Abbreviations:** adj, adjusted; CI, confidence interval; COL, colonoscopy; CRC, colorectal cancer; DCRC, detected colorectal cancer; FN, false negative; HR, hazard ratio; NOSCOPE, no colonoscopy within 36 months of diagnosis; OR, odds ratio; PCCRC, post-colonoscopy colorectal cancers; pts, patients; RR, risk ratio; TP, true positive: DETECTED, diagnosed within 6 months of first colonoscopy.

## Table 4.5. PCCRC: Root Cause Analysis-2 studies.

| Study/ participants | Objective /methods | Results | Comments |
|---|---|---|---|
| Aerts, 2021 (23)<br><br>A single-centre analysis of post- | To classify PCCRC into subcategories by WEO | **PCCRC subcategories:**<br>Interval type: 9 (19.15%)<br>Non-interval type:<br>Type A: 14 (29.7%)<br>Type B: 12 (25.53%)<br>Type C: 12 (25.54%) | |

| Study/ participants | Objective /methods | Results | Comments |
|---|---|---|---|
| colonoscopy colorectal cancer<br><br>2014-2020<br>6 years of data collection in prospective registration of patients with CRC and COL | | **Root Cause Possible explanation for CRC:**<br>○ Total cases of PCCRC 47 (100%)<br>○ Possible missed lesion, prior examination adequate<br>○ PCCRC:12 (25.5%)<br>○ Possible missed lesion, prior examination negative but inadequate<br>○ PCCRC: 4 (8.5%)<br>○ Detected lesion, not resected<br>○ PCCRC: 0 (0%)<br>○ Likely incomplete resection of previously identified lesion<br>○ PCCRC: 7 (14.9%)<br><br>Likely new CRC (>4 years past first colonoscopy) excluded:<br>○ Total cases of PCCRC 23 (100%)<br>○ Possible missed lesion, prior examination adequate<br>○ PCCRC:12 (52.2%%)<br>○ Possible missed lesion, prior examination negative but inadequate<br>○ PCCRC: 4 (17.4%)<br>○ Detected lesion, not resected<br>○ PCCRC: 0 (0%)<br>○ Likely incomplete resection of previously identified lesion<br>○ PCCRC: 7 (30.4%)<br><br>Deviation from the planned mgmt. pathway 12 (25.5%)<br>• Same cases meet criteria for PCCRC<4 year | |
| Anderson, 2020 (24)<br><br>Causes of Post-Colonoscopy Colorectal Cancers Based on World Endoscopy Organization System of Analysis<br><br>107 PCCRCs identified at a single medical | Perform a root-cause analysis for each PCCRC case<br>appearing in the 6- to 48-month interval<br>Define factors that lead to PCCRCs<br>Categorize PCCRCs using the WEO method<br>Determine what proportion of PCCRCs are preventable<br>and propose a target for PCCRC-3y rates<br>For each case, we reviewed clinical, | • **Interval types – not reported**<br><br>**Root cause consistent with WEO (colonoscopy 6 mos to 48 mos prior to CRC dx)**<br>**Root Cause Possible explanation for CRC:**<br>• 27 (27%) PCCRCs were categorized as possible missed lesion, prior examination adequate<br>• 58 (58%) PCCRCs were categorized as possible missed lesion, prior examination negative but inadequate<br>• 8 (8%) PCCRCs were categorized as detected lesion, not resected (C)<br>• 7 (7%) PCCRCs were categorized as likely incomplete resection of previously identified lesion (D)<br>• 7 (7%) could not be categorized<br><br>One flaw in the WEO categorization: To be categorized as C or D requires the lesion in the affected segment to be an advanced adenoma, defined as a | **Recommendation 4: Recommendations to the WEO Categorization**<br>On the basis of this study, we recommend some adaptations to the WEO categorization:<br>1. Rectal retroflexion and malfunctioning or inadequate equipment should be mandatory elements of colonoscopy adequacy.<br>2. Small cancers (to be defined) should be excluded from analysis on the basis that they are |

| Study/ participants | Objective /methods | Results | Comments |
|---|---|---|---|
| centre in England from January 1, 2010, through December 31, 2017, using coding and endoscopy data.<br><br>Retrospective analysis | pathology, radiology, and endoscopy findings. Using the WEO recommendations, we performed a root-cause analysis of each case, categorizing lesions as follows: possible missed lesion, prior examination adequate; possible missed lesion, prior examination inadequate; detected lesion, not resected; or likely incomplete resection of previously identified lesion. | polyp larger than 1 cm, and/or villous and/or containing high-grade dysplasia. In 13 cases, a polyp had been seen at index colonoscopy, but could not be categorized as an advanced adenoma because of the following:<br>1. The polyp was <1 cm or its size was unclear on the endoscopy report<br>2. The polyp was not excised/retrieved; therefore, it was not possible to assess for villous component or high-grade dysplasia<br>3. There was discrepancy between the location of the polyp and the subsequent cancer, when it was clear the index endoscopist was unsure of his or her position within the colon<br>4. A stricture (rather than a polyp) was diagnosed at index colonoscopy, but not biopsied and subsequently was found to be cancerous<br><br>Other flaws: the omission of information from previous colonoscopies, relevance of completion for distal lesions, omission of rectal retroflexion in adequacy criteria, and other factors, such as malfunctioning equipment. Our data also highlight that many PCCRCs are related to nontechnical factors and suggest that to be clear about how to reduce PCCRCs, these be categorized as follows:<br>1. Patient factors<br>2. Administrative process factors<br>3. Clinical decision-making factors | unlikely to have been detectable at index colonoscopy and are unlikely to have a significant impact because they are likely to be early-stage disease.<br>3. There should be more flexibility regarding the definition of “advanced adenoma,” particularly if a lesion was seen at index colonoscopy but not biopsied.<br>4. If a patient has undergone more than 1 colonoscopy, the previous colonoscopies/flexible sigmoidoscopies should be reviewed to identify if a precursor lesion was seen in the cancerous segment before the index colonoscopy. If a lesion was seen previously, this should influence the categorization of the PCCRC.<br>• Greater clarity is needed with respect to “deviation from the planned management pathway.”<br>• Gathering and reviewing the entire WEO data set will be too time-consuming for most endoscopy services. It is recommended the WEO create an abbreviated version for everyday use, reserving the complete |

| Study/ participants | Objective /methods | Results | Comments |
|---|---|---|---|
| | | | data set for academic studies.<br>• The WEO should reconsider use of unadjusted PCCRC-3y rates for benchmarking purposes: there are instances when there should be adjustment of PCCRC-3y rates. |

**Abbreviations:** COL, colonoscopy; CRC, colorectal cancer, dx, diagnosis; mo, months; PCCRC, post-colonoscopy colorectal cancers; WEO, World Endoscopy Organization; yr, year.

**Table 4.6. Rates of Surgical Resection for Large/Complex Polyps: Study Characteristics.**

| Study | Location | Design | Lesion characteristics | Number of Participants or procedures and description | Data Source | Data Collection | Purpose of Study | Outcomes of interest |
|---|---|---|---|---|---|---|---|---|
| Parker, 2023 (50) | UK | Retrospective cohort | Colorectal lesions ≥ 10 mm and with complexity indicators such as difficult access, recurrence or advanced histology signs | 2,109 patients<br><br>2292 complex polyps<br><br>32.1 mm (mean) | 6 complex polyp multi-disciplinary team meetings in the UK utilising the STROBE recommendations<br>Data were collected from digital hospital records onto pre-defined spreadsheets. | Each centre provided prospective lists of patients referred to meetings from commencement for review and assessed until March 2020 at the latest. | To assess procedures and clinical outcomes of patients managed through approaches of multidisciplinary management meetings for complex colorectal polyps | Length of stay, AEs (classified using the Clavien-Dindo system), bleeding controlled during a procedure, readmission rate, residual or recurrent disease |
| Chaoui, 2022 (45) | Belgium | Retrospective cohort | Located in the colon, non-pedunculated and ≥ 15 mm in size | 167 consecutive patients referred for EMR of 193 polyps | University Hospitals Leuven | 2017-2019 | To assess efficacy, safety and recurrence rate of EMR in a tertiary centre and to identify risk factors for recurrence at follow-up endoscopy | Procedure success, rate of polyp recurrence during first follow-up colonoscopy, risk factors |

| Study | Location | Design | Lesion characteristics | Number of Participants or procedures and description | Data Source | Data Collection | Purpose of Study | Outcomes of interest |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | associated with polyp recurrence, and rate of adverse events after EMR |
| Chiba, 2022 (46) | Japan | Retrospective cohort | Colorectal lesions ≥ 10 cm in diameter, or 5-10 cm | 3591 colorectal lesions<br>270 patients with polyps 5-10 cm and<br>50 patients with lesions ≥ 10 cm | Omori Red Cross Hospital and NTT Medical Center Tokyo | 2012-2020 | To investigate the feasibility and safety of ESD procedures for colorectal lesions ≥ 10 cm in diameter | En bloc resection rate, curative resection rate, rate of AEs, DS, and procedure time |
| Mandic, 2022 (48) | Serbia | Retrospective cohort | Colorectal polyps ≥ 20 mm in diameter | 472 patients with ≥ 20 mm polyps | University Hospital Medical Center Bezanijska Kosa | 2014-2019 | To identify risk factors contributing to the malignancy of colorectal polyps and risk factors for recurrence after the successful endoscopic mucosal resection of large colorectal polyps in a referral center | En bloc resection rate, piecemeal resection rate, accessibility of polyp, and resection success |
| Tidehag 2022 (56) | Sweden | Retrospective cohort | Early colorectal neoplasm > 20mm without signs of deep invasion | 660 colorectal ESD procedures | Electronic medical records used by 5 of 6 emergency hospitals and 90% of all healthcare providers in Stockholm County. | 2014-2020 | To investigate if ESD of colorectal lesions can be performed in an outpatient setting | Resection speed, and resection rate (En bloc, piecemeal, cancelled) |
| Zammit, 2022 (60) | Australia | Retrospective cohort | Malignant polyps diagnosed on colonoscopy, sigmoidoscopy or other | 1,646 pts (malignant polyps) | Queensland Oncology Repository (QOR) QOR links the Queensland | 2011 - 2019 | The primary aim was to evaluate the OS and CSS of patients diagnosed with malignant polyps and the association | OS, CSS, association between survival outcomes and management |

| Study | Location | Design | Lesion characteristics | Number of Participants or procedures and description | Data Source | Data Collection | Purpose of Study | Outcomes of interest |
|---|---|---|---|---|---|---|---|---|
| | | | endoluminal excision | | Cancer Registry (QCR) with over 60 population-wide sources | | between survival outcomes and management strategy. The secondary aim was to explore how management strategy affected OS and CSS. | strategy, how management strategy affected OS and CSS |
| Wickham, 2022 (58) | USA | Retrospective case control | Median polyp size was 3 cm (0.4–10 cm) | 95 patients referred to CRC surgery for "endoscopically unresectable" histologically proven benign polyps<br>190 matched controls | Institutional database | 2015-2018 | To assess the ability of using advanced endoscopic techniques to allow colon preservation and avoid segmental resection | Successful polyp removal<br>Length of stay, adverse events, ileus, NGT insertion, AKI, unplanned re-admission and 30-day re-operation, UTI, leaks |
| Patel, 2021 (51) | USA | Retrospective cohort | Adenomatous polyps or intra-mucosal cancers ≥2 cm | 310 ER patients<br>81 SR patients | Two Tertiary Veterans Affairs Medical Centers | 2005-2018 | To assess success rates and complications of ER in veterans with large and complex colorectal polyps | Success rate, complication rate |
| Qu, 2021 (53) | China | Retrospective cohort | Early CRC and precancerous lesions 2-3 cm | 65 ESD<br>65 surgery | Single centre | 2020 | To compare the efficacy and safety between ESD and conventional surgery in the treatment of early CRC and precancerous lesions. | Resection rate, recurrence, hospital stay, adverse events, QoL |
| Rodrigues, 2020 (54) | France | Retrospective cohort | Benign lesions (low-grade dysplasia, high-grade dysplasia, and in situ carcinoma) ≥ 20 mm, | 1571 patients who had abnormal FOBT or FIT tests followed by colonoscopy during 2012, 2016, and 2017 | The Haute Vienne administrative area | 2012, 2016, 2017 | To analyze the evolution of the surgical referral rate for benign lesions detected due to a CRC screening program before and after implementation of a | Surgical mgmt. rate for benign lesions, risk factors, results, and costs |

| Study | Location | Design | Lesion characteristics | Number of Participants or procedures and description | Data Source | Data Collection | Purpose of Study | Outcomes of interest |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | regional referral network. | |
| Azevedo, 2020 (43) | Brazil | Retrospective cohort | Average diameter of 40.08 mm, ranging from 30 to 80 mm | 63 patients with non-pedunculated lesions larger than 3 cm | Single centre | 2014-2017 | To evaluate the recurrence and surgical complementation rates after ER of large colorectal non-pedunculated lesions. | Recurrence rate, rate of complementary surgery |
| Bosch, 2020 (44) | Nether-lands | Retrospective cohort | 45.5% of polyps were sessile, with a median size of 3.5 cm. | 164 patients who underwent colorectal surgical procedures: 115 segmental col; 22 TEM; 27 LEAWR | Single centre | 2012-2017 | To assess the number of referrals for surgery and the type of surgery for polyps since the introduction of the Dutch national bowel screening programme. | Number and type of surgical procedures for polyps, adverse events |
| Moon, 2020 (49) | USA | Retrospective cohort | Median polyp size was 30 mm | 315 patient referred to CRS for non-malignant polyps: 117 ER; 136 surgery | Single centre | 2014-2019 | To evaluate referral patterns to colorectal surgery for non-malignant colorectal polyps, to compare outcomes between attempted ER and surgery, and to identify factors associated with surgery | Referral pattern to surgery and factors associated with surgery |
| Li, 2020 (47) | Singa-pore | Retrospective cohort | Mean size was 23mm (range 12–50) | 41 patients who underwent ESD | Single centre | 2014-2018 | To audit the clinical outcome of our initial experience in colorectal ESD, focusing on its safety and efficacy. | Successful en bloc or R0 resection, adverse events, proportion of cases upstaged |
| Spychalski, 2021 (55) | Poland | Retrospective cohort | (LST-NGs) of ≥ 20 mm, (LST-Gs) or tumour of ≥ 20 to 30 mm, near or at dentate line, non-lifting | 601 patients who underwent ESD procedure for colorectal neoplasm | Single centre | 2016-2019 | To analyze the safety and efficiency of colorectal ESD based on a large cases series | Success rate, adverse events, |

| Study | Location | Design | Lesion characteristics | Number of Participants or procedures and description | Data Source | Data Collection | Purpose of Study | Outcomes of interest |
|---|---|---|---|---|---|---|---|---|
| Peery, 2018 (52) | USA | Retrospective Cohort | Non-malignant colorectal polyps | All patients ≥20 years old, who had diagnoses for either benign neoplasms of the colon, rectum, or anal canal or colorectal cancer and underwent elective colectomy or proctectomy were eligible for inclusion. | Healthcare Cost and Utilization Project NIS | 2000–2014 | To quantify and examine trends in the use of surgery for non-malignant colorectal polyps in a nationally representative sample | Incidence of surgery for non-malignant colorectal polyps |
| Yu, 2020 (59) | USA | Retrospective cohort | | All outpatient colonoscopies | Optum's de-identified Clinformatics Data Mart Database | 2011-2015 | To quantify and examine the trends in the use of EMR and its outcomes for large benign nonpedunculated colorectal lesions | Volume of EMR use over time, regional variation, rates of GIB, perforations, cardiovascular adverse events, infectious adverse events and admissions for any indication |
| Vu, 2021 (57) | USA | Retrospective cohort | Benign polyp | 280,815 Medicare beneficiaries who underwent colectomy for CRC or benign polyp. Overall, 157,802 (65.8%) patients underwent | Medicare Provider Analysis and Review files | 2010-2015 | To compare regional variation in colectomy rates for CRC versus benign polyp | Annual rate of colectomy; hospital rate of colectomy for benign polyps |

| Study | Location | Design | Lesion characteristics | Number of Participants or procedures and description | Data Source | Data Collection | Purpose of Study | Outcomes of interest |
|---|---|---|---|---|---|---|---|---|
| | | | | colectomy for CRC compared to 81,937 (34.2%) for benign polyp. | | | | |

**Abbreviations:** AKI, acute kidney injury; CSS, cancer specific survival; CRC, colorectal cancer; CRS, colorectal surgery; CSS, cancer specific survival; EMR, endoscopic mucosal resection; ER, endoscopic resection; ESD, endoscopic submucosal dissection; FIT, fecal immunochemical test; FOBT, fecal occult blood test; GIB, gastrointestinal bleeding; LEAWR, limited endoscopic-assisted wedge resection; LST-Gs, granular-type laterally spreading tumours; LST-NGs, nongranular-type laterally spreading tumours; NGT, nasogastric tube; NIS, National Inpatient Sample; OS, overall survival; QoL, quality of life; SR, surgical resection; TEM, transanal endoscopic microsurgery; USA, United States of America; UTI, urinary tract infection.

**Table 4.7 Rates of Surgical Resection for Large/Complex Polyps: Systematic Reviews**

| Study | Purpose | Location | Search terms | Inclusion/exclusion criteria | Results | Outcomes |
|---|---|---|---|---|---|---|
| Thorlacius, 2019 (42) | To summarize the experience of colorectal ESD in Europe. | Sweden | Searched PubMed for studies accepted or published up to July 2018. | Included: studies with patients diagnosed with non-pedunculated undergoing standard ESD<br>Excluded: fewer than 20 patients, carcinoid lesions or only rectal tumours | 15 studies | R0 resection rate on a per-lesion basis; duration of ESD procedure; number of patients undergoing surgery after ESD; adverse events and recurrence rate. |
| De Neree Tot Babberich, 2019 (40) | To determine postoperative outcomes and the characteristics of surgically resected benign colonic polyps. | Netherlands | Searched MEDLINE, EMBASE, and the Cochrane Library 1980 -July 2017 | Included: At least one postoperative outcome reported of surgical resection for benign colonic polyps<br>Excluded: outcomes of other indications for surgery, > 50% polyps located in rectum, emergency surgeries | 26 studies | Postoperative morbidity and mortality, surgical re-intervention rate after adverse events, referral rates for surgery of benign polyps, indications for surgery, and polyp characteristics |
| Hassan, 2016 (41) | To assess the efficacy and safety of ER of large colorectal polyps. | Italy | MEDLINE/EMBASE/Cochrane Central Register for the period 1966–2014. | Included: Studies in which ≥20 mm colorectal neoplastic lesions treated with ER and main outcomes reported<br>Excluded: animal and review studies | 50 studies | Rates of surgery for non-curative ER of colorectal polyps ≥20 mm; and rates of (a) complete ER, (b) invasive cancer, (c) adverse events, (d) polyp recurrence at follow-up, (e) invasive cancer at follow-up, (f ) successful endoscopic treatment of |

| Study | Purpose | Location | Search terms | Inclusion/exclusion criteria | Results | Outcomes |
|---|---|---|---|---|---|---|
| | | | | | | any recurrence, (g) as well as the different indications for surgery, (h) the rate of patients lost at follow-up, (i) the impact of ESD on surgery for non-curative resection and recurrence, and ( j) the mortality rate related with the management of large polyps |

**Abbreviations: ER,** endoscopic resection; ESD, endoscopic submucosal dissection.

## Table 4.8 Rates of Surgical Resection for Large/Complex Polyps -Data Tables 18 studies, 3 systematic reviews, 2 guidelines

| Study | Study goals and population | Findings |
|---|---|---|
| **Endoscopic vs. surgical resection** | | |
| Parker 2023 (50)<br><br>Retrospective cohort | To assess procedures and clinical outcomes of patients managed through approaches of multidisciplinary management meetings for complex colorectal polyps<br><br>A total of 2149 procedures were performed on 2192 lesions<br><br>2010 were primary procedures, 135 secondary and 4 were tertiary interventions | Most polyps presented symptomatically, and the mean polyp size was 32.1 mm.<br><br>• Primary endoscopic therapy was performed in 1657 (75.6%) polyps.<br>• Surgical procedures were performed in 14.9% including trans-anal surgery (6.8%) or colonic resection (8.1%).<br><br>Median length of stay:<br>• endoscopic procedures: 0 days<br>• colonic resection: 5 days, p<0.001<br>Adverse events:<br>• Endoscopic procedure: 5.5%<br>• Colonic resection: 31.7% p<0.001<br>30-day re-admission:<br>• Endoscopic procedure:3.3%<br>• Colonic resection: 4.8%, p=0.127<br><br>Proportion of primary colonic resections fell from 34.6% in 2012 to 1.7% in 2020<br>The use of organ preserving procedures increased from 62.7 to 83.8%.<br>More patients were managed conservatively with 2.7% in 2012 compared to 14.5% in 2020.<br>Secondary procedures were required in 7.8%.<br><br>Benign polyp recurrence occurred in 13.1% with a median follow up of 30.4 months.<br>There was no difference in recurrence between screening and symptomatic cohorts (12.8% vs 13.2%, p = 0.827)<br>• |

| Study | Study goals and population | Findings |
|---|---|---|
| Zammit, 2022 (60)<br><br>Retrospective cohort | To evaluate the OS and CSS of patients diagnosed with malignant polyps and the association between survival outcomes and management strategy. | A total of 1,646 patients were included with 240 deaths and 52 colorectal cancer related deaths until censor date.<br><br>• Polypectomy alone vs. colorectal resection: multivariable analysis<br>• Overall survival: p<0.001<br>• Cancer specific survival: p=0.073 |
| Wickham, 2022 (58)<br><br>Retrospective cohort | To assess the ability of using advanced endoscopic techniques to allow colon preservation and avoid segmental resection<br><br>95 patients referred to surgery for endoscopically unresectable benign polyps<br><br>190 propensity score matched controls who had undergone elective segmental colectomy for other reasons | • Of 95 patients, 70% achieved complete polyp removal without colectomy (66 patients)<br><br>• Compared with 190 matched colectomy controls, endoscopic polyp resection resulted in:<br>  • lower rates of:<br>  ○ postoperative adverse events (4.2% vs. 33.9%; p<0.001)<br>  ○ ileus (2.1% vs. 19.2%; p=0.001)<br>  ○ NGT insertion (3.3% vs. 22.3%; p<0.005)<br>  ○ AKI (0% vs. 10.1%; p=0.03)<br>  • significantly shorter hospital length of stay (1.13 ± 2.41vs. 3.89 ± 4.57 days; p<0.001),<br>  • lower unplanned 30-day readmission (1.1% vs. 7.7%; p<0.05) |
| Patel, 2021 (51)<br><br>Retrospective cohort | To assess success rates and adverse events of ER in veterans with large and complex colorectal polyps<br><br>310 patients identified in database as having ER since introduction of single endoscopist model at 2 VAMCs<br><br>81 patients with similar polyps manages surgically at 1 VAMC | • ER was successful in 97% of all patients and in 79/85 (93%) of patients with polyps ≥ 4 cm in size<br>• The risk of a serious complication was significantly lower with ER (0.6%) compared to the estimated risk with laparoscopic surgery (22%), p=0.00001<br>• Serious adverse events occurred in 2 patients in the ER group (0.6%), both with polyps > 4 cm in size (1 perforation, 1 death)<br>• Serious adverse events occurred in 18 patients in the SR group (22%), of whom 6 had polyp > 4 cm in size (2 deaths)<br>• Patients in ER group required 1.1 more colonoscopies per patient than those in SR group<br>• Longer duration of hospitalization with SR compared to ER (8 days vs. 0.4 days, p<0.0001) |
| Qu, 2021 (53)<br><br>Retrospective cohort | To compare the efficacy and safety between ESD and conventional surgery in the treatment of early CRC and precancerous lesions<br><br>130 patients diagnosed with early CRC or precancerous lesions and receiving endoscopic or surgical treatment<br>(Early CRC refers to colorectal epithelial tumour of any size with the invasion depth limited to the mucosa and submucosa regardless of the | • ER was successful: rate of en bloc tumour resection was 89.2% (58/65) the rate of tumour curative resection was 92.3% (60/65)<br><br>• The ESD group vs. surgery group:<br>  ○ shorter operation time: 45.57±19.46 vs. 88.43±18.48 min (p=0.001)<br>  ○ mean hospital stay: 6.82±2.60 vs. 10.39±2.95 days (p=0.001)<br><br>• Using the EORTC-QLQ-C30 scoring, the ESD had significantly higher score than the surgery group in:<br>  ○ general quality of life: 77.46±20.45 vs. 69.52±21.04, p=0.031<br>  ○ emotional functioning: 87.74±16.76 vs. 81.77±17.47, p=0.049<br>  ○ fatigue: 23.83±10.98 vs. 19.70±8.09, p=0.016<br>  ○ constipation: 44.88±9.49 vs. 41.43±6.93, p=0.019<br>  ○ diarrhea: 14.79±4.75 vs. 12.83±5.73, p=0.036 |

| Study | Study goals and population | Findings |
|---|---|---|
| | presence or absence of lymph node metastasis)<br><br>65 patients received ER; 65 received surgery | |
| Bosch, 2020 (44)<br>Retrospective cohort | To assess the number of referrals for surgery and the type of surgery for polyps since the introduction of the Dutch national bowel screening program<br><br>164 patients who underwent colorectal surgical procedures because of polyps that were technically unresectable endoscopically due to size, location and/or non-lifting sign | • Of the 164 patients with endoscopically unresectable benign polyps of<br>  ○ 125 (76.2%) polyps were unresectable due to location, size, or non-lifting, 45.5% of those polyps were sessile with a median size of 3.5 cm<br>  ○ CRC in 24%, 37%% HGD, 34% LGD, 5% had no/unknown dysplasia<br>  ○ 54.9% were located in the right colon<br>  ○ 20.1% had one or more attempts at ER<br>• 115 (70%) had segmental resection (colectomy),<br>• 49 (30%) had organ preserving surgery (TEM n=22 or LEAWR n=27)<br>• Postoperative mortality was zero overall<br>• Overall complication rate was 36.0%<br><br>• For segmental resection (n=115):<br>  ○ 44.3% (51) had a complication<br>  ○ 6.1% (7) had a major complication<br>  ○ 3.5% (4) had an anastomotic leakage<br>  ○ Median length of stay: 5 days<br>  ○ Readmission 7.8% (9)<br><br>• For organ-preserving surgery (n=49):<br>  ○ 16.3% (8) had a complication (p=0.001 vs. seg res)<br>  ○ 2% (1) had a major complication<br>  ○ No anastomotic leak<br>  ○ Median length of stay 2 days (p<0.001 vs. seg res)<br>  ○ Readmission 4.1% (2) (p=0.51 vs. seg res) |
| Moon, 2020 (49)<br><br>Retrospective Study | To evaluate referral patterns to colorectal surgery for non-malignant colorectal polyps, to compare outcomes between attempted ER and surgery, and to identify factors associated with surgery<br><br>315 patient referred to CRS for non-malignant polyps: 117 ER; 136 surgery | Of the 315 patients with non-malignant polyps referred to surgery,<br>• 37% (117/315) were referred for attempt at ER.<br>• 43% (136/315) underwent surgery<br><br>• Distribution of patients was similar between ER vs. surgery for polyps with LGD (54.5% ER vs. 45.5% surgery; p=0.16) and HGD (42.9% ER vs. 57.1% surgery; p=0.11).<br>• Surgery was significantly performed more frequently for patients with intramucosal carcinoma; on baseline histopathology versus attempt at ER; 83.9%; n=26 vs. 16.1%; n=5; p=0.0001<br><br>Associated with a higher likelihood of surgery on multivariate analysis:<br>• Intramucosal adenocarcinoma on baseline pathology (OR, 5.7; 95% CI, 1.2-28.2)<br>• Referrals by academic gastroenterologists (OR, 2.5; 95% CI, 1.11-5.72) |

| Study | Study goals and population | Findings |
|---|---|---|
| | | Complete ER was achieved in 87.2% (n=102), with polyp recurrence in 27.2% at a median of 14 months (range, 0-72).<br><br>When compared with surgery, ER was associated with:<br>o lower hospitalization rate (24.8% vs. 95.6%; p<0.0001 (n=117 vs. n=130))<br>o shorter hospital stays (mean, 0.5 ± 0.9 vs. 2.23 ± 1 days; p<0.0001)<br>o fewer adverse events (5.9% vs. 22.8%; p<0.001)<br>o no deaths were reported in either group at the 90-day follow-up.<br>o no patients referred for a second ER attempt declined the procedure (0/128)<br><br>Among those who required further treatment after ER, none declined repeat endoscopy (0/128), whereas 7.1% of patients (12/168) declined surgery (p=0.002). |
| Rodrigues, 2020 (54)<br><br>Retrospective cohort | To analyze the evolution of the surgical referral rate for benign lesions detected due to a CRC screening program before and after implementation of a regional referral network.<br><br>1571 patients who had abnormal FOBT or FIT tests followed by colonoscopy during 2012, 2016, and 2017 led to:<br>105 benign polyps ≥20 mm analyzed, 50 were treated by endoscopy (47.62%) and 55 by surgery (52.38%). | Risk Factors for surgery<br>• The year 2012: OR: 3.35; 95% CI, 1.20—9.40; p=0.022; the proportion of surgical management then decreased in 2016 and 2017.<br>• Histology for high-grade dysplasia (OR, 2.49, 95% CI,1.04—5.97; p=0.04) and carcinoma in situ (OR, 5; 95% CI, 1.73—14.45; p=0.003).<br>• The size of the lesion, for lesions ≥ 20 mm: OR, 17.39; 95% CI, 5.50—54.99; p<0.0001.<br>• Private establishment was also a significant risk factor: OR. 6.59; 95% CI, 2.41—18.01; p=0.0002.<br>• The rectal location of the lesions was a protective factor for surgical management: OR: 0.13, 95% CI,0.003-0.56, p=0.006.<br><br>Reasons for referral for lesions ≥20 mm<br>• Large size: 25/55 (45.5%).<br>• Inaccessibility: 8/55 (14.5%).<br>• Endoscopic suspicion of malignancy: 16/55 (29.09%).<br>• ER failure: 6/55 (10.91%).<br><br>Adverse events:<br>• Morbidity at 30 days was higher in the surgery group with 20% morbidity compared to 6% in the ER group (p=0.044).<br>• 4% of the patients who underwent ER required additional surgery (2 patients)<br>• Minor adverse events in 30% ER patients (15) all were bleeds and resolved by endoscopic haemostatic therapy<br>• Three (6%) postprocedural bleeding episodes required endoscopic haemostatic therapy<br>• Surgical adverse events were observed in 11 patients (20% of those operated on)<br>o The median length of stay was significantly longer in the surgery group (10 days (9-12) vs. 2 days (1-3), p<0.0001) |
| **Endoscopic Resection Only** | | |
| Chaoui, 2022 (45) | To assess efficacy, safety and recurrence rate of EMR in a tertiary | • 4 (2.4%) early adverse events: 3 bleeds and 1 perforation<br>• 12 (7.2%) delayed bleeding |

| Study | Study goals and population | Findings |
|---|---|---|
| Retrospective cohort | centre and to identify risk factors for recurrence at first surveillance colonoscopy<br><br>EMR was performed for 165 colorectal polyps in 142 patients with technical success in 158 cases (95.2%) | • Recurrent adenoma in 19 (16.2%) after a median time of 6.2 months (IQR 5-9.9)<br>• Independent risk factors for recurrence were lesion size ≥40 mm (OR=403; p=0.018) and presence of high-grade dysplasia (OR 3.89; p=0.034) |
| Chiba, 2022 (46)<br><br>Retrospective cohort | To investigate the feasibility and safety of ESD procedures for colorectal lesions ≥ 10 cm in diameter<br><br>ESD comparison for polyps ≥10 cm group (50 patients) and polyps 5–10 cm (270 patients) | Polyps ≥10 cm group vs. polyps 5–10 cm group<br>• Lesions were most often in the rectum in ≥10 cm group (50.0%),<br>• Longer mean ESD procedure time in ≥10 cm group (186.0 vs. 94.4 min, p<0.001)<br>• Dissection speed was higher for ≥10 cm group (0.50 vs. 0.41cm$^2$/min, p=0.003)<br>• En bloc and curative resection rates were comparable between groups (4% vs. 0%)<br>• Adverse events were similar between groups (16 vs. 7, p=0.115) |
| Mandic, 2022 (48)<br><br>Retrospective cohort | To identify risk factors contributing to the malignancy of colorectal polyps, as well as risk factors for recurrence after the successful endoscopic mucosal resection of large colorectal polyps in a referral center<br><br>472 patients with large colorectal polyps ≥ 20 mm | The majority of patients had one polyp (73.7%) less than 40 mm in size (74.6%) sessile morphology (46.4%), type IIA polyps (88.2%) or polyps localized in the descending colon (52.5%).<br><br>The accessibility of the polyp was complicated in 17.4% of patients.<br><br>En bloc resection success rate: 61.0%<br>Piecemeal resection success rate: 26.1%.<br>Due to incomplete endoscopic resection, surgery was performed in 5.1%<br>7.8% were referred to surgery directly<br><br>After ER 8.3% (30 patients) colorectal polyp recurrence<br>• Piecemeal resection (p = 0.048) and incomplete resection success (p = 0.013) were significant independent predictors of polyp recurrence in the multivariate logistic regression analysis. |
| Tidehag, 2022 (56)<br><br>Retrospective cohort | To investigate if ESD of colorectal lesions can be performed in an outpatient setting.<br><br>Early colorectal neoplasm > 20mm without signs of deep invasion<br><br>660 colorectal ESD procedures | Of 660 lesions, 323 (48.9%) were localized in the proximal colon, 102 (15.5%) in the distal colon, and 235 (35.6%) in the rectum.<br>Median lesion size was 38 mm (interquartile range, 30-50) and median procedure duration 70 minutes (interquartile range, 45-115).<br><br>En-bloc resection was achieved in 620 cases (93.9%)<br>R0 resection was achieved in 492 en-bloc resections (79.4%)<br>Rx and R1 resections were 124 (20.0%) and 4 (0.6%), respectively<br>Adverse events:<br>• Perforation: 38 (5.8%), 3 required surgery<br>• Unplanned admission: 33 cases; mean duration 1.36 days ±0.74 days<br>• 30-day adverse events: 46 patients (7.0%)<br>• Bleeding: 21 cases (3.2%)<br>• Abdominal pain: 16 cases (2.4%) |

| Study | Study goals and population | Findings |
|---|---|---|
| | | |
| Spychalski, 2021 (55)<br><br>Retrospective cohort | To analyze the safety and efficiency of colorectal ESD based on a large cases series<br><br>601 patients who underwent ESD procedure for colorectal neoplasm in a single centre | • Mean colorectal lesion diameter was 44.3±23.3mm and 4.33% of them were classified as giant tumours (>10 cm).<br>• Success rate: 83.53%; en bloc 88.02%; R0 resection 86.36%<br>• Adverse events:<br>o Post ESD bleeding 3.83% (23 patients); severe (0.67%) in 4 patients<br>o ESD related perforations in 5.32% (32 patients; 27 managed by endoscopy, 5 managed by surgery)<br>o The mean hospitalization stay of patients after colorectal ESD was 4.36±1.42 days. |
| Azevedo, 2020 (43)<br><br>Retrospective cohort | To evaluate the recurrence and surgical complementation rates after ER of large colorectal non-pedunculated lesions.<br><br>63 patients with non-pedunculated lesions larger than 3 cm | • Mean lesion size 40.08 mm<br>• The clinical success of endoscopic treatment was 95.2%.<br>• Subsequent surgical resection due to an unsuccessful endoscopic treatment was necessary in three lesions (4.8%)<br>• Recurrence: 25.8% (16 cases) due to mean lesion size (40.08 mm) or fragmented resection, which occurred in 87.1% |
| Li, 2020 (47)<br><br>Retrospective cohort | To audit the clinical outcome of our initial experience in colorectal ESD, focusing on its safety and efficacy.<br><br>41 patients who underwent ESD | • Overall endoscopic curative rate of 95.1% (n=39)<br>• Adverse events: perforation in 7.3% (n=3)<br>• Median length of stay: 1 day (range: 1-7 days)<br>• Upstaging of histological severity from the initial biopsy results occurred in 14 (34.1%) patients after ESD |
| **Complex polyps: rates and trends at population level** | | |
| Bosch, 2020 (44)<br><br>Retrospective cohort | To assess annual numbers of surgeries prior to and after introduction of Dutch national bowel screening program<br><br>164 patients who underwent colorectal surgical procedures because of polyps that were technically unresectable endoscopically due to size, location and/or non-lifting sign | • Of the 164 patients with endoscopically unresectable benign polyps of 2169 referred for surgery in 2014<br>• Prior to screening program launch, the annual number of patients who underwent surgical removal of polyps was 18 (2012) and 17 (2013), then increased to 36/year in 2016 and 2017.<br>• 16.7% of those having surgery for benign polyps in 2014 had colonoscopy because of abnormal FIT while 50% had colonoscopy because of abnormal FIT in 2017. |
| Rodrigues, 2020 (54)<br><br>Retrospective cohort | To analyze the evolution of the surgical referral rate for benign lesions detected due to a CRC screening program before and after implementation of a regional referral network<br><br>1571 patients who had abnormal FOBT or FIT tests followed by | Surgery rate before and after regional referral network implemented in 2015:<br>• Overall, for benign lesions decreased from: 14.6% in 2012 to 7.7% in 2016 and 5% in 2017 (p=0.017).<br>• For benign lesions ≥20 mm, it did not change significantly: 62.5% in 2012 to 53.62% in 2016 and 40% in 2017; p=0.381.<br><br>Risk Factors for surgery<br>• The year 2012: OR, 3.35; 95% CI, 1.20—9.40; p=0.022; the proportion of surgical management then decreased in 2016 and 2017. |

| Study | Study goals and population | Findings |
|---|---|---|
| | colonoscopy during 2012, 2016, and 2017 led to:<br>105 benign polyps ≥20 mm analyzed, 50 were treated by endoscopy (47.62%) and 55 by surgery (52.38%) | • Histology for high-grade dysplasia (OR, 2.49; 95% CI,1.04—5.97, p=0.04) and carcinoma in situ (OR, 5; 95% CI, 1.73—14.45; p=0.003).<br>• The size of the lesion, for lesions ≥ 20 mm: OR, 17.39; 95% CI, 5.50—54.99; p<0.0001.<br>• Private establishment was also a significant risk factor: OR. 6.59, 95% CI, 2.41—18.01; p=0.0002.<br>• The rectal location of the lesions was a protective factor for surgical management: OR, 0.13, 95% CI, 0.003-0.56; p=0.006.<br><br>Reasons for referral for lesions ≥ 20 mm<br>• Large size: 25/55 (45.5%)<br>• Inaccessibility: 8/55 (14.5%)<br>• Endoscopic suspicion of malignancy: 16/55 (29.09%)<br>• ER failure: 6/55 (10.91%)<br><br>Adverse events:<br>• Morbidity at 30 days was higher in the surgery group with 20% morbidity compared to 6% in the endoscopy group (p=0.044)<br>• 4% of the patients who underwent ER required additional surgery (2 patients)<br>• Minor adverse events in 30% ER patients (15) all were bleeds and resolved by endoscopic haemostatic therapy<br>• Three (6%) postprocedural bleeding episodes required endoscopic haemostatic therapy<br>• Surgical complications were observed in 11 patients (20% of those operated on)<br>• The median length of stay was significantly longer in the surgery group (10 days (9-12) vs. 2 days (1-3), p<0.0001) |
| Vu, 2021 (57)<br><br>Retrospective cohort | Compared regional variation in colectomy rates for CRC versus benign polyp | • In 2010-2015 Medicare patients who underwent colectomy: 65.8% (157,802) for CRC; 34.2% (81,937) for benign polyp.<br>• Hospitals that had advanced endoscopy services had a 1.1% increased proportion of colectomy for benign polyp (95% CI, 1.0–1.3)<br><br>• Across Hospital referral regions, colectomy rates varied 5.8-fold for cancer (0.32–1.84 per 1000 beneficiaries).<br>• There was a 69-fold variation for benign polyp (0.01–0.69).<br>• The rate of colectomy for CRC was correlated with the rate of colectomy for benign polyp (slope=0.61; 95% CI, 0.48–0.75), hospital referral regions with the lowest or highest rates of colectomy for CRC did not necessarily have similarly low or high rates for benign polyp. |
| Yu, 2021 (59)<br><br>Retrospective cohort | Aimed to quantify and examine the trends in the use of EMR and its outcomes for large benign nonpedunculated colorectal lesions in the USA | • The rate of EMR use in the USA increased from 1.62% of all colonoscopies in 2011 to 2.48% of colonoscopies in 2015 (p<0.001)<br>• There were significant regional differences in the use of EMRs, from 2.4% of colonoscopies in the western United States to 2.0% of colonoscopies in the southern United States<br>• Between 2011 and 2015, there were stable rates of perforation, GI bleeding (GIB), infections, and cardiac adverse events and decreasing rates of admissions after EMR<br>• Multivariate analysis showed EMR was an independent risk factor for adverse events, although rates of adverse events were low (1.35% GIB, 0.22% perforation) |

| Study | Study goals and population | Findings |
|---|---|---|
| Peery, 2018 (52)<br><br>Retrospective cohort | Aimed to quantify and examine trends in the use of surgery for non-malignant colorectal polyps in a nationally representative sample | In 2014, the incidence rate for non-malignant colorectal polyp surgery was<br>• 1.0 per 100,000 among those 20–49 years old,<br>• 14.4 per 100,000 among those 50–64 years old,<br>• 34.5 per 100,000 among those 65–79 years old, and<br>• 13.4 per 100,000 among those ≥80 years old<br>• 9.4 per 100,000 overall<br><br>Trends 2000-2014<br>• Incidence of surgery for non-malignant colorectal polyps has increased significantly, from 5.9 in 2000 to 9.4 in 2014 per 100,000 adults (IRD: 3.56; 95% CI, 3.40–3.72)<br>• Rate of surgery for non-malignant colorectal polyps has significantly increased from 2000-2014 among adults 50–64 years old (IRD: 7.95; 95% CI, 7.58-8.31), and 65–79 years old (IRD: 12.13; 95% CI, 11.26-12.99)<br>• Incidence of surgery for CRC has significantly decreased, from 31.5 to 24.7 surgeries per 100,000 adults (IRD: −6.80; 95% CI, −7.11 to −6.49)<br>• Incidence of surgery for non-malignant colorectal polyps has increased significantly in all individuals 20–79, in men and women and including all races and ethnicities, among hospitals in the Northeast, Midwest and South, in urban, teaching hospitals of all bed sizes, and small and medium nonteaching urban hospitals, and small nonteaching rural hospitals |
| **Systematic Reviews** | | |
| Thorlacius, 2019 (42) | To summarize the experience of colorectal ESD in Europe<br><br>SR of 15 studies<br>Studies with patients diagnosed with non-pedunculated undergoing standard ESD | • En bloc resection rate was 83% with a range between 67–93%<br>• R0 resection rate was 70% ranging from 35 to 91%<br>• Recurrence rate was provided on 12 studies and median recurrence rate was 4% ranging between 0 to 12%.<br>• Adverse events:<br>  ○ 13 reports median perforation rate was 7% with a range between 0 and 19%<br>  ○ Percentage of ESD cases undergoing emergency surgery was 2% (range 0–6%)<br>  ○ 13 studies reported significant bleeding rate: median rate of 5% with a range between 0 and 12%. |
| Hassan, 2016 (41) | To assess the efficacy and safety of ER of large colorectal polyps.<br><br>SR & MA of 50 studies<br><br>Studies in which ≥20 mm colorectal neoplastic lesions treated with ER and main outcomes reported | • 14% (95% CI 12% to 15%); patients underwent surgery before any attempt of ER (248/179)<br>• Polyp size was reported in 38 studies, the median being 33 mm (range: 20–51).<br>• 91% :(6089/6625) polyps were nonpedunculated (sessile or non-polypoid).<br>• 47%: (2804/5977) large lesions were in the proximal colon, the remaining 3173 being in the distal tract.<br>• Reason for surgery:<br>  ○ 58% invasive cancer at histology<br>  ○ 28% non-curative ER<br>  ○ 2.2% synchronous lesions<br>  ○ 5.9% recurrence |

| Study | Study goals and population | Findings |
|---|---|---|
| | | • Multivariate analysis showed that the only variables that remained weakly significantly associated with the pooled rate of post endoscopic surgeries due to non-curative resection among studies were 'patient enrolment' (≥29 vs. <29 patients per year; 10.0% vs. 6.1%; p=0.05, random effects model) and 'mean age of the study population' (>67 vs. ≤67 years; 8.7 vs. 5.7; p=0.05, random effects model).<br>• Following ER of a ≥20 mm polyp, a total of 534 (8.3%) patients underwent surgery for any reason, with a random effect pooled rate of 8% (95% CI 7% to 10%)<br>• For patients who underwent surgery:<br>o 503/6442 (pooled rate: 8%; 95% CI, 7% to 10%; $I^2$ =78.6%) due to non-curative ER<br>o 31/6442 (pooled rate: 1%; 95% CI, 0.7% to 1.4%, I2=0%) to adverse events<br>o ER appeared to be effective in preventing surgery in 92% of the cases<br>o Endoscopic treatment was successful in 664/735 cases (90.3%; 95% CI, 88.2% to 92.5%)<br>o Recurrence was detected in 735/5334 patients (13.8%; 95% CI, 12.9% to 14.7%), being an invasive cancer in 14/5334 (0.3%; 95% CI, 0.1% to 0.4%)<br>o Mortality was reported in 5/6278 cases (0.08%; 95% CI, 0.01% to 0.15%)<br>o ER appeared also to be a safe technique with surgery for adverse event limited to 1% of the patients<br>• Adverse events in ER:<br>o perforation occurred in 96/6595 (1.5%, 95% CI 1.2% to 1.7%) polyps,<br>o bleeding in 423/6474 (6.5%, 95% CI 5.9% to 7.1%) polyps |
| de Neree Tot Babberich, 2019 (40) | SR & MA of 26 studies<br><br>To determine postoperative outcomes and the characteristics of surgically resected benign colonic polyps<br><br>At least one postoperative outcome reported of surgical resection for benign colonic polyps | 3 studies reported rate of surgical resection referral:<br>• 9.6% :49 of 513 adenomas larger than 2 cm were referred for surgery<br>• 21.7%: 121 of 557 polyps larger than 2 cm with sessile or flat morphology<br>• 4.1% :175 out of 4251 patients with a benign polyp<br><br>5 studies reported explicit reasons for surgical resection:<br>• 3 studies reported that the most common reason for referral was right-sided colon<br>• 2 studies had polyp size being the commonest reason for referral (1 had a median polyp size 4.0cm, and the other a mean polyp size of 3.8cm)<br>• The most common indications for surgical resection were polyp location in the right-sided colon, non-pedunculated morphology, and large polyp size.<br><br>21 studies reported on polyp size:<br>• overall pooled results of 11 studies that reported on mean polyp size demonstrated a mean polyp size of 3.1 cm (95% CI, 2.9-3.3 cm).<br>• in 4 studies that used a categorization for polyp size, many of the polyps that were referred for surgery were >2 cm<br>• in the 4 studies that reported on median polyp sizes, sizes ranged from 1.8-4.0 cm<br>• 8 studies reported most polyps that were surgically resected were sessile (range 46.3-100%)<br><br>Postoperative outcomes: |

| Study | Study goals and population | Findings |
|---|---|---|
| | | • 3 three studies reported specifically on the prevention of surgery through a second assessment of the patient/polyp by an advanced interventional endoscopist; surgery was avoided in between 32%-74% of the patients by the endoscopy being repeated by an experienced surgeon or gastroenterologist<br><br>Mortality rates were reported in 21 studies<br>• The pooled 1-month mortality rate of studies that included patients after the year 2000 (5 studies) was 0.7% (95% CI, 0.6%–0.8%), respectively.<br><br>Complication rates -26 studies reported -which were differently defined by the studies<br>• pooled 1-month complication rate from studies that included patients after the year 2000 (6 studies) was 24% (95% CI, 15-36%)<br>• with a surgical complication rate of 17% (95% CI, 10-29%) and a nonsurgical complication rate of 9% (95% CI, 6-13%)<br><br>Severe adverse events (Clavien Dindo 3 +) were reported in six studies and ranged from 0% to 10.1% and Surgical re-interventions ranged from 0% to 8.9%<br>o Anastomotic leakage (11 studies) range: 0.3–8.7%<br>o Bleeding (12 studies) range: 0.6-11.4%<br>o Ileus (13 studies) range: 0.6-28%<br>o Infections (includes abscess) (19 studies) 1.1-22.2%<br>o Wound dehiscence/hernia (10 studies) 0.5-9.7%<br>o Organ injury (3 studies) 1.1-6.7%<br>o Other (11 studies) 0.7-15.6%<br><br>Length of stay was reported in 22 studies, either as a mean (11) or a median (11).<br>• overall pooled results from the studies that reported on mean length of stay (11 studies) showed a pooled length of stay of 5.1 days (95% CI, 4.4 – 5.9)<br>• the studies reporting a median length of stay had a range of 4 to 11 days |
| **Guideline** | **Information** | |
| ESGE 2017 (16) | Large (≥20mm) sessile and laterally spreading or complex polyps, should be removed by an appropriately trained and experienced endoscopist, in an appropriately resourced endoscopy centre. (Moderate quality evidence, strong recommendation.) | |
| Rees, 2016 (39) | Management of polyps—all units should have a policy for management of polyps including a policy for dealing with large and large sessile polyps.<br><br>In expert centres, around 10% of patients ultimately undergo surgery for different reasons. Patients with complex polyps should be assessed in centres with full surgical back up, where a minimally invasive ER may still be possible. Use of complex polyp multidisciplinary team meetings may be beneficial when deciding upon management.<br><br>The Paris classification is based upon polyp shape and relationship to the surrounding mucosa and reflects the morphology of lesions.<br>The Kudo classification based on the pit pattern on the surface of the polyp is very important in indication of malignancy.<br>National Institute for Health and Care Excellence classification, which uses enhanced optical imaging techniques to evaluate lesions, showed high levels of accuracy in predicting submucosal invasion. | |

**Abbreviations:** AKI, acute kidney injury; CI, confidence interval; CSS, cancer specific survival; CRC, colorectal cancer; CRS, colorectal surgery; ESGE, European Society of Gastrointestinal Endoscopy EMR, endoscopic mucosal resection; EORTC-QLQ-C30, European Organization for Research and Treatment of Cancer quality of life questionnaire Core 30; ER, endoscopic resection; ESD, endoscopic submucosal dissection; FIT, fecal immunochemical test; FOBT, fecal occult blood test; GIB, gastrointestinal bleeding; HGD, high-grade dysplasia; IRD, incidence rate differences; LEAWR, limited endoscopic-assisted wedge resection; LGD, low-grade dysplasia; MA, meta-analysis; NGT, nasogastric tube; OR, odds ratio; OS, overall survival; R0, complete histologic resection rate; seg res, segmental resection; SR, surgical resection; SR, systematic reviews; TEM, transanal endoscopic microsurgery; USA, United States of America.

**Table 4.9. Adverse events: Study Characteristics -20 studies.**

| Study | Design/ Study period | Data Source | Ascertainment | Number of Patients/ Colonoscopies | Indication for Colonoscopy | Age | Follow-up (days post colonoscopy) | Other | Outcomes |
|---|---|---|---|---|---|---|---|---|---|
| **Population based Studies** | | | | | | | | | |
| Benazzato, 2021 (70)<br><br>Italy | Retrospective cohort<br><br>2004-2014 | Regional CRC Screening Program Database | Chart review: linked records at 30 hospitals in region (2 reviewers) | 117,881 COL<br>66,584 with ER | Abnormal FIT (85%), previous incomplete (1%), surveillance (14%) | 50+<br><br>59% male | 30-day post-procedure<br>No other dates provided | 56.5% ER | Overall<br>Perforation<br>Bleeding<br>Unplanned admissions after polypectomy (unknown reason)<br>Polypectomy syndrome<br>Cardiovascular<br>Other<br>Death |
| Kim, 2021 (89)<br><br>South Korea | Retrospective cohort<br><br>2012-2017 | Health Insurance Review and Assessment-National Patient Samples database | Linked health administrative databases | 387,647 EGD<br>241,094 COL<br>89,059 polypectomies | Diagnostic | Age group: 18-65 yrs<br><br>51% male | 30 days post-procedure | | Bleeding<br>Perforations<br>Cerebrovascular accident<br>Acute myocardial infarction<br>Congestive heart failure |
| Kooyker, 2021 (68)<br><br>Netherlands | Retrospective cohort<br><br>2013-2017 | National Endoscopy Complication Registry/ National Screening Database/ Personal Records Database/ | 3 methods, linked datasets:<br>1. endo-specific complication registry<br>2. screening database linked to health records | 172,797 pts | Abnormal FIT | All screening participants: Median age 65 yrs<br>48.1% male | 30 days post-procedure | | 1. Fatal complication rate (endo reported)<br>2. Excess death rate (FIT pos vs. FIT neg)<br>3. COL-relative mortality (registry) |

| Study | Design/ Study period | Data Source | Ascertainment | Number of Patients/ Colonoscopies | Indication for Colonoscopy | Age | Follow-up (days post colonoscopy) | Other | Outcomes |
|---|---|---|---|---|---|---|---|---|---|
| | | National Statistical Office | 3. screening database linked to death registry | | | | | | |
| Paszat, 2021 (67)<br><br>Canada | Retrospective cohort<br><br>2008-2017 | Screening program Ontario Health Insurance Plan database | Linked health administrative databases | 121,626 pts 51,310 with polypectomies | Abnormal FOBT | 68.1% between 50-64 yrs<br><br>53.6% male | 7 days (perforation and unplanned admissions) and 14 days (bleeding) post-procedure | 42.2% 1+ polypectomy | Perforation<br>Post polypectomy bleeding |
| Tomaszewski, 2021 (66)<br><br>Canada | Prospective cohort<br><br>2013-2017 | Provincial CRC Screening Database | Standardized colonoscopy report forms and follow-up forms (latter completed by trained RNs) and adjudication by quality 99 directors of the BCCSP | 96,192 COL 62,647 with polypectomies<br><br>Adverse event data available for 78,831 (82%) | Abnormal FIT | Median age 62 (52-71) yrs<br><br>56% male | 14 days post-procedure | 65.1% 1+ polyp removed 15.7% a large precancerous polyp removed | Overall<br>Perforation<br>Bleeding<br>Post-polypectomy syndrome<br>Bowel prep related<br>Splenic injury<br>Cardiovascular<br>Respiratory<br>Other<br>Death |
| Yoshida, 2021 (65)<br><br>Japan | Retrospective cohort<br><br>2005-2018 | Insurance claims | Extracted data from the health insurance database | 341,852 COL 123,087 COL with lesion resection | Screening and diagnostic | Mean age 50.7 ±11.3 yrs<br><br>64.8% males | 7 days post-procedure | | Post-colonoscopy bleeds<br>Perforation<br>Mortality<br>Risk factors |
| Causada-Calo, 2020 (72)<br><br>Canada | Retrospective cohort<br><br>2008-2017 | Ontario administrative databases | Extracted data from the health insurance database | 38 069 patients | Screening or surveillance | Mean age 65.2 ±10.1 yrs<br><br>50% males | 30 days post-procedure | | Adverse events<br>Bleeding<br>Perforations<br>Mortality |
| Kobiela, 2020 (71)<br><br>Poland | Case-Control study<br><br>2012-2015 | Screening database National Cancer Registry | Emergency admissions were categorized by 3 specialist medical doctors | 338,477 COL group<br><br>338,557 no COL control group | Screening colonoscopy | Mean age 59.3 ±2.8 yrs | 6 weeks before and 30 days post-procedure | | Mortality<br>Unplanned admission |

| Study | Design/ Study period | Data Source | Ascertainment | Number of Patients/ Colonoscopies | Indication for Colonoscopy | Age | Follow-up (days post colonoscopy) | Other | Outcomes |
|---|---|---|---|---|---|---|---|---|---|
| | | National Health Fund | | | | 46.5 males in both groups | | | |
| Laanani, 2019 (74)<br><br>France | Retrospective cohort<br><br>2010-2015 | SNIIRAM-PMSI national claims databases | Identified by discharge diagnosis and surgical procedures | 4,088,799 pts | Screening or diagnostic | 44.8% male<br>55% between ages 50-70 | 5 days and 30 days post-procedure | | Perforations<br>Bleeding<br>Splenic injuries<br>Mortality |
| Vanaclocha-Espi, 2019 (73)<br><br>Spain | Case-control study<br><br>2000-2012 | Six regional CRC screening programs database | Identified through the endoscopist report or linking of colonoscopies and hospital admission | 48,730 diagnostic COL<br><br>483 cases of serious adverse events<br><br>942 matched controls (2:1) | Abnormal FOBT | 58% males<br>50-70 yrs (46% 50-59 yrs.) | 30 days post -procedure | Risk factors: cases vs. controls<br><br>Overall serious adverse events, classified as early (same day), late (1-30d), perforation, bleeding | Serious adverse events (hospital admission or death due to perforation, bleeding requiring transfusion, vagal syndrome or peritonitis):<br>Bleeding<br>Perforation<br>Death |
| Arana-Arri, 2018 (77)<br><br>Spain (Basque) | Retrospective cohort<br><br>2009-2014 | Hospital admission data | Colonoscopy records were reviewed | 39,254 COL with sedation | Abnormal FIT | Mean age: 61.7 yrs<br><br>70.2% males | 30 days post-procedure | | Perforation<br>Bleeding<br>Sedation-analgesia<br>Other<br>Minor adverse events |
| Derbyshire, 2018 (80)<br><br>England | Prospective cohort<br><br>2006-2014 | English NHS Bowel Cancer Screening Programme database | Specialist Screening Practitioners enter endoscopy related data (same day, phone | 263,129 COL | All colonoscopies<br>Abnormal FOBT, diagnostic, therapeutic | Mean age: 65.5 yrs<br><br>60.5% males | 30 days post-procedure | Risk factors & clinical course/outcomes | Perforations<br>Mortality |

| Study | Design/ Study period | Data Source | Ascertainment | Number of Patients/ Colonoscopies | Indication for Colonoscopy | Age | Follow-up (days post colonoscopy) | Other | Outcomes |
|---|---|---|---|---|---|---|---|---|---|
| | | | call at 1 d, survey at 30 d) | | | | | following perforation | |
| Mikkelsen, 2018 (76)<br><br>Denmark | Prospective cohort<br><br>2014 | Danish National Patient Registry (DNPR), and the National Pathology Registry | Chart review of cases identified through hospital admission data | 14,671 COL | Abnormal FIT | Mean age: 64.9 yrs<br><br>62.9% males | 14 d for bleeding<br>30 d for other SAEs<br>90 d for death | | Perforation<br>Bleeding<br>Other adverse events related to sedation or colonoscopy<br>Post-polypectomy syndrome |
| Hoff, 2017 (79)<br><br>Norway | Retrospective cohort<br><br>2017 | Gastronet Norwegian national quality register | Free text patient feedback forms | 16,552 COL<br>11,248 with 2 report forms, patient, and COL | Diagnostic and therapeutic | - | 1 d post-procedure | | Hospital admission<br>Bleeding<br>Perforation<br>Bradycardia<br>Abdominal pain<br>Nausea<br>Stroke<br>Soiling |
| Tepes, 2017 (78)<br><br>Slovenia | Retrospective cohort<br><br>2009-2011 | National colorectal screening program database | Physician and/or patient had option of mailing standardized form to program | 13,919 COL | Abnormal FIT | - | NR | | Serious adverse events<br>Perforation<br>Bleeding<br>Hospitalizations |
| Saraste 2016 (81)<br><br>Sweden | Retrospective cohort<br><br>2008-2012 | National screening register | Linked health administrative data with hospital overnight stay | 2984 COL | Abnormal FOBT | | 30 days post-procedure | | Bleeding<br>Perforation<br>Unplanned admissions<br>Mortality |
| Rutter, 2014 (82)<br><br>England | Prospective cohort<br><br>2006-2012 | National screening database | Data from procedures, 1-day post-procedure contact and mailed questionnaire | 130,831 COL<br><br>69,028 with 1+ polypectomies | Abnormal FOBT | Mean age 65.7 yrs<br>98% were 60-74 yrs<br><br>60.7% males | 30 days post-procedure | | Perforation<br>Bleeding |

| Study | Design/ Study period | Data Source | Ascertainment | Number of Patients/ Colonoscopies | Indication for Colonoscopy | Age | Follow-up (days post colonoscopy) | Other | Outcomes |
|---|---|---|---|---|---|---|---|---|---|
| | | | 30 d after colonoscopy | | | | | | |
| Denis 2013 (83)<br><br>France | Retrospective Cohort<br><br>2003-2010 | French National Programme | Gastroenterologist reported, postal questionnaires, patient phone calls, colonoscopy reports and hospital charts | 10,277 COL | Abnormal FOBT | Mean age 62.7 yrs | 30 days post-procedure | | Bleeding<br>Perforation<br>Post polypectomy syndrome<br>Abdominal pain<br>Diverticulitis<br>Cardiovascular events<br>Acute urinary retention<br>Minor incidents |
| Gupta 2012 (84)<br><br>England | Prospective cohort<br><br>2006-2009 | Bowel Cancer Screening Centre's database | Data extraction from screening database and interviews | 1202 COL | Abnormal FOBT (88%), surveillance (6%), other follow up (6%) | 57% males | 30 days post-procedure | | Bleeding<br>Perforation<br>Mortality<br>Post polypectomy syndrome<br>Non-procedure related adverse events |
| EMR, ESD | | | | | | | | | |
| Amato, 2019 (75)<br><br>EMR, ESD only<br><br>Italy | Prospective cohort | SCALP Study 24 practices, web database | 2016, 6-month period | 1504 patients diagnosed with Large colorectal lesions ≥2 cm | Any indication | Mean age: 66.1±11.6 yrs<br><br>57.9% males | 15 days post-procedure | | Post-colonoscopy bleeds<br>Delayed bleeding<br>Perforations |

**Abbreviations:** BCCSP, British Columbia Colon Screening Program; COL, colonoscopy; CRC, colorectal cancer; d, days; DNPR, Danish National Patient Registry; EGD, esophagogastroduodenoscopy; EMR, endoscopic mucosal resections; ER, endoscopic resection; ESD, endoscopic submucosal dissection; FIT, fecal immunochemical test; FOBT, fecal occult blood testing; neg, negative; NHS, National Health Service; pos, positive; PMSI, French National Hospital Discharge Database; pts, patients; RN, registered nurse; SAE, serious adverse events; SCALP, Study on ComplicAtions of Large Polypectomy; SNIIRAAM, French National Health Insurance Claims Information System; vs, versus; yrs, years.

**Table 4.10. Systematic Reviews of Colonoscopy Adverse events Table.**

| Study | Purpose | Location | Search Terms | Inclusion/Exclusion Criteria | Results | Outcomes |
|---|---|---|---|---|---|---|
| Kothari, 2019 (63) | To estimate the 3 most common and important AEs of colonoscopy (bleeding, perforation, and mortality) and to provide evidence-based estimates of AEs related to EMR and ESD | USA | Ovid MEDLINE: Epub Ahead of Print, In-Process & Other Non-Indexed Citations, Ovid MEDLINE Daily and Ovid MEDLINE 1946 to present, Embase Classic + Embase 1947 to January 2018, and Wiley Cochrane | Included English, retrospective and prospective cohort studies with data collected between January 2001 and March 2017<br><br>Because only a subset of population-level studies reported the indication for colonoscopy (screening, surveillance, or diagnostic), this variable was not included in the meta-regression analysis. | 21 studies | Post-colonoscopy bleeds rate: 2.4/1000<br><br>Perforation rate: 0.58/1000<br><br>Mortality rate: 0.03/1000 |
| Reumkens, 2016 (4) | To examine the pooled prevalence of post-colonoscopy perforation, bleeding, and mortality | Netherlands | Searched PubMed, Embase, and the Cochrane library for population-based studies examining post-colonoscopy adverse events (within 30 days), performed from 2001 to 2015 and published by 1 December 2015 | Included English, prospective and retrospective, population-based studies of post-colonoscopy adverse events in patients undergoing colonoscopy from January 2001 until December 2015. In case of multiple studies from the same group, most recent and most extensive data was included | 18 studies | Post-colonoscopy bleeds rate: 2.6/1,000 (95% CI, 1.7-3.7)<br><br>Perforation rate: 0.5/1,000 (95% CI, 0.4-0.7)<br><br>Mortality rate: 0.029/1000 (95% CI, 0.011–0.055) |
| Takamaru, 2020 (64) | To discuss the risk factors, the prevention, and the management of perforation during ESD and EMR. | Japan | Search via Ovid MEDLINE for articles up to April 2020 was performed | Included only English studies.<br><br>Excluded the studies without analysis of risk factors of adverse events related to endoscopic treatment for colorectal neoplasms. Excluded the studies with missing data of an actual number of patients or events for pooled analysis | 23 studies | The pooled analysis revealed the risk factors of perforation during ESD were fibrosis, size of the lesion, and location (colon segment). Closing methods for mucosal defect combined end clips with other devices such as string minimizes the adverse events. |

| Study | Purpose | Location | Search Terms | Inclusion/Exclusion Criteria | Results | Outcomes |
|---|---|---|---|---|---|---|
| Jaruvongvanic 2017 (62) | To identify significant risk factors for delayed PPB | Hawaii | MEDLINE and EMBASE databases were searched through January 2016 | Inclusion criteria: (1) retrospective or prospective, cohort or case–control studies, (2) adult patients (≥ 18 years of age), (3) undergoing colonic polypectomy, and (4) at least three studies reported similar risk factors.<br><br>Exclusion criteria: (1) young patients (< 18 years of age) and (2) studies assessing periprocedural bleeding. | 12 studies | PPB rate: 15/1000<br><br>Cardiovascular disease (OR=1.55), hypertension (OR=1.53), polyp size > 10 mm (OR=3.41), and polyps located in the right colon (OR=1.60) were identified as significant risk factors for delayed PPB, whereas age, sex, alcohol use, smoking, diabetes, cerebrovascular disease, pedunculated morphology, and carcinoma histology were not. |

**Abbreviations:** AE, adverse events; CI, confidence interval; EMR, endoscopic mucosal resections; ESD, endoscopic submucosal dissection; OR, odds ratio; PPB, post-polypectomy bleeding; USA, United States of America.

**Table 4.11. Overall Adverse events Rate -12 studies.**

| Study | Description | Overall complication rate | Items included |
|---|---|---|---|
| **FIT** | | | |
| Benazzato, 2021 (70) | 117,881 colonoscopies in a regional screening program<br>(Abnormal FIT, completion after an incomplete colonoscopy, or follow-up/surveillance colonoscopies)<br>30 days post-procedure<br><br>ER in 56.5% of colonoscopies | All colonoscopies: 4.22/1000<br>ER: 6.35/1000<br>No ER: 1.44/1000<br><br>No polyps: 4.43/1000<br>1-5 polyps 4.03/1000<br>Polyp size:<br>• 1-9 mm: 4.83<br>• 10-19 mm: 1.87<br>• ≥ 20 mm: 2.37<br>• Missing: 4.41 | Includes:<br>Perforation<br>Bleeding<br>Unplanned admission after polypectomy (unknown reason)<br>Cardiovascular<br>Post-polypectomy syndrome<br>Other<br>Death |

| Study | Description | Overall complication rate | Items included |
|---|---|---|---|
| Tomaszewski, 2021 (66) | Screening program FIT<br><br>96,192 colonoscopies<br>62,647 with polypectomies<br><br>14 days post-procedure | All colonoscopies: 4.4/1000<br><br>Splenic injury: 0.05/1000 | Includes:<br>Perforation<br>Bleeding<br>Cardiovascular<br>Post-polypectomy syndrome<br>Bowel preparation related<br>Splenic injury (n=4)<br>Respiratory<br>Other |
| Arana-Arri, 2018 (77) | Screening program<br><br>39,254 colonoscopies<br><br>30, days post-procedure | All colonoscopies 11.2/1000 | Includes:<br>Perforation<br>Bleeding<br>Sedation analgesia<br>Minor adverse events<br>Other |
| Mikkelsen, 2018 (76) | Screening program<br><br>14,671 colonoscopies<br><br>14 days post-procedure | All colonoscopies: 6.1/1000 | Includes:<br>Perforation<br>Bleeding<br>Other adverse events related to sedation or colonoscopy<br>Polypectomy syndrome |
| Tepes. 2017 (78) | Screening program<br><br>13,919 colonoscopies<br><br>NR | All colonoscopies: 0.8/1000 | Includes:<br>Perforation<br>Bleeding |
| **FOBT** | | | |
| Vanaclocha-Espi, 2019 (73) | Biennial FOBT screening test<br>All SC that required hospitalizations<br><br>48,730 colonoscopies<br><br>30 days post-procedure | All colonoscopies: 3.3/1000<br>Early severe adverse events (same day): 1.7/1000<br>Late severe adverse events (between 1-30 days): 1.6/1000 | Includes hospital admission or causing death due to:<br>Perforation<br>Bleeding requiring transfusion<br>Vagal syndrome<br>Peritonitis |
| Saraste, 2016 (81) | Screening program<br><br>2984 colonoscopies<br><br>30 days post-procedure | All colonoscopies: 10/1000 | Includes:<br>Bleeding<br>Perforation<br>Thromboembolic<br>Infections<br>Re-operations<br>Re-admissions |

| Study | Description | Overall complication rate | Items included |
|---|---|---|---|
| | | | Mortality |
| Rutter, 2014 (82) | Screening program<br><br>130,831 colonoscopies<br><br>69,028 with 1+ polypectomies<br><br>30 days post-procedure | All colonoscopies: 14.2/1000 | Includes:<br>Bleeding<br>Perforation |
| Denis 2013 (83) | Screening program<br><br>10,277 colonoscopies<br><br>30 days post-procedure | All colonoscopies: 10/1000<br><br>With polypectomy: 18.4/1000<br><br>No polypectomy: 2.1/1000 | Includes:<br>Bleeding<br>Perforation<br>Post polypectomy syndrome<br>Abdominal pain<br>Diverticulitis<br>Cardiovascular events<br>Infectious adverse events<br>Acute urinary retention |
| Gupta 2012 (84) | Screening Program<br><br>1200 colonoscopies<br><br>30 days post-procedure | All colonoscopies: 10.8/1000<br><br>With polypectomy: 17.1/1000 (10/583) | Includes:<br>Bleeding<br>Perforation<br>Post polypectomy syndrome |
| **Others** | | | |
| Causada-Calo, 2020 (72) | Population-based retrospective cohort study<br><br>38,069 patients<br><br>30 days post procedure<br><br>Admission or ED visit | All colonoscopies: 34/1000 | Includes:<br>Post-colonoscopy bleeding<br>Bowel perforation<br>Cardiovascular-related admission<br>Non-gastrointestinal malignancy<br>Infection-related admission<br>Colorectal surgery<br>Non-surgically treated CRC<br>Diverticular disease<br>Palliative care<br>Other |
| Hoff, 2017 (79) | Patient reported outcomes | All colonoscopies: 17/1000 | Includes: |

| Study | Description | Overall complication rate | Items included |
|---|---|---|---|
| | 11,248 eligible colonoscopies<br><br>1-day post- procedure | Patient form: 6.7/1000<br>Colonoscopy report: 10.2/1000 | Vasovagal without syncope<br>Syncope<br>Bleeding<br>Perforation<br>Bradycardia<br>Technical failure<br>Abdominal pain with fever<br>Abdominal pain without fever<br>Nausea, unwell<br>Hypoxia<br>Soiling on the way home after colonoscopy<br>Stroke<br>Other events<br>Unspecified |

**Abbreviations**: CRC, colorectal cancer; ER, endoscopic resection; FIT, fecal immunochemical test; FOBT, fecal occult blood testing; NR, not reported; SC, severe complications.

**Table 4.12. Perforation Rate (all colonoscopies) -2 Systematic Reviews, 18 Studies.**

| Study | Description | Perforation rate<br>All colonoscopies | Perforation rate<br>Colonoscopies with polypectomy |
|---|---|---|---|
| Kothari, 2019 (63) | Meta-analysis<br><br>21 Population-level studies: 2001-2017<br>1,152,158 colonoscopies<br><br>29 EMR of polyps ≥20 mm and ESD studies: 2008-2018<br>6529 procedures | Population studies*:<br>All colonoscopies: 21 studies in MA:<br>0.58/1000 (95% CI, 0.57-0.60) $I^2$=0.98 | Population studies*:<br>No association of perforation with polypectomy<br><br>EMR and ESD studies:<br>EMR and ESD: 29 pooled studies: 19/1000<br>ESD perforation: 20 pooled studies: 9/1000 or 11<br>EMR perforation: 12 pooled studies: 60 /1000 or 72 |
| Reumkens, 2016 (4) | 21 studies<br>2001-2015<br><br>Meta-analysis | All colonoscopies: 0.5/1,000 (95% CI 0.6-1.0)<br><br>No significant decline 2001-2010 | All colonoscopies: 0.5/1000 (95% CI 0.6-1.0)<br><br>Post-polypectomy: 0.8/1000 (95% CI 0.6-1.0) |
| **FIT** | | | |
| Benazzato, 2021 (70) | Screening program FIT<br><br>117,881 colonoscopies | All colonoscopies: 0.55/1000<br>No ER: 0.29/1000 | With ER: 0.75/1000 |

| Study | Description | Perforation rate<br>All colonoscopies | Perforation rate<br>Colonoscopies with polypectomy |
|---|---|---|---|
| | 30 days post-procedure | | |
| Tomaszewski, 2021 (66) | Screening program FIT<br><br>96,192 colonoscopies<br>62,647 with polypectomies<br><br>14 days post-procedure | All colonoscopies: 0.6/1000 | Polypectomy related perforations: 0.49/1000 |
| Arana-Arri, 2018 (77) | Screening program<br><br>39,254 colonoscopies<br><br>30 days post-procedure | All colonoscopies: 2.7/1000<br><br>No polypectomy: n=15 (no denominator provided) | With polypectomy: n=91 (no denominator provided) |
| Mikkelsen, 2018 (76) | National screening program<br><br>14,671 colonoscopies<br><br>30 days post-procedure | All colonoscopies: 1.0/1000 | - |
| Tepes, 2017 (78) | National screening program<br><br>13,919 colonoscopies<br><br>NR | All colonoscopies: 0.5/1000 | - |
| **FOBT** | | | |
| Paszat, 2021 (67) | Population-based ColonCancerCheck program<br>FOBT<br><br>121,626 colonoscopies<br>51,310 with polypectomies<br><br>14 days post-procedure | All colonoscopies: 0.5/1000<br><br>Years of perforation rates:<br>2008-2012: 0.6/1000<br>20132017: 0.4/1000 | With polypectomy: 0.7/1000 |
| Vanaclocha-Espi, 2019 (73) | Biennial FOBT screening test<br><br>48,730 colonoscopies<br><br>30 days post-procedure | All colonoscopies: 2.0/1000 | - |
| Derbyshire, 2018 (80) | National screening colonoscopy records<br><br>263,129 colonoscopies<br><br>30 days post-procedure | All colonoscopies: 0.56/1000 | - |

| Study | Description | Perforation rate<br>All colonoscopies | Perforation rate<br>Colonoscopies with polypectomy |
|---|---|---|---|
| | | | |
| Saraste, 2016 (81) | Screening program<br><br>2984 colonoscopies<br><br>30 days post-procedure | All colonoscopies: 1/1000 | With polypectomy: 2.5/1000 |
| Rutter, 2014 (82) | Screening program<br><br>130,831 colonoscopies<br>69028 with 1+ polypectomies<br><br>30 days post-procedure | All colonoscopies: 0.6/1000<br><br>No polypectomy: 0.3/1000 | With polypectomy: 0.9/1000 |
| Denis 2013 (83) | Screening program<br><br>10,277 colonoscopies<br><br>30 days post-procedure | All colonoscopies: 1.0/1000<br><br>Diagnostic: 0.4/1000 | Therapeutic: 1.6/1000 |
| Gupta 2012 (84) | Screening program<br><br>12,002 colonoscopies<br><br>30 days post-procedure | All colonoscopies: 0.8/1000 | - |
| **Other** | | | |
| Kim, 2021 (89) | Retrospective, observational cohort study<br><br>241,094 colonoscopies<br>89,059 polypectomies<br><br>30 days post- procedure | All colonoscopies: 0.04/1000 | With polypectomy: 0.08/1000 |
| Yoshida, 2021 (65) | Insurance claims<br><br>341,852 colonoscopies and<br>123,087 colonoscopies with lesion resection<br><br>7 days post-procedure | Colonoscopies: 0.032/1000 | With polypectomy: 0.333/1000 |
| Causada-Calo, 2020 (72) | Population-based retrospective cohort study<br><br>38,069 patients | All colonoscopies: 0.5/1000 | - |

| Study | Description | Perforation rate<br>All colonoscopies | Perforation rate<br>Colonoscopies with polypectomy |
|---|---|---|---|
| | 30 days post procedure | | |
| Laanani, 2019 (74) | SNIIRAM-PMSI national claims databases in France<br><br>4,088,799 colonoscopies<br><br>5 days post-procedure | All colonoscopies: 0.73 per 1000 | - |
| Hoff, 2017 (79) | Patient reported outcomes<br><br>11,248 eligible colonoscopies<br><br>1-day post-procedure | All colonoscopies: 0.08/1000<br><br>Patient form: 0.08/1000<br>Colonoscopy report: 0/1000 | - |
| **EMR/ESD** | | | |
| Amato, 2019 (75)<br><br>Large colorectal lesions ≥ 2 cm | Prospective, multicentre, observational study<br><br>1504 patients | - | Polypectomy/EMR/ESD: 10/1000 (1%) |

**Abbreviations:** CI, confidence interval; EMR, endoscopic mucosal resections; ESD, endoscopic submucosal dissection; FIT, fecal immunochemical test; FOBT, fecal occult blood testing; MA, meta-analysis; NR, not reported; SR, systematic review.
*: Might have included EMR/ESD but not specific to EMR and/or ESD only.

## Table 4.13. Bleeding Rate -3 Systematic Reviews, 17 Studies.

| Study | Description | Bleeding Rate | Bleeding Rate with Polypectomy |
|---|---|---|---|
| Kothari, 2019 (63) | Meta-analysis<br>21 Population studies: 2001-2017<br><br>29 EMR of polyps ≥20 mm and ESD studies: 2008-2018<br><br>Delayed bleeding= after procedure and up to 30 days post-procedure | Population studies:<br>All colonoscopies: 15 pooled studies: 2.4/1000 (95% CI, 2.4-2.5) I2=0.66<br><br>Association with polypectomy: 2.7% increase in risk of bleeding for every 1% increase in rate of polypectomy (p<0.001). | EMR and ESD studies:<br>EMR and ESD: 27 pooled studies: 37/1000<br>ESD delayed bleeding: 11 pooled studies: 22/1000*<br>EMR delayed bleeding: 19 pooled studies: 40/1000*<br>*Not significantly different between EMR and ESD |
| Reumkens, 2016 (4) | 21 studies<br>2001-2015<br><br>Meta-analysis | All colonoscopies: 16 pooled studies: 2.6/1000<br><br>No polypectomy: 11 pooled studies: 0.6/1000 | With polypectomy: 14 pooled studies: 9.8/1000 |

| Study | Description | Bleeding Rate | Bleeding Rate with Polypectomy |
|---|---|---|---|
| | | Declined from 2001: 6.4/1000 to 2010: 1.0/1,000, p=0.07 | |
| Jaruvongvanich, 2017 (62) | Meta-analysis for post-polypectomy<br><br>12 studies included with 14,313 patients | - | Colonoscopies with polypectomy: 12 studies: 15/1000 |
| **FIT** | | | |
| Benazzato, 2021 (70) | Regional screening program<br>Abnormal FIT (84%),<br><br>117,881 colonoscopies<br><br>ER in 56.5% of colonoscopies<br><br>30 days post-procedure | All colonoscopies: 2.38/1000<br>No polypectomy: 0.68/1000 | With polypectomy: 3.69/1000 |
| Tomaszewski, 2021 (66) | Screening program FIT<br><br>96,192 colonoscopies<br>62,647 with polypectomies<br><br>14 days post-procedure | All colonoscopies: 2.6/1000 (95% CI 2.2–3) | - |
| Arana-Arri, 2018 (77) | Screening program<br><br>39,254 colonoscopies<br><br>30 days post-procedure | All colonoscopies: 6.2/1000<br><br>No polypectomy: n=3 (no denominator provided) | With polypectomy: n=242 (no denominator provided) |
| Mikkelsen, 2018 (76) | National screening program<br><br>14,671 colonoscopies<br><br>14 days post-procedure | All colonoscopies: 4.1/1000 | - |
| Tepes, 2017 (78) | National screening program<br><br>13,919 colonoscopies<br><br>NR | All colonoscopies: 0.3/1000 | - |
| **FOBT** | | | |

| Study | Description | Bleeding Rate | Bleeding Rate with Polypectomy |
|---|---|---|---|
| Paszat, 2021 (67) | Population-based ColonCancerCheck program<br><br>121,626 colonoscopies<br>51,310 with polypectomies<br><br>14 days post-procedure | - | Colonoscopies with ≥1 polypectomy: 4.3/1000<br><br>Years of bleeding rates:<br>2008-2012: 4.4/1000<br>20132017: 4.2/1000 |
| Vanaclocha-Espi, 2019 (73) | Biennial FOBT screening test<br><br>48,730 colonoscopies<br><br>30 days post-procedure | All colonoscopies: 1.3/1000 | - |
| Saraste, 2016 (81) | Screening program<br><br>2984 colonoscopies<br><br>30 days post-procedure | All colonoscopies: 6.0/1000 (Table 1 -18/2984) | With polypectomy: 14/1000 |
| Rutter, 2014 (82) | Screening program<br><br>130,831 colonoscopies<br>69,028 with 1+ polypectomies<br><br>30 days post-procedure | All colonoscopies: 6.5/1000<br>No polypectomy: 1/1000 | With polypectomy: 11.4/1000 |
| Denis 2013 (83) | Screening program<br><br>10,277 colonoscopies<br><br>30 days post-procedure | All colonoscopies: 3.0/1000<br>No polypectomy: 0/1000 | With polypectomy: 6.2/1000 |
| Gupta 2012 (84) | Screening program<br><br>1202 colonoscopies<br><br>30 days post-procedure | All colonoscopies: 6.6/1000 | With polypectomy: 13.7/1000 (8/583) (pg. 169) |
| **Others** | | | |
| Kim, 2021 (89) | Retrospective, observational cohort study<br><br>2012 to 2017<br><br>241,094 colonoscopies<br>89,059 polypectomies | All colonoscopies: 0.51/1000 | With polypectomy: 0.73/1000 |

| Study | Description | Bleeding Rate | Bleeding Rate with Polypectomy |
|---|---|---|---|
| | 30 days post-procedure | | |
| Yoshida, 2021 (65) | Insurance claims<br><br>341,852 colonoscopies and 123,087 colonoscopies with lesion resection<br><br>7 days post-procedure | No polypectomy: 0.059/1000 | With polypectomy: 1.36/1000 |
| Causada-Calo, 2020 (72) | Population-based retrospective cohort study<br><br>38,069 patients<br><br>30 days post procedure | All colonoscopies: 4/1000 | - |
| Laanani 2019 (74) | SNIIRAM-PMSI national claims databases in France<br><br>4,088,799 colonoscopies<br><br>5 days and 30 days post-procedure | All colonoscopies: 2.31/1000 | - |
| Hoff, 2017 (79) | Patient-reported outcomes<br><br>11,248 eligible colonoscopies<br><br>1-day post- procedure | All colonoscopies: 2.84/1000<br>Patient form: 0.9/1000<br>Colonoscopy report: 1.8/1000 | - |
| **EMR/ESD** | | | |
| Amato, 2019 (75)<br><br>Large colorectal lesions ≥ 2 cm | Prospective, multicentre, observational study<br><br>1504 patients<br><br>15 days post-procedure | - | Overall: 112/1000<br>Immediate: 85/1000<br>Delayed: 21/1000 |

**Abbreviations:** CI, confidence interval; EMR, endoscopic mucosal resections; ER, endoscopic resection; ESD, endoscopic submucosal dissection; FIT, fecal immunochemical test; SR, systematic review.

**Table 4.14. Mortality Rate Data Table 2 Systematic Reviews, 13 Studies.**

| Study | Description | Mortality Rate* | Ascertainment |
|---|---|---|---|
| Kothari, 2019 (63) | 21 Population-level studies 2001-2017<br>EMR and ESD -2008-2018<br><br>Meta-analysis<br>Number of studies for each outcome<br><br>1,152,158 colonoscopies | Population studies:<br>All colonoscopies: 9 pooled studies: 0.03/1000 | Colonoscopy specific mortality |
| Reumkens, 2016 (4) | 21 studies<br>2001-2015<br><br>Meta-analysis | All colonoscopies: 0.029/1000 (95% CI, 0.011–0.055)<br><br>No significant decline 2001-2010 | Colonoscopy specific mortality |
| **FIT** | | | |
| Benazzato, 2021 (70) | Screening program FIT<br><br>117,881 colonoscopies<br><br>30 days post-procedure<br><br>ER in 56.5% of colonoscopies | All colonoscopies: 0.13/1000<br>With polypectomy: 0.19/1000<br>No polypectomy: 0.039/1000 | Chart review: linked records at 30 hospitals in region (2 reviewers)<br>All-cause |
| Kooyker, 2021 (68) | National Screening Program<br><br>172,797 abnormal FIT that underwent colonoscopy (158,949 without CRC)<br><br>3,532,023 FIT-negatives, no colonoscopy<br><br>30-day post-colonoscopy | 3 methods:<br>1. Fatal complication rate, endoscopist-reported: 0.023/1000 (95% CI, 0.0090-0.06)<br>2. Adj all-cause 30-day mortality for abnormal FIT: 0.32/1000 (0.036%)<br><br>All-cause 30-day mortality for FIT-negatives (ref): 0.23/1000<br><br>Adj 30-day excess death rate (FIT-pos vs. FIT-neg): 0.091/1000 (95% CI, 0.044–0.138)<br><br>3. Colonoscopy-Related Mortality (registry: 0.089/1000 (95% CI, 0.048–0.163) | 3 methods, linked datasets:<br>1. Endo-specific complication registry<br>2. Screening database linked to health records<br>3. Screening database linked to death registry |
| Tomaszewski, 2021 (66) | Screening program FIT<br><br>96,192 colonoscopies | All colonoscopies: 0.03/1000 (95% CI 0.01–0.1) All-cause | Standardized colonoscopy report forms and follow-up forms (latter completed by |

| Study | Description | Mortality Rate* | Ascertainment |
|---|---|---|---|
| | 62,647 with polypectomies<br><br>14 days post-procedure | Colonoscopy specific: 0.013/1000 | trained RNs) and adjudication by quality 115 directors of the BCCSP |
| Arana-Arri, 2018 (77) | Screening program<br><br>39,254 colonoscopies<br><br>30 days post-procedure | No deaths were reported. | Colonoscopy records were reviewed |
| Mikkelsen, 2018 (76) | National screening program<br><br>14,671 colonoscopies<br><br>90 days post-procedure | 0.07/1000 | Chart review of cases identified through hospital admission data<br>Colonoscopy specific |
| **FOBT** | | | |
| Derbyshire, 2018 (80) | National screening colonoscopy records<br><br>263,129 colonoscopies<br><br>30 days post-procedure | 30-day mortality rate:<br>0.87/1000 | Specialist Screening Practitioners enter endoscopy-related data (same day, phone call at 1d, survey at 30d) |
| Saraste, 2016 (81) | Screening program<br><br>2984 colonoscopies<br><br>30 days post-procedure | All colonoscopies: 0.3/1000 | Linked health administrative data with hospital overnight stay<br>All-cause |
| Denis 2013 (83) | Screening program<br><br>10,277 colonoscopies<br><br>30 days post-procedure | 0 | Gastroenterologist reported, postal questionnaires, patient phone calls, colonoscopy reports and hospital charts<br>All-cause |
| Gupta 2012 (84) | Screening Program<br><br>1200 colonoscopies<br><br>30 days post-procedure | 1 death but was post op after CRC resection | Data extraction from screening database and interviews<br>All-cause |
| **Other** | | | |
| Kim, 2021 (89) | Retrospective, observational cohort study<br>2012 to 2017<br>241,094 colonoscopies<br>89,059 polypectomies<br>30 days post-procedure | All colonoscopies: 0.06/1000<br><br>With polypectomy: 0.11/1000 | Linked health administrative databases<br>All-cause |

| Study | Description | Mortality Rate* | Ascertainment |
|---|---|---|---|
| Yoshida, 2021 (65) | Insurance claims<br>341,852 colonoscopies and<br>123,087 colonoscopies with lesion resection<br>7 days post-procedure | With polypectomy: 0.0081/1000 (95% CI 0-0.035) (n=1)<br><br>No polypectomy: 0.0029/1000 (95% CI 0-0.012) (n=1) | Extracted data from the health insurance database<br>All-cause |
| Causada-Calo, 2020 (72) | Population-based retrospective cohort study<br><br>38,069 patients<br>27,831 colonoscopies<br><br>30 days post-procedure | All colonoscopies: 1/1000 | Extracted data from the health insurance database<br>All-cause |
| Kobiela, 2020 (71) | Case control study<br>Screening program<br><br>338,477 colonoscopy group<br>342,027 unscreened controls<br><br>30 days after post-procedure | All colonoscopies:<br>Screened: 1/1000<br>Control: 0.9/1000, p=0.551 | Emergency admissions were categorized by 3 specialist medical doctors<br>All-cause |
| Laanani 2019 (74) | SNIIRAM-PMSI national claims databases in France<br><br>4,088,799 colonoscopies<br><br>30 days post-procedure | 30-day mortality rate:<br>13.2/1000 post-colonoscopy bleeds<br>29.2/1000 perforations<br>36.1/1000 splenic injuries | Identified by discharge diagnosis and surgical procedures<br>All-cause |

**Abbreviations:** CI, confidence interval; CRC, colorectal cancer; d, days; EMR, endoscopic mucosal resections; ER, endoscopic resection; ESD, endoscopic submucosal dissection; FIT, fecal immunochemical test; neg, negative; PMSI, French National Hospital Discharge Database; pos, positive; SNIIRAAM, French National Health Insurance Claims Information System; SR, systematic review.
*Assume a 30-day post-procedure mortality rate unless otherwise specified.
Kooyker definitions:
Fatal complication rate: endoscopist-reported fatal colonoscopy-related complications within 30 days after colonoscopy divided by the number of abnormal FIT that underwent colonoscopy
Excess death rate: difference in all-cause 30-day mortality rate between abnormal FIT undergoing colonoscopy and a reference population not undergoing colonoscopy normal FIT
Colonoscopy-Related Mortality Based on Causes of Death: Number of causes of death that were likely to be colonoscopy related divided by the number of abnormal FIT undergoing colonoscopy.

## Table 4.15 Unplanned Admissions Rate Data Table -7 studies.

| Study | Description | Unplanned admissions |
|---|---|---|
| **FIT** | | |
| Benazzato, 2021 (70) | Regional screening program<br><br>117,881 colonoscopies in a | For unknown cause only:<br>All colonoscopies: 0.5/1000<br>With ER: 0.87/1000 |

| Study | Description | Unplanned admissions |
|---|---|---|
| | ER in 56.5% of colonoscopies<br><br>30 days post-procedure | No ER: 0.02/1000 |
| **FOBT** | | |
| Vanaclocha-Espi, 2019 (73) | Biennial FOBT screening test<br><br>48,730 colonoscopies<br><br>30 days post-procedure | Serious adverse events requiring hospitalization:<br>3.3/1000<br><br>Not all admissions |
| Saraste, 2016 (81) | Screening program<br><br>2984 colonoscopies<br><br>30 days post-procedure | All admissions: 3.6/1000 |
| Denis 2013 (83) | Screening program<br><br>10,277 colonoscopies<br><br>30 days post-procedure | Serious adverse events admissions: 9.5/1000 |
| **Other** | | |
| Causada-Calo, 2020 (72) | Population-based retrospective cohort study<br><br>38,069 patients<br><br>30 days post procedure | ED visit or all admission: 34/1000 |
| Kobiela, 2020 (71) | Screening program<br>Case control study<br><br>338,477 colonoscopy group<br>342,027 unscreened controls<br><br>30 days post procedure | All admissions<br>Rate after colonoscopy:<br>Screened: 0.11/1000<br>Control: 0.10/1000, p<0.001 |
| Hoff, 2017 (79) | Patient reported outcomes<br><br>11,248 eligible colonoscopies<br><br>1-day post- procedure | All admissions:<br>All colonoscopies:<br>According to patient report: 1.3/1000<br>According to colonoscopy report: 0.3/1000 |

**Abbreviations:** ED, emergency department; ER, endoscopic resection; FIT, fecal immunochemical test; FOBT, fecal occult blood testing.

**Table 4.16. Patient Comfort and Pain with Procedure.**

| Study and Scale | Participants | Objective /methods | Description | Validation |
|---|---|---|---|---|
| **Development and Validation** | | | | |
| Forbes, 2021 (91)<br><br>**PRO-STEP**<br><br>Patient-Reported Scale for Tolerability of Endoscopic Procedures<br><br>Patient completes before discharge | 255 patients<br>91 COL<br>73 EGD<br>91 ERCP<br><br>Patients under conscious sedation | To design and validate PRO-STEP specifically assessing the tolerability of endoscopic procedures performed under conscious sedation and to examine predictors of inferior tolerability.<br><br>Methods:<br>1. Literature review to identify domains and inform questions<br>2. Draft of PRO-STEP was circulated for feedback by endoscopist, nurses and patients<br>3. Assessed PRO-STEP internal consistency using Cronbach's α | 6 questions in 2 domains<br>• Domain 1 -intraprocedural<br>  ○ 2 questions on discomfort/pain and awareness (Likert scale 1-10, higher score= higher pain/awareness)<br>• Domain 2 -post procedural<br>• 4 questions: pain, nausea, distention, either throat or anal pain (Likert scale 1-10, higher scores=higher pain/awareness) | Reliability: Internal consistency<br>• Intradomain consistency for (Cronbach's α):<br>  ○ Domain 1 (intraprocedural): acceptable 0.71 (95% CI, 0.62-0.78)<br>  ○ Domain 2 (post procedural): poor 0.29 (95% CI, 0.04-0.55)<br>• Interdomain consistency:<br>  ○ Intra vs. post procedure pain: poor 0.18 (95% CI, 0.01-0.34)<br><br>Predictors of awareness:<br>• Increasing use of midazolam (per 1mg) was associated with lower intraprocedural awareness AOR, 0.23 (95% CI, 0.09-0.54) for scores of 7 or higher and AOR, 0.43 (95% CI, 0.25-0.75) for score of 3 or higher<br>• Increasing use of fentanyl (by 25 µg) was associated with a higher awareness score of 7 or more (AOR, 3.03; 95% CI, 1.11–8.34)<br>• Criterion/construct validity not tested |
| Telford, 2020 (13)<br><br>**SPECS**<br><br>St. Paul's Endoscopy Comfort Scale<br><br>Completed by an observer or nurse during colonoscopy | Single centre consecutive 350 subjects getting COL June-August 2014<br><br>Tailored for colonoscopy with mild or moderate sedation | To develop and validate a pain assessment tool based on objective behavioural cues tailored to outpatients undergoing COL<br><br>Methods:<br>1. Developed through review of other scales with input from physicians and nurses<br>2. The following scales were completed during or after COL by:<br>  ○ SPECS: endoscopist, nurse, research asst<br>  ○ MGCS: endoscopist, nurse, research asst<br>  ○ NAPCOMS: Observer (Research asst) | The nurse (or observer) judged these areas:<br>• Three questions/areas:<br>  ○ **Vocalization**: frequency signs of whimpering, moaning, grunting, or vocalized pain complaint (1->10) =score (0-3)<br>  ○ **Positioning/body language:** frequency: signs of tensing/guarding due to pain/clutching/leg movements (1->10) =score (0-3)<br>  ○ **Patient anxiety/emotion:** frequency (level: none, slightly agitated, upset and | Reliability: Interobserver<br>• The mean total SPECS scores for the physician, nurse and research assistant were 2.1 (SD 2.0), 2.2 (SD 2.2) and 2.5 (SD 2.2), respectively.<br>• The SPECS: excellent inter-rater reliability among all three raters (see above), ICC of 0.81 (95% CI, 0.78–0.84)<br>• The MGCS excellent inter-rater reliability among all three raters, ICC of 0.77 (95% CI, 0.73–0.80)<br>• Patient self-reported VAS showed mild to moderate correlation with SPECS (ρ=0.53), GCS (ρ=0.50), NPAT (ρ=0.47) and NAPCOMS (ρ=0.49), using the observers' scores for each subject. Significance was not reported. |

| Study and Scale | Participants | Objective /methods | Description | Validation |
|---|---|---|---|---|
| | | ○ NPAT: Observer (Research asst)<br>○ RASS: Observer (Research asst)<br>○ mGHAA -patient 30 min after COL<br>○ VAS for pain-patient 30 min after COL<br>Similar number of procedures were evaluated by 9 physicians, 15 nurses and 4 observers.<br>3. Measured inter-rater reliability of SPECS and MGCS using ICC<br>4. Measured correlation between SPECS and patient VAS using Spearmans's correlation<br>5. Repeated #4 for other measures | can be calmed down or upset and can't be calmed down) =score (0-3)<br>○ **Total score** /9 | |
| Rostom, 2013 (93)<br><br>**NAPCOMS**<br><br>Nurse-Assisted Patient Comfort Score<br><br>Nurse completes during procedure | 300 consecutive patients having colonoscopy in 2 screening and surveillance programs (3 hospitals)<br><br>Minimal to moderate sedation | To develop and validate the Nurse-Assessed Patient Comfort Score<br><br>Methods:<br>1. Based on Modified GCS<br>2. Literature review<br>3. 7 endoscopists and 4 nurses on Delphi panel to identify important comfort elements which was similar to the GCS. The items were voted on and if 80% agreed the item was added. The scale was modified based on feedback and voted on again.<br>4. Nurses completed the NAPCOMS; patients completed a visual 4-point Likert scale and the NHS GRS; endoscopists completed a visual 4-point Likert scale to rate patient comfort | • 3 Domains:<br>○ **Pain** (with 3 sub sections):<br>• intensity, (score 0-3; none-severe)<br>• frequency, (score 0-3; none-frequent >4 episodes)<br>• duration (score 0-3; none->1 min)<br>• total pain score (out of 9)<br>○ **Sedation**: level of consciousness (score 0-3; alert-unresponsive)<br>○ **Global:** tolerability (score 0-3; very well to poorly tolerated)<br>• Results in three scores | Reliability: Interobserver<br>• Overall NAPCOMS score between 2 nurses: very good, ICC=0.84 (95% CI, 0.80-0.87)<br><br>Criterion Validity<br>• NAPCOMS and endoscopist ratings of comfort: ICC=0.77; 95% CI, 0.72-0.81)<br>• NAPCOMS and patient ratings of comfort: ICC=0.61; 95% CI, 0.53-0.67 |

**Abbreviations:** AOR, adjusted odds ratio; Asst, assistant; CI, confidence interval; COL, colonoscopy; EGD, esophagogastroduodenoscopy; ERCP, endoscopic retrograde cholangiopancreatography; GCS, Gloucester comfort scale; ICC, intraclass coefficient; ICU, intensive care unit; MGCS, Modified Gloucester Comfort

scale; mGHAA, modified Group Health Association of America Patient Satisfaction Survey; NAPCOMS, nurse-assessed patient comfort score; NHS GRS, National Health Service Global Rating Scales; NPAT, nonverbal pain assessment tool; PRO-STEP, patient-reported scale for tolerability of endoscopic procedures; RASS, Richmond agitation sedation scale; SPECS, St. Paul's Endoscopy Comfort Scale; UK, United Kingdom; VAS, visual analogue scale.

**Table 4.17. Patient Satisfaction with Whole Process/Visit -4 Scales, 6 Studies.**

| Study and Scale | Participants | Objective /methods | Description | Validation |
|---|---|---|---|---|
| **Development and Validation** | | | | |
| Kutyla, 2022 (96)<br><br>**CEST**<br><br>Development and Validation of a Patient-Reported Experience Measure for Gastrointestinal Endoscopy The Comprehensive Endoscopy Satisfaction Tool (CEST) | The CEST was distributed between October 2016 and April 2021 to 7800 patients aged above 18 years who had attended the Department of Gastroenterology and Hepatology at the Princess Alexandra Hospital, a large tertiary hospital, for an outpatient endoscopic procedure | Item generation<br>developed by a team of medical practitioners, a quality and safety manager, and a clinical scientist in close collaboration with patients. After an environmental scan (including a review of current services, perceived patient needs, and service gaps) and a literature review, 6 randomly selected patients were interviewed in a focus group session regarding their experience of a recently conducted endoscopic procedure. a draft questionnaire was developed, which contained 40 satisfaction questions and open-ended questions after more stakeholder input reduced to 30 questions | The questionnaire had 30 satisfaction questions across 4 domains,<br>Preprocedure -8 questions<br>Peri procedure -6 questions<br>Facilities -8 questions<br>Post procedure – 8 questions<br>Overall -2 questions<br>Demographic details -14 questions<br>Comments<br><br>Using a scale from 1 to 7, with 1 being "very poor" and 7 being "excellent" | • Confirmatory factor analysis showed an internal consistency of the items within each factor: Cronbach α > 0.80<br><br>• A linear regression analysis of domain sub scores showed the preprocedure (ß=0.330; SE = 0.086) and peri procedure (ß=0.342; SE =0.104) experiences were more strongly related to the overall satisfaction rating than the post procedure experience (ß=0.193; SE=0.071) or hospital facilities (ß=0.074; SE= 0.105)<br><br>Patient satisfaction was significantly higher in older patients (r=0.161; p<0.001) but not in any other factors (nationality, marital status, education level, or employment status) |
| Neilson, 2021 (97)<br><br>**ENDOPREM™**<br><br>The Newcastle ENDOPREM™: a validated patient reported experience | Multisite validation and was given to 1650 eligible patients of whom 799 responded (response rate=48.4%). | To develop a patient-reported experience measure (PREM) for GI procedures<br><br>Four Phases<br>Phase 1: semi structured interviews with 35 patients who had recently undergone GI endoscopy or CT colonography identified six overarching themes: anxiety, expectations, information & communication, embarrassment & dignity, choice & control and comfort. | Final Prem:<br>• 10 demographic/patient characteristic questions<br>• 54 patient experience questions (5 levels from strongly agree-strongly disagree)<br>• four explanatory questions for comments | Psychometric properties<br>• Response rate =48.4%<br>• 2 pairs of questions correlated strongly (r >0.8)<br>• 4 questions poorly correlated with any others (r<0.3)<br>• 8 questions, including the four which poorly correlated with any others, had poor corrected item-total correlation (ITC <0.3)<br>• 25 questions had a ceiling effect (>40% of respondents endorsed the 'best' response). No questions had |

| Study and Scale | Participants | Objective /methods | Description | Validation |
|---|---|---|---|---|
| measure for gastrointestinal endoscopy | | Phase 2: Informed by the qualitative interviews and a focused literature review, a question bank was generated. Cognitive interviews with patients who had attended for GI endoscopy or CTC were invited to complete the PREM which refined questionnaire items and response options. Psychometric properties were investigated<br>Phase 3: the PREM was distributed to 1650 patients with 799 completing (48%). Psychometric properties were found to be robust.<br>Phase 4: final questionnaire refined including 54 questions assessing patient experience across five temporal procedural stages. | | floor effects (>40% choosing the 'worst' option). |
| Brotons, 2019 (90)<br><br>**CSSQP**<br><br>The Colonoscopy Satisfaction and Safety Questionnaire for Colorectal Cancer Screening: A Development and Validation Study<br><br>Patient completes at home the day after the colonoscopy | 505 patients having screening colonoscopy after an abnormal fecal occult blood test from 2 hospitals in Spain were invited to complete the questionnaire for validation. 378 completed with 370 valid responses (Tier 2 analysis)<br><br>All patients were sedated with Propofol | The aim of this study was to design a new valid and reliable tool for measuring patient experiences, including satisfaction and safety perception, after a colorectal cancer screening colonoscopy after an abnormal fecal occult blood test.<br><br>Methods:<br>Tier 1: Design, face and content validity<br>1. A systematic literature review was carried out to identify factors associated with positive experiences and perception of safety and item generation; (SR and consultation with experts)<br>2. Three focus groups involving physicians (n=4), nurses (n=3), and patients (n=14) were conducted to explore the dimensions of quality and safety relevant for patients. In addition, | The final version has 3 sections:<br>• A satisfaction scale, with 13 items on satisfaction regarding: information, care and service environment and facilities (scale 1-5),<br>• A perceived safety scale, with two items; (yes/no) and<br>• A space to include additional comments. | Metric Properties<br>• Floor and ceiling effects were not identified to eliminate any of the elements in either the satisfaction or the perceived safety questionnaire.<br>• Two items were excluded due to low item-total correlation (<0.5)<br><br>Reliability: internal consistency<br>• A value greater than 0.70 was considered acceptable for all statistics<br>• Cronbach's α was 0.86<br>• Split-half readability: Spearman-Brown coefficient was 0.85<br><br>Construct validity<br>• Eigenvalues greater than 0.40 and factor loading greater than 0.5 were considered to represent an acceptable level of missing data.<br>• The principal components analysis of the satisfaction items isolated three |

| Study and Scale | Participants | Objective /methods | Description | Validation |
|---|---|---|---|---|
| and return via mail | | a patient readability group (n=15) was used to assess face validity.<br>Tier 2: Validation<br>Metric properties of the items (floor, ceiling and inter-item correlation), reliability, construct and criterion validity analysis<br>Tier 3: Translation from Spanish to English | | factors that explained 64% of the variance with saturation of elements above 0.52 and with high internal consistency and split-half readability: Information, Care, and Service and Facilities features<br>• The analysis of the safety items isolated two factors with element saturations above 0.58: Information Gaps and Safety Incidents. Kendall coefficient of concordance was 0.71 reflecting coherent differences between patients suffering safety incidents and patients without safety incidents<br><br>Criterion validity:<br>• Linear regression was used to estimate the predictive capacity of the CSSQP scores. The variables "wait time", "overall satisfaction", and "occurrence of complications" were used as external control variables for this analysis<br>• Predictive/empirical validity<br><br>Overall Satisfaction:<br>• Information: ß=0.30 (0.18–0.41), p=0.000<br>• Care: ß=0.52 (0.40–0.65), p=0.000<br>• Service Environment and Facilities: ß=0.08 (-0.01–0.17), p=0.054 |
| Veldhuijzen, 2020 (14)<br><br>**D-GESQ**<br><br>Patient completes 30 days after | 227 of 1065 patients after endoscopy completed response rate of 21.3%<br><br>No level of sedation reported but patients undergoing | To translate and validate the GESQ in a Dutch endoscopic population<br><br>Methods:<br>1. Translation: To Dutch using backward-forward method. Used think aloud method to test whether Dutch questions were | The exploratory factor analysis showed the 21 questions could best be clustered into five clusters instead of four in the original GESQ<br>• Information before endoscopy<br>• Information after endoscopy | Translation: Made 2 small word changes<br><br>Reliability: internal consistency<br>• Overall, there was high internal consistency (Cronbach α=0.88)<br>• Subscales also had a high internal consistency except for the hospital subscale. A Cronbach's α between 0.7 |

| Study and Scale | Participants | Objective /methods | Description | Validation |
|---|---|---|---|---|
| procedure via email with link to online computer-based education platform | Propofol sedation were excluded | interpreted correctly (n=17 patients).<br>2. Validation using confirmatory factor analysis to confirm four factor model. Conducted exploratory factor analysis to test internal consistency. | • Pain and discomfort during or after endoscopy<br>• Skills and satisfaction<br>• Hospital | and 0.95 was accepted for internal consistency<br>○ Information before endoscopy α=0.848,<br>○ Skills and satisfaction α=0.868,<br>○ Pain or discomfort α=0.831,<br>○ information after endoscopy α=0.724<br>○ Hospital α=0.449 |
| Yoon, 2018 (98)<br><br>**K-GESQ**<br><br>Patient Satisfaction Gastrointestinal Korean-Endoscopy Satisfaction Questionnaire<br><br>Patient completes in endoscopy centre | 350 consecutive patients after gastrointestinal endoscopy at Kyung Hee University Hospital between March and July 2016<br><br>94.3% of participants underwent endoscopy under sedation (amount or type not reported) | To translate and validate the GESQ in Korea and identify predictors for patient satisfaction during gastrointestinal endoscopy<br><br>Methods:<br>1. Translation: To Korean using forward and back translation method<br>2. Conversion of scores: converted the negative status of all component items to 1 and positives to 5 for analyzing and validating the GESQ, also 3-point Likert scales (1,3,5) and binary questions (1 or 5)<br>3. Validation:<br>a. Content validity was determined for the areas measured by each test item. A correlation matrix was calculated to identify redundant or irrelevant items<br>b. Structural validity was demonstrated with confirmatory factory analysis<br>c. Construct validity was assessed through convergent and discriminant validity<br>d. Internal consistency for verifying reliability was tested by | (See below for description) | Reliability: internal consistency<br>• Internal consistency was acceptable overall (Cronbach α=0.87)<br>• The Cronbach α for each subcategory ranged from 0.72 to 0.82 which met the threshold criterion range<br>• Exploratory and confirmatory factor analyzes reconfirmed that 4 factors were extracted from the K-GESQ.<br><br>Criterion Validity:<br>• Convergent validity: correlation coefficient between the K-GESQ and 5-point Likert satisfaction scale was 0.513 (p<.001)<br>• Pearson correlation coefficients between domains were all comparatively low (<0.70) and revealed that the 4 subscales consisting of 21 items were not collinear, suggesting separate satisfaction scales |

| Study and Scale | Participants | Objective /methods | Description | Validation |
|---|---|---|---|---|
| | | calculating corrected item-total correlations | | |
| Hutchings, 2015 (95)<br><br>**GESQ**<br><br>Development and validation of the Gastrointestinal Endoscopy Satisfaction Questionnaire<br><br>Patient completes 1 day after endoscopy and returns via mail<br><br>(Reminders sent at 2 and 4 weeks) | 1. 207 endoscopy patients who participated in the initial validation<br>2. 1782 patients from MINuET RCT comparing flex sig to upper GI endoscopy<br><br>86.2% response rate<br><br>Level of sedation not reported | To develop a valid and reliable instrument and to measure patients' cognitive and emotional response to their experience of endoscopy<br><br>Method:<br>1. Item generation; (via SR and consultation with experts)<br>2. Initial validation using the questionnaires and 3 open-ended questions regarding difficulty in understanding or answering and other comments. Plus 20 patients in semi-structured interviews. (To identify ambiguity or missing items, face, and content validity)<br>3. Main study of validation occurred in a large multicentre trial. The principle component analysis was applied to questionnaire data and the internal consistency of the GESQ was assessed by examining each item and calculating total correlations and Cronbach's α | 21 items from 4 subscales<br>• Skills and hospital (7 items) (5-1, very poor -very good)<br>• Pain and discomfort during and after endoscopy (4 items) (5-1, none-severe)<br>• Information before endoscopy (5 items; 5-1)<br>• Information after endoscopy (5 items; 0-3 or 5-1)<br><br>Scoring:<br>• Scoring 5 is the worst, yes=1, no=5.<br>• Summing responses in that subscale and dividing by # responses<br>• Then transform the component scores to the range 0–100 using the formula: ([score-lowest possible/score range] × 100). | Reliability: internal consistency<br><br>Principal components analysis revealed four subscales all with high internal consistency:<br>• Skills and hospital (seven items; Cronbach α=0.83)<br>• Pain and discomfort during and after endoscopy (four items; Cronbach α=0.84)<br>• Information before endoscopy (five items; Cronbach α=0.80)<br>• Information after endoscopy (five items; Cronbach α=0.76) |

**Abbreviations:** CSSQP, Colonoscopy Satisfaction and Safety Questionnaire based on patients' experiences; D-GESQ, Dutch gastrointestinal endoscopy satisfaction questionnaire; GESQ, gastrointestinal endoscopy satisfaction questionnaire; GI, gastrointestinal; K-GESQ, Korean gastrointestinal endoscopy satisfaction questionnaire; MINuET, multi-institution nurse endoscopy trial; RCT, randomized controlled trial; SR, systematic review.

## Table 4.18. Study Characteristics ADR and PDR – 26 studies.

| Study | Design/ Study period/ Jurisdiction | Data Source | Ascertainment | Number of Patients/ Colonoscopies/ endoscopists | Indication for Colonoscopy | Age of Inclusion | Aims | Outcomes |
|---|---|---|---|---|---|---|---|---|
| Zessner-Spitzenberg, 2023 (111)<br><br>Austria | Retrospective cohort<br><br>Multi-centre | Austrian Society of Gastroenterology and Hepatology, the Austrian | Extracted data from linked databases | 229 729 COL<br><br>308 endoscopists | Screening colonoscopy | ≥ 50 years<br><br>Median: 59.9 years (IQR, 54.1-67.7) | To investigate the correlation between ADR and PSPDR at screening colonoscopy and association with PCCRC mortality | ADR<br>PSPDR<br>PCCRC |

| Study | Design/ Study period/ Jurisdiction | Data Source | Ascertainment | Number of Patients/ Colonoscopies/ endoscopists | Indication for Colonoscopy | Age of Inclusion | Aims | Outcomes |
|---|---|---|---|---|---|---|---|---|
| | January 2013-December 2020 | Cancer Aid, and the Austrian Federation of Statutory Insurance Institutions database | | | | | | |
| Zorzi 2023 (112)<br><br>Italy | Retrospective cohort<br><br>Multi centre<br><br>January 2003-December 2017 | Regional individual identification code linked with the database of the regional tumor registry, the regional database of pathology records, and hospital discharge records | Extracted data from linked databases | 49,626 COL<br><br>113 endoscopists | Abnormal FIT | 50-69 years<br><br>Mean: 59.7 years | To examine the association between ADR and post colonoscopy CRC (PCCRC) risk in a FIT-based screening program. | ADR<br>PCCRC<br>Interval CRC |
| Schottinger, 2022 (126)<br><br>USA | Retrospective cohort<br><br>Multi-centre<br><br>January 2011-December 2017 | Clinical and administrative databases; California and Washington State cancer registries | Manually validated methods including systematized nomenclature of medicine (SNOMED) coding in electronic pathology databases (KPNC and KPSC) and natural | 852,624 COL<br><br>383 endoscopists | Screening colonoscopy | 50-75 years<br><br>Median: 61.4 (IQR, 55.5-67.2) | To investigate the relationship between physician ADR and the risks of PCCRC and related deaths across multiple regions in large community-based populations with reliable pathologic review and cancer diagnosis | ADR<br>PCCRC |

| Study | Design/ Study period/ Jurisdiction | Data Source | Ascertainment | Number of Patients/ Colonoscopies/ endoscopists | Indication for Colonoscopy | Age of Inclusion | Aims | Outcomes |
|---|---|---|---|---|---|---|---|---|
| | | | language processing of pathology reports (KPWA) | | | | | |
| Schwarz, 2022 (108)<br><br>Germany | Retrospective cohort<br><br>Multi-centre<br><br>January 2008-December 2017 | German Pharmacoepidemiological Research Database | Extracted data from databases | 822 715 patients<br><br>1752 physicians | Screening and diagnostic colonoscopies | ≥ 55 years<br><br>Mean: 65.4 (SD=7.8) | To assess whether the cumulative incidence of PCCRC in persons undergoing colonoscopy in Germany differs according to their physician's PDR | PDR<br>CRC |
| van Toledo, 2022 (109)<br><br>Netherlands | Retrospective cohort<br><br>Multi-centre<br><br>January 2014-December 2020 | Centralised database called ScreenIT and the Netherlands Cancer Registry | Extracted data from databases | 277 555 COL<br><br>441 endoscopists | Abnormal FIT | 55-76 years<br><br>Median: 68 years (IQR, 63-72) | To evaluate the association between PSPDR and PCCRC | ADR<br>SPDR<br>PSPDR<br>PCCRC |
| Wisse, 2022 (110)<br><br>Nederland | Retrospective cohort<br><br>Multicentre (national)<br><br>2014-2016 | National central database | CRC screening program and Dutch cancer registry | 103,900 COL<br><br>311 endoscopists | Abnormal FIT | 55-75 years<br><br>Screening mean: 67 years (range: 63-70)<br><br>PCCRC mean: 67 years (range: 65-75) | To assess the association between ADR and interval PCCRC | ADR<br>PCCRC<br>HRADR<br>APP (MAP)<br>APP+<br>PRR |
| Aniwan, 2021 (100)<br><br>Thailand | Retrospective cohort<br><br>Single centre<br><br>Jan 2007 - June 2018 | Center of Excellence for Gastrointestinal Endoscopy, King | Extracted data from hospital database | 7339 COL<br><br>73 endoscopists | Screening | 50 – 75 years<br><br>Mean: 61.7 years (SD=7.3) | To evaluate the usefulness of the APP value in identifying more meticulous endoscopists, who can detect greater numbers of advanced and proximal adenomas. | APP<br>ADR |

| Study | Design/ Study period/ Jurisdiction | Data Source | Ascertainment | Number of Patients/ Colonoscopies/ endoscopists | Indication for Colonoscopy | Age of Inclusion | Aims | Outcomes |
|---|---|---|---|---|---|---|---|---|
| | | Chulalongkorn Memorial Hospital Database | | | | | Also compared the prevalence of high APP endoscopists among endoscopists with different levels of acceptable ADR. | |
| Gingold-Belfer, 2021 (129)<br><br>Israel | Prospective cohort study<br><br>Single centre<br><br>2003 - 2010 | Clalit Health Services-Rabin Medical Center | Extracted data from national cancer registry | 16 610 COL<br><br>18 endoscopists | Diagnostic | ≥50 years<br><br>Median: 64 years (IQR= 57–62) | To evaluate whether PDR is associated with PCCRC in the context of diagnostic colonoscopy. | PDR<br>ADR |
| Han, 2021 (102)<br><br>Korea | Prospective cross-sectional study<br><br>Multicentre<br><br>July 2018 – June 2020 | Soonchunh-yang University | 2nd colonoscopy | 742 COL<br><br>8 endoscopists | Screening | 50 – 75 years<br><br>Mean: 58.5 years (SD=7.4) | To investigate whether the ADR and surrogate quality indicators reflect the AMR when performing qualified colonoscopy. | ADR<br>PDR<br>APC<br>ADR-P<br>APP<br>AMR |
| Kaltenbach, 2021 (103)<br><br>USA | Retrospective cohort<br><br>Multicentre<br><br>July 2015 – December 2015 | 2 Veterans Affairs centres (Palo Alto VA and Indiannapolis Roudebush VA) | Extracted patient, procedure, and pathology data from the VA electronic medical record database (VistA/CPRS) | 2628 COL<br><br>21 endoscopists | Screening, surveillance, and diagnostic (patients who reported symptoms before examination and/or screening abnormal FITs) | ≥50 years<br><br>Mean: 63.2 years (SD =10.1) | To determine whether the ADR for all colonoscopies, irrespective of the indication, would be equivalent to the ADR for screening colonoscopies. | ADR |
| Murphy, 2021 (105)<br><br>Ireland | Retrospective cohort study<br><br>Single Centre | Prospectively built database University Hospital Kerry and | Extracted data from colonoscopy report system | 3274 COL<br><br>8 endoscopists | Diagnosis or surveillance | ≥18 years<br><br>NR | To investigate the validity of PDR as a surrogate marker for ADR in an Irish hospital setting. | ADR<br>PDR<br>APDRQ<br>Estimated ADR (PDR x APDRQ) |

| Study | Design/ Study period/ Jurisdiction | Data Source | Ascertainment | Number of Patients/ Colonoscopies/ endoscopists | Indication for Colonoscopy | Age of Inclusion | Aims | Outcomes |
|---|---|---|---|---|---|---|---|---|
| | July 2015 – July 2017 | Institute of Technology Tralee | | | | | | |
| Buerger, 2020 (101)<br><br>Germany | Retrospective cohort study<br><br>Multicentre<br><br>January 2012-December 2016 | Endoscopy reports from the participating centres. | Endoscopy reports from the participating centres. | 4304 individuals | Screening | ≥50 years<br><br>Median: 62 years (IQR 56-69) | To evaluate the estimation of ADR by individualized DRRs in a large multicentre primary colonoscopy screening cohort of average-risk individuals and to translate this concept to SPs and CSSPs. | ADR<br>PDR<br>SP DR<br>CSSDR |
| Leite, 2020 (104)<br><br>Brazil | Retrospective cohort study<br><br>Single centre<br><br>January 2018 - June 2018 | Medical records at Mater Dei Hospital endoscopy service were evaluated | Extracted data from colonoscopy reports | 981 COL<br><br>Number of endoscopists: NR | Screening, surveillance, and diagnosis | ≥50 years<br><br>Screening mean: 60 years (SD=7.2)<br><br>Other mean: 63 years (SD=7.6) | To analyze and compare the difference in ADR and PSPDR between patients undergoing screening colonoscopy and an unselected population with other indications for colonoscopy, including surveillance and diagnosis | ADR<br>PSPDR |
| Park, 2020 (106)<br><br>South Korea | Retrospective cohort study<br><br>Single centre<br><br>May 2013 – December 2016 | Preventive Health Care Center at Kangbuk Samsung Hospital | Extracted data from hospital database | 26,627 COL<br><br>30 endoscopists | Screening or surveillance | NR<br><br>Mean: 55.6 years | To investigate which simpler SDR indicator is most relevant to CSSDR or ADR and provide benchmark data | ADR<br>CSSDR<br>SDR-pathology<br>SDR-size<br>SDR-location |
| Penz, 2020 (107)<br><br>Austria | Retrospective cohort study<br><br>Multicentre<br><br>2007-2010 | Prospectively built database | Extracted data from hospital database | 218,193 COL<br><br>262 endoscopists | Screening | ≥50 years<br><br>Mean: 64.74 years (SD= 9.67) | To investigate whether endoscopists with higher ADRs detect more AAs or if the proportion of more negligible NAAs is raised | ADR<br>HRADR<br>NAADR<br>Endoscopic adverse events |

| Study | Design/ Study period/ Jurisdiction | Data Source | Ascertainment | Number of Patients/ Colonoscopies/ endoscopists | Indication for Colonoscopy | Age of Inclusion | Aims | Outcomes |
|---|---|---|---|---|---|---|---|---|
| Wadhwa 2020 (122)<br><br>USA | Retrospective chart review<br><br>Single centre<br><br>January 1, 2012 -August 31, 2014 | Cleveland Clinic electronic medical records | Chart review | 4158 COL<br><br>32 endoscopists | Screening and surveillance | ≥50 years<br><br>Mean: 60 years (SD= 7.7) | To calculate ADR and HRADR in a large cohort of average risk screening colonoscopy patients and propose HRADR which correlates with current threshold ADR | ADR<br>HRADR |
| Vojtechova, 2020 (121)<br><br>Czech Republic | Prospective cohort study<br><br>Multicentre<br><br>2012-2016 | Preventive Colonoscopy Database | Standardized colonoscopy report forms | 1614 COL<br><br>16 endoscopists | Screening or abnormal FOBT (gFOBT/FIT) | 45–75 years<br><br>Mean: 60.1 years (SD =7.3) | (1) To determine the degree of correlation between the PDR and the ADR to determine the conversion factor to predict the ADR from the PDR in preventative colonoscopies and (2) to compare the two methods used for the calculation of the conversion factor | ADR<br>Conversion factor for ADR from PDR<br>PDR<br>APDRQ |
| Yamaguchi, 2020 (123)<br><br>Japan | Retrospective cohort<br><br>Single centre<br><br>October 2008 - August 2017 | Tokyo Medical University Hachioji Medical Center Database | Extracted data from hospital database | 1513 patients<br>76 with post-colonoscopy CRC<br><br>26 endoscopists | Screening and surveillance | NR<br><br>Mean: 70.94 years (SD =10.45) | To elucidate the association between the clinical characteristics of post-colonoscopy colorectal cancer and quality indicators of colonoscopy | ADR<br>BPQ |
| Gessl, 2019 (116)<br><br>Austria | Retrospective cohort study<br><br>Multicentre<br><br>Jan 1, 2016 - Sept 13, 2017 | Database records from the quality certificate for screening colonoscopy | Extracted data from hospital database | 44,142 COL<br><br>202 endoscopists | Screening | ≥50 years<br><br>Mean 60.2 years (SD= 9.2) | To evaluate APP and APC as new quality parameters in screening colonoscopy. To assess whether these parameters differ depending on the setting or profession. | ADR<br>APC<br>HRADR<br>APP<br><br>Association between ADR and above measures |
| Hilsden, 2019 (117)<br><br>Canada | Historical cohort study<br><br>Multicentre | Endoscopy reporting program endoPRO | Extracted data from database | 13,685 COL<br><br>40 endoscopists (2014) and 31 | Screening (patients with an abnormal | 50-74 years<br><br>NR | To extend methods previously proposed for defining an ADR benchmark for | ADR<br>benchmarks (Minimally Acceptable, |

| Study | Design/ Study period/ Jurisdiction | Data Source | Ascertainment | Number of Patients/ Colonoscopies/ endoscopists | Indication for Colonoscopy | Age of Inclusion | Aims | Outcomes |
|---|---|---|---|---|---|---|---|---|
| | 2014 (year 0) and 2015 (year 1) | (Pentax Medical)<br><br>and<br><br>CCSC Pathology Database | | endoscopists (2015) | FIT were excluded) | | colonoscopies performed on abnormal FIT patients. To show the calculation and behaviour of these benchmarks in two hypothetical examples, and then apply these methods to endoscopists providing screening colonoscopies at a regional colon cancer screening centre in Canada. | Standard of Care, and Aspirational benchmarks) |
| Sastra Lozano, 2019 (128)<br><br>Spain | Observational retrospective study<br><br>Single centre<br><br>January 1st, 2011-December 31st 2014 | Hospital Universitario Santa Lucia | Extracted data from endoscopic reports of colonoscopies performed in Digestive Endoscopy Unit, recorded in the Medical Explorer form<br><br>Extracted data from medical records and Pathology reports obtained from the Selene computer program used by the hospital | 12,482 COL<br><br>14 endoscopists | Screening | ≥18 years<br><br>NR | To evaluate the relationship between the PDR and its influence on post-colonoscopy colorectal cancer rate | PDR<br>PCCRC |
| Murchie, 2018 (118)<br><br>USA | Retrospective and prospective cohort study | Cleveland Clinic Florida database | Extracted data from hospital database | 2203 patients<br><br>14 endoscopists | Screening | NR<br><br>Median age: 55 (51-62) years | To evaluate whether active monitoring affects PDR | ADR<br>PDR<br>APDRQ |

| Study | Design/ Study period/ Jurisdiction | Data Source | Ascertainment | Number of Patients/ Colonoscopies/ endoscopists | Indication for Colonoscopy | Age of Inclusion | Aims | Outcomes |
|---|---|---|---|---|---|---|---|---|
| | Single centre<br><br>September 2014-February 2015 | | | | | | | |
| Tjaden, 2018 (120)<br><br>USA | Retrospective and prospective cohort study<br><br>Multicentre<br><br>Retrospective: 2006 – 2012<br><br>Prospective: 2013 - 2016 | Rush University Medical Center or Rush Oak Park Hospital | Extracted data from colonoscopy and pathology reports | 3031 COL<br><br>15 endoscopists<br><br>119/591 low-quality endoscopist cases for screening ADR<br><br>816/2440 high-quality endoscopist cases for S-ADR | Screening | NR<br><br>Mean: 58.3 years | To describe the strength of association between S-ADR and CRC-ADR and to report CRC-ADR for HQDs<br><br>Endoscopists were dichotomized into those achieving high-quality screening defined by ADR ≥25% vs. low-quality screening defined by ADR <25% in the screening cohort. | ADR<br>CRC-ADR as reported in HQD or LQD |
| Yoon, 2018 (124)<br><br>Korea | Retrospective cohort study<br><br>Multicentre<br><br>February 2006 – March 2012 | Colonoscopy reports from 12 university hospitals in Korea | Extracted data from patient colonoscopy reports | 5272 patients<br><br>Number of endoscopists: NR | Screening | <50 years<br><br>Mean: 43.5 years (SD =4.3) | To investigate a new ADR target for adults below 50 years old. | ADR |
| Abdelfatah 2017 (113)<br><br>USA | Retrospective cohort study<br><br>Single centre<br><br>October 2007 - October 2012 | Electronic health records University Medical Center of El Paso | Electronic database system (Provation, Minneapolis, Minnesota) was used to collect details of the procedure including performing endoscopists, polyp size and number of polyps | 2116 COL<br><br>6 endoscopists | Screening | 50-75 years<br><br>Mean: 58 years (SD= 6) | To determine the correlation between ADR and novel quality indicators | ADR<br>HRADR<br>HRADR-2<br>NAADR<br>APC<br>MDR<br>APP<br>ADR-P |

| Study | Design/ Study period/ Jurisdiction | Data Source | Ascertainment | Number of Patients/ Colonoscopies/ endoscopists | Indication for Colonoscopy | Age of Inclusion | Aims | Outcomes |
|---|---|---|---|---|---|---|---|---|
| Anderson, 2017 (127)<br><br>USA | Prospective cohort study<br><br>Multicentre<br><br>April 2009 to December 2014 | Population-based, statewide registry | Extracted data from hospital database | 45,996 COL<br><br>77 endoscopists | Screening and surveillance | ≥50 years<br><br>Median: 59 (IQR =53-66) | To stratify a large, diverse group of endoscopists into high and low performers based on ADR, and provide data for corresponding target SDR benchmarks | ADR<br>CSSDR<br>PSPDR and PSPDR-SF |
| Cubiella, 2017 (115)<br><br>Spain | Cross-sectional study<br><br>Multicentre<br><br>June 2009 - June 2011 | 8 Spanish regions (Aragon, Basque Country, Canarias, Catalonia, Galicia, Madrid, Murcia and Valencia) with the participation of 15 tertiary hospitals identified through the correspondin g CHR | Screening Diagnostic | 5722 COL<br><br>Number of endoscopists: NR | FIT- ≥75 ng hemoglobin/ ml of buffer solution (≥ 15 µg/g of feces) | 50-69 years<br><br>NR | To determine whether there is a correlation between the ADR in primary and FIT-based screening colonoscopy and, if this correlation does exist, to establish the equivalent figure in FIT-based screening to the well-defined and accepted ADR of 20% in a colonoscopy-based setting | ADR |
| Kaminski, 2017 (3)<br><br>Poland | Prospective cohort study<br><br>Multicentre<br><br>January 1, 2004, to December 31, 2008 | National Colorectal Cancer Screening Program Database | Extracted data from database | 146,860 COL<br><br>294 endoscopists | Screening | 40-66 years<br><br>Mean: 55.7 years (SD=5.4) | To investigate whether increasing ADRs from individual endoscopists is associated with reduced risks of interval colorectal cancer and subsequent death | ADR association with risk of CRC and death |
| Aniwan, 2016 (114) | Cross-sectional study | King Chulalongkor n Memorial | Extracted data from database | 200 patients<br><br>4 endoscopists | Asymptomati c back-to- | 50-75 years | To evaluate other quality indicators plus | Relationship between: ADR |

| Study | Design/ Study period/ Jurisdiction | Data Source | Ascertainment | Number of Patients/ Colonoscopies/ endoscopists | Indication for Colonoscopy | Age of Inclusion | Aims | Outcomes |
|---|---|---|---|---|---|---|---|---|
| Thailand | Single centre<br><br>August 2014–June 2015 | Hospital database | | | back colonoscopy | Mean: 59.8 years (SD=6.5) | ADR vs. ADR alone in prediction of AMR | APP<br>APC<br>ADR-P<br>AMR |
| Park, 2016 (119)<br><br>Korea | Retrospective and prospective cohort study<br><br>Multicentre<br><br>December 2007 - November 2008<br><br>and<br><br>May 2010 - February 2011 | Prospectively collected databases | Extracted data from database | 1 142 patients<br><br>28 endoscopists<br><br>(10 experienced endoscopists + 18 trainees) | Screening | ≥50 years<br><br>Mean: 58.6 years (SD= 7.1) | To investigate the correlation between ADR and APC among endoscopists, and compare the validity of ADR and APC by investigating their correlation with the HRADR | Relationship between:<br>ADR-APC<br>ADR-HRADR<br>APC-HRADR |
| Hilsden, 2016 (99)<br><br>Canada | Historical cohort study<br><br>Single centre<br><br>January 1, 2014 - June 30, 2015 | Alberta Health Services' Colon Cancer Screening Centre database | Extracted data from database | 15 329 patients<br><br>6 colorectal surgeons and 24 endoscopists | Screening or Abnormal FIT | 50-74 years<br><br>NR | To propose methods for establishing a benchmark ADR and APC for abnormal FIT patients | Benchmarks for:<br>ADR<br>APC |

**Abbreviations:** AAs, advanced adenomas; ADR, adenoma detection rate; ADR-P, adenoma detection rate plus; AMR, adenoma miss rate; APDRQ, adenoma to polyp detection rate quotient; APC, adenomas per colonoscopy; APP, adenomas per positive participant; BPQ, bowel preparation quality; CCSC, Colon Cancer Screening Centre; CHR, Community Health Registry; COL, colonoscopies; CPRS, computerized patient record system; CRC, colorectal cancer; CRC-ADR, colorectal cancer adenoma detection rate; CSSP, clinically relevant serrated polyp; CSSDR, clinically significant serrated polyp detection rate; DR, detection rate; DRR, detection rate ratios; FIT, fecal immunochemical test; FOBT, fecal immunochemical test; HQD, high-quality detectors; HR, high risk; HRADR, high-risk adenoma detection rate; IQR, interquartile range; LQD, low-quality detectors; MAP, mean number of adenomas per procedure; MDR, multiplicity detection rate; NAADR, nonadvanced adenoma detection rate; NAAs, non-advanced adenomas; NR, not reported; PCCRC, post-colonoscopy colorectal cancer; PDR, polyp detection rate; PRR, polyp removal rate; PSPDR, proximal serrated polyp detection rate; PSPDR-SF, proximal serrated polyp detection rate, proximal to the

splenic flexure; S-ADR, screening adenoma detection rate; SF, splenic flexure; SD, standard deviation; SDR, serrated detection rate; SP, serrated polyps; USA, the United States of America; VA, veterans affair; vs, versus.

**Table 4.19. ADR Definition, Rates, and Validation: 1 Systematic Review and 23 Studies.**

| Study | Definition | Indication for colonoscopy | Age of Inclusion | ADR | Benchmarking/targeting |
|---|---|---|---|---|---|
| Rees, 2016 SR (39) | ADR was defined as the proportion of colonoscopies where one or more adenomas are detected. | All Colonoscopies | All | - | Minimal ADR should be 15%. Aspirational ADR should be 20%. |
| Zessner-Spitzenberg, 2023 (111)<br><br>Retrospective cohort<br><br>Multicentre<br><br>January 2013-December 2020 | ADR was calculated for each endoscopist the number of colonoscopies with at least one adenoma detected (tubular, villous, tubulovillous) divided by the total number of colonoscopies performed by the endoscopist<br><br>PSPDR was calculated by determining the number of colonoscopies with at least one serrated polyp detected in the proximal colon, either exclusively or in both the proximal and distal segments, divided by the total number of colonoscopies performed by the endoscopist | Screening | ≥ 50 years<br><br>Median: 59.9 years (IQR, 54.1-67.7) | ADR (mean) =23.0 % (SD=10.5%)<br><br>PSPDR (mean) =10.6% (SD=7.95%)<br><br>ADR and PSPDR: r=0.70 95% CI, 0.70-0.71)<br><br>1% increase in ADR associated with 2% point decrease of PCCRC death, HR=0.98, 95%CI, 0.96-0.99, p=0.01)<br><br>1% increase in PSPDR associated with 3% lower PCCRC death, HR=0.97, 95%CI, 0.94-0.99, p=0.01) | None |
| Zorzi, 2023 (112)<br><br>Retrospective cohort<br><br>Multicentre<br><br>January 2003-December 2017 | ADR was defined as the proportion of abnormal FIT colonoscopies done with the finding of at least 1 adenoma or advanced adenoma | Abnormal FIT<br><br>Threshold ≥20 mg of hemoglobin per gram of feces | 50-69 years<br><br>Mean: 59.7 years (SD=6.1) | Mean, 48.3% (range, 23% and 70%)<br><br>Adjusted HR for PCCRC associated with 1% increase in ADR = 0.96 (CI, 0.95 to 0.98)<br><br>Significant inverse association between ADR and PCCRC incidence risk: 2.35- fold risk increase (95% CI, 1.63-3.38) comparing the lowest quintile ADR= 20-39%) with the highest quintile (ADR=55-70%) | None |
| Schottinger, 2022 (126) | ADR was calculated annually and defined as the percentage of screening colonoscopies in which at least 1 adenoma was detected | Screening | 50-75 years | ADR median: 28.3%<br><br>ADR as a continuous measure were significantly associated with lower | None |

| Study | Definition | Indication for colonoscopy | Age of Inclusion | ADR | Benchmarking/targeting |
|---|---|---|---|---|---|
| Retrospective cohort<br><br>Multicentre<br><br>January 2011-December 2017 | | | Median: 61.4 years (IQR, 55.5-67.2) | risks of PCCRC: HR=0.97 per 1% absolute ADR increase (95% CI, 0.96-0.98)<br><br>ADR < 28.3% compared with ADR > 28.3% significantly associated with a lower risk of PCCRC: HR= 0.61 (95% CI, 0.52-0.73)<br><br>Death from PCCRC with 1% absolute ADR increase: HR= 0.95 per (95% CI, 0.92-0.99) | |
| Schwarz, 2022 (108)<br><br>Retrospective cohort<br><br>Multicentre<br><br>January 2008-December 2017 | PDR was calculated by dividing the number of colonoscopies with detected polyps by the number of all colonoscopies conducted by that physician. | Screening and diagnostic colonoscopies | ≥ 55 years<br><br>Mean: 65.4 (SD=7.8) | Median PDR: 29.9%<br>Low quartile:21.8%<br>High quartile: 39.8%<br><br>The cumulative CRC incidence at was statistically significantly higher in persons examined by physicians with a PDR ≤21.8% vs >21.8% for snare polypectomy, forceps polypectomy and no polypectomy groups at 3, 5 and 9 yr follow-up | None |
| van Toledo, 2022 (109)<br><br>Retrospective cohort<br><br>Multicentre<br><br>January 2014-December 2020 | ADR was defined as the proportion of all colonoscopies in which at least one conventional adenoma was detected, confirmed by histopathology<br><br>PSPDR was defined as the proportion of colonoscopies in which at least one serrated polyp proximal to the descending colon was detected, confirmed by histopathology<br><br>SPDR was defined as the proportion of all colonoscopies in which at least one HP, SSL, or TSA was detected, confirmed by histopathology | Abnormal FIT<br><br>cut-off 15 µg Hb/g faeces at start and changed mid-2014 to 47 µg Hb/g faeces | 55-76 years<br><br>Median: 68 years (IQR, 63-72) | Median ADR was 66.3% (95% CI,61.4–69.9)<br><br>Median PSPDR was 11.9% (IQR 8.3–15.8)<br><br>Correlation between the PSDPR and ADR was moderate (r=0.59; p<0·0001)<br><br>1% increase in PSPDR associated with 7% point decrease of PCCRC: HR= 0.93 (95% CI, 0.90–0.95; p<0·0001) | None |

| Study | Definition | Indication for colonoscopy | Age of Inclusion | ADR | Benchmarking/targeting |
|---|---|---|---|---|---|
| Wisse, 2022 (110)<br><br>Retrospective cohort<br><br>Multicentre (national)<br><br>2014-2016 | ADR was defined as the proportion of procedures with detection of an adenoma (advanced or nonadvanced) | Abnormal FIT threshold 47 ug/g | 55-75 years<br><br>Screening mean: 67 years (range: 63-70)<br><br>PCCRC mean: 67 years (range: 65-75) | Overall (median): 67% (range: 40-82%)<br><br>ADR associated with interval PCCRC: adjHR, 0.95 (95% CI, 0.92-0.97, p<0.001) per 1% increase in ADR | Program threshold ≥30% Between 2014-2016: 100% of endoscopists above threshold<br><br>In this study, ADR 67% correlates with median ADR of 25% in Corley and 15% in Kaminski (other landmark studies of ADR and PCCRC in primary colonoscopy).<br><br>Therefore, ADR threshold should be increased for abnormal FIT colonoscopy, but the abnormal FIT threshold should be considered. |
| Aniwan, 2021 (100)<br><br>Retrospective cohort<br><br>Jan 2007 - June 2018 | ADR was defined as the number of patients with at least 1 adenoma detected during the colonoscopy divided by the number of colonoscopies performed by the same endoscopist. | Screening | 50 – 75 years<br><br>Mean: 61.7 years (SD=7.3) | Overall, screening (mean): 36.7% (SD= 8.0%) | None |
| Han, 2021 (102)<br><br>Prospective cross-sectional study<br><br>July 2018 – June 2020 | ADR was calculated as the number of participants with ≥1 adenoma detected during the first colonoscopy divided by the number of first colonoscopies. | Screening | 50 – 75 years<br><br>Mean: 58.5 years (SD=7.4) | Overall, screening (weighted mean): 58% (range: 44-75.4%, p=0.024) | None |
| Kaltenbach, 2021 (103)<br><br>Retrospective cohort | Overall ADR: the number of procedures where 1 or more adenomas were detected over the total number of colonoscopies (irrespective of indication). | Screening, surveillance, and diagnostic (patients who reported | ≥50 years<br><br>Mean: 63.2 years (SD =10.1) | Overall (mean): 50% (95% CI, 45-56%)<br><br>Screening (mean): 49% (95% CI, 43-56%) | Ran simulations, varying the proportions by indication (screening, surveillance, diagnostic (which included abnormal FIT colonoscopies)) |

| Study | Definition | Indication for colonoscopy | Age of Inclusion | ADR | Benchmarking/targeting |
|---|---|---|---|---|---|
| July 2015 – December 2015 | Overall age of participants: Mean: 63.2 years, SD: 10.1 years<br><br>Screening ADR: the number of screening procedures where 1 or more adenomas were detected divided by the total number of screening colonoscopies in average-risk patients<br>Age of participants: ≥ 50 years of age.<br><br>Non-screening ADR: the proportion of non-screening colonoscopies (surveillance or diagnostic, including FIT) in which at least 1 adenoma was found.<br>Age of participants: NR | symptoms before examination and/or screening for abnormal FITs)<br>Abnormal FIT threshold NR | | Non-screening (mean:) 50% (95% CI, 45-56%)<br><br>Surveillance (mean): 56%<br><br>Diagnostic (mean): 38% | and found no difference in ADR screening (51% (95% CI, 45–56%)) vs. non-screening (surveillance + diagnostic) (50% (95% CI, 44–55%)) across simulations. |
| Murphy, 2021 (105)<br><br>Retrospective cohort study<br><br>July 2015 – July 2017 | ADR was defined as the number procedures in which ≥1 histologically confirmed adenoma was detected | Diagnosis or surveillance | ≥18 years | Overall, diagnostic and surveillance (mean): 19.6%<br>(range: 12-24%) | None |
| Buerger, 2020 (101)<br><br>Retrospective cohort study<br><br>January 2012-December 2016 | ADR was defined as the percentage of procedures, in which at least one adenoma was detected | Screening | ≥50 years<br><br>Median: 62 years (IQR=56–69) | ADR Overall (mean): 33.2% (Range: 13.0–46.0%) | None |
| Leite, 2020 (104) | ADR was obtained by dividing the total number of colonoscopies with one or more adenomas by the total number of colonoscopies. | Screening, surveillance, and diagnosis | ≥50 years<br><br>Screening | Overall, non-screening indications (mean): 50.6%<br><br>Overall, screening (mean): 44.6% | None |

| Study | Definition | Indication for colonoscopy | Age of Inclusion | ADR | Benchmarking/targeting |
|---|---|---|---|---|---|
| Retrospective cohort study<br><br>January 2018 – June 2018 | | | mean: 60 years (SD=7.2)<br><br>Other mean: 63 years (SD=7.6) | Higher proportion of patients in the screening group had adenomatous polyps (*p*=0.03)<br><br>Males (mean): 55.9%<br>Females (mean): 41.8% | |
| Park, 2020 (106)<br><br>Retrospective cohort study<br><br>May 2013 – December 2016 | ADR was defined as the number of colonoscopies with at least one adenoma or adenocarcinoma divided by the total number of colonoscopies. | Screening or surveillance | NR<br><br>Mean: 55.6 years | Overall, screening or surveillance (mean): 40.1% (95% CI, 37.7-42.5%) | None |
| Penz, 2020 (107)<br><br>Retrospective cohort study<br><br>2007 - 2010 | ADR was defined by the proportion of colonoscopies with at least 1 detected adenoma of all screening colonoscopies. | Screening colonoscopies | ≥50 years<br><br>Mean: 64.7 years (SD= 9.7) | Overall, screening (mean): 22.02% (95% CI,<br>17.06 – 28.66%) | None |
| Wadhwa, 2020 (122)<br><br>Retrospective chart review<br><br>January 1, 2012 – August 31, 2014 | ADR was defined as proportion of colonoscopies with at least one adenoma detected in average risk patients aged ≥50 years. | Screening and surveillance | ≥50 years<br><br>Mean: 60 years (SD= 7.7) | Overall, screening and surveillance (mean): 26.4 (SD= 10.9%)<br><br>Males (mean): 32.7 (SD= 14.5%)<br><br>Females (mean): 22.1 (SD= 12.6%) | None |
| Vojtechova, 2020 (121)<br><br>Prospective cohort study<br><br>2012 - 2016 | ADR was defined as the ratio of patients undergoing screening colonoscopy who have at least one adenoma detected to the total number of patients undergoing colonoscopies. | Screening or abnormal FOBT (gFOBT/FIT) abnormal FIT threshold NR | 45–75 years<br><br>Mean: 60.1 years (SD=7.3) | Overall, screening, or abnormal FOBT (mean): 42.6% | None |

| Study | Definition | Indication for colonoscopy | Age of Inclusion | ADR | Benchmarking/targeting |
|---|---|---|---|---|---|
| Yamaguchi, 2020 (123)<br><br>Retrospective case control<br><br>October 2008 – August 2017 | ADR was calculated as the number of colonoscopies at which one or more histologically confirmed adenomas were found divided by the total number of colonoscopies performed in the same time period. | Screening and surveillance<br><br>Cases PCCRCs, Controls, normally detected CRCs | NR<br><br>Mean: 70.9 years (SD =10.5) | Overall: Endoscopists performing colonoscopies: (mean): 38.6% (SD= 6.6%, range=30.2 – 52.8%) | None |
| Gessl, 2019 (116)<br><br>Retrospective cohort study<br><br>Jan 2016 – Sept 2017 | ADR was calculated as a percentage of colonoscopies, in which at least 1 adenoma could be detected. | Screening | ≥50 years<br><br>Mean 60.2 years (SD= 9.2) | Overall, screening (mean): 22.1% (SD= 9.7%) | None |
| Hilsden, 2019 (117)<br><br>Historical cohort study<br><br>2014 (year 0) and 2015 (year 1) | ADR was calculated as the percentage of colonoscopies in which at least 1 adenoma was detected. | Screening (patients with an abnormal FIT were excluded) | 50-74 years | Overall (2014), screening (mean): 29%<br><br>Overall (2015), screening (mean): 32% | None |
| Murchie, 2018 (118)<br><br>Retrospective and prospective cohort study<br><br>September 2014 – February 2015 | ADR was defined as the proportion of screening colonoscopies where at least one adenoma is detected. | Screening | NR<br><br>Median: 55 years (range =51-62) | Pre-intervention (mean): 29.3% (8.0–54.5%)<br><br>Post-intervention (mean): 29.6% (7.9–55.8%) | None |
| Tjaden, 2018 (120) | ADR was defined as the proportion of all screening colonoscopies where an adenoma is detected. | Screening | NR<br><br>Mean: 58.3 years | Overall Screening (mean): 30.8%<br><br>Overall ADR (surveillance) (mean): 29.1% | None |

| Study | Definition | Indication for colonoscopy | Age of Inclusion | ADR | Benchmarking/targeting |
|---|---|---|---|---|---|
| Retrospective and prospective cohort study<br><br>Retrospective: 2006 – 2012<br><br>Prospective: 2013 - 2016 | | | | | |
| Yoon, 2018 (124)<br><br>Retrospective cohort study<br><br>February 2006 – March 2012 | ADR was the proportion of screening colonoscopies in which ≥ 1 adenomas are found. | Screening | <50 years<br><br>Mean: 43.5 years (SD=4.3) (range: 30 – 49) | Overall (mean): 27.3% (SD= 11.0%)<br><br>Overall (median): 24.1% | Suggest 20% ADR target in 50 years old and younger populations<br><br>41% of patients had a surveillance COL 52.1 months later (± 21 months)<br><br>Surveillance colonoscopies:<br>Using ADR 20% at screening:<br>Risk of metachronous neoplasia in high vs. low:<br>adenoma: 25.7 vs. 35.4 p<0.001<br>advanced adenoma: 3.7 vs. 8.3, p=0.001<br>High ADR group: 32.7 ±9.5<br>Low ADR group: 16.7 ±3.2<br><br>Using ADR 25% at screening:<br>Risk of metachronous neoplasia in high vs. low:<br>adenoma: 29.3 vs. 29.1 p=0.913<br>advanced adenoma: 4.7 vs. 5.83, p=0.449<br>High ADR group: 36.3 ±7.9<br>Low ADR group: 18.4 ± 3.6 |
| Abdelfatah, 2017 (113) | ADR was calculated by dividing the total number of patients with at least one histologically confirmed | Screening | 50-75 years | Overall (mean): 25.5% (range: 14.7-34.7%) | None |

| Study | Definition | Indication for colonoscopy | Age of Inclusion | ADR | Benchmarking/targeting |
|---|---|---|---|---|---|
| Retrospective cohort study<br><br>October 2007 – October 2012 | adenoma, by the total number of patients undergoing screening or surveillance procedures. | | Mean: 58 years (SD= 6) | | |
| Cubiella, 2017 (115)<br><br>Cross-sectional study: post-hoc analysis<br><br>June 2009 – June 2011 | ADR was defined as the proportion of individuals with at least one detected adenoma among those tested. | Screening: Primary colonoscopy and abnormal FIT (COLONPREV study)<br><br>(≥15 mg/g of feces) | 50-69 years | Primary screening group (median): 31% (range: 14-51%)<br><br>Abnormal FIT group (median): 55% (range: 21-83%) | Correlation in ADR between primary and abnormal FIT colonoscopy (r=0.716, 95% CI, 0.378–0.819; p<0.001)<br>In the multivariate regression, the regression coefficient for FIT vs. primary colonoscopy ADR was 0.71, 95% CI, 0.19–1.22; p=0.009.<br><br>Using multivariable regression analysis:<br>An ADR of 20% for endoscopists performing primary screening colonoscopy is estimated to be equivalent to 45% ADR in abnormal FIT colonoscopy (95% CI, 35-57%)<br><br>Estimated ADR for ASGE thresholds:<br>Overall:25% (primary colonoscopy), 49% (95% CI, 36%–62%) (abnormal FIT)<br>Men: 30% (primary colonoscopy), 54% (95% CI, 39%–69%) (abnormal FIT)<br>Women, 20% (primary colonoscopy) 44% (95% CI, 34%–54%) (abnormal FIT) |
| Kaminski, 2017 (3) | ADR was defined as the proportion of screenees with at least 1 adenoma identified. | Screening | 40-66 years<br><br>Mean: 55.7 years (SD=5.4) | Endoscopists were placed in quintile categories of improvement from previous year. | Compared with no increase in ADR, reaching or maintaining the highest quintile ADR category (such as an ADR > |

| Study | Definition | Indication for colonoscopy | Age of Inclusion | ADR | Benchmarking/targeting |
|---|---|---|---|---|---|
| Prospective cohort study<br><br>January 1, 2004 – December 21, 2008 | | | | No improvement: category 1 (mean): 10.8%<br>category 2 (mean): 13.1%<br>category 3 (mean): 17.1%<br>category 4 (mean): 28.8%<br>category 5 (mean): 31.3% | 24.56%) decreased the adjHR for interval colorectal cancer to 0.27 (95% CI, 0.12–0.63; p=0.003), and 0.18 (95% CI, 0.06–0.56; p=0.003), respectively.<br><br>Annual ADR in excess of 24.56% had significantly lower risk of interval CRC and death. |
| Aniwan, 2016 (114)<br><br>Cross-sectional study<br><br>June 2009 – June 2011 | ADR was calculated as the number of participants with ≥1 adenoma detected during the first colonoscopy divided by the number of first colonoscopies. | Asymptomatic back-to-back colonoscopy | 50-75 years<br><br>Mean: 59.8 years (SD=6.5) | Overall (mean)=48.5% | None |
| Park, 2016 (119)<br><br>Retrospective and prospective cohort study<br><br>December 2007 – November 2008 and May 2010 – February 2011 | ADR was defined as the proportion of screening colonoscopies in which one or more adenomas are removed. | Screening | ≥50 years<br><br>Mean: 58.6 years (SD= 7.1) | Overall (range): 16.67- 66.67%<br><br>Overall (mean): 37.29% (SD= 12.51%) | None |
| Hilsden, 2016 (99)<br><br>Historical cohort study | ADR was calculated as the percentage of colonoscopies in which at least one adenoma was detected for each endoscopist. | Screening or Abnormal FIT (≥75 ng/ml) | 50-74 years | Average risk patients:<br>Low Detectors (ADR <25%) (mean): 21% (range 18-23%)<br>Mid Detectors (ADR 25–34%) (mean):29% (range 25-34%) | Benchmark abnormal FIT ADRs were estimated using meta-regression: |

| Study | Definition | Indication for colonoscopy | Age of Inclusion | ADR | Benchmarking/targeting |
|---|---|---|---|---|---|
| January 1, 2014 – June 30, 2015 | | | | High Detectors (ADR ≥35%) (mean): 39% (range 35-42%)<br><br>Abnormal FIT patients:<br>Low Detectors (ADR <25%) (mean): 52% (range 45-66%)<br>Mid Detectors (ADR 25–34%) (mean):58% (range 47-67%)<br>High Detectors (ADR ≥35%) (mean): 65% (range 47-75%) | Method 1 (minimally acceptable): estimated ADR for abnormal FIT patients that corresponded an ADR of 25% in average risk individuals<br>Method #2: (standard of care) estimated the average ADR in all abnormal FIT patients<br>Method #3: (aspirational) the average abnormal FIT ADR that corresponded to an ADR of ≥35% (high detectors) in average risk patients<br><br>Benchmark abnormal FIT ADR thresholds:<br>Method #1: 55%<br>Method #2: 60%<br>Method #3: 65% |

**Abbreviations:** adjHR, adjusted hazard ratio; ADR, adenoma detection rate; CI, confidence interval; COL, colonoscopy; CRC, colorectal cancer; FIT, fecal immunochemical testing; FOBT, fecal occult blood test; IQR, interquartile range; NR, not reported; PCCRC, post colonoscopy colorectal cancer; PSPDR, proximal serrated polyp detection rate; SD, standard deviation; SR, systematic review.
**Note:** PCCRCs were classified as interval if the cancer was detected before the recommended next surveillance but still at least 6 months after the first colonoscopy.

### Table 4.20. ADR comparison with Other Indicators: PDR, HRADR, NAADR, APP, APC, ADR-plus, CRC-ADR, SSPDR (CSSDR, PSPDR).

| Study | Endoscopist number/ factors | Indication for colonoscopy/ Number of colonoscopies/ patients | Gold standard | Results |
|---|---|---|---|---|
| **Adenoma detection rate (ADR)**: Calculated by dividing the total number of patients with at least one histologically confirmed adenoma, by the total number of patients undergoing screening or surveillance procedures.<br>**Adenoma miss rate (AMR):** Calculated as the number of adenomas missed in the first colonoscopy divided by the total number of adenomas detected during both the first and second colonoscopies.<br>**Adenoma per colonoscopy (APC):** Calculated by dividing the total number of adenomas by the total number of screening colonoscopies done by one endoscopist.<br>**PDR** (The number of participants with ≥1 polyp including adenoma detected during the first colonoscopy divided by the number of first colonoscopies) | | | | |

| Study | Endoscopist number/ factors | Indication for colonoscopy/ Number of colonoscopies/ patients | Gold standard | Results |
|---|---|---|---|---|
| Han, 2021 (102)<br><br>Prospective cross-sectional study<br><br>July 2018 – June 2020 | 8 endoscopists | Screening<br><br>742 COL | ADR<br>AMR | One-way analysis of variances and chi-square tests were used for the continuous and categorical variables. To assess the quality of the colonoscopy, endoscopists' PDR were compared to AMR and ADR using the Spearman correlation coefficients. A two-sided p-value<0.05 was considered significant.<br><br>Overall (weighted mean) PDR: 67.6%<br><br>ADR significantly correlated with PDR: r=0.826 (p=0.011)<br>AMR not significantly correlated with PDR: r=0.204 (p=0.629) |
| Murphy, 2021 (105)<br><br>Retrospective cohort study<br><br>July 2015 – July 2017 | 8 endoscopists | Diagnosis or surveillance<br><br>3274 COL | ADR | Inferential procedures employed included the Pearson's correlation coefficient and binomial logistic regression.<br><br>Overall (mean): 27%<br><br>ADR significantly correlated with PDR: r=0.734 (p=0.038)<br><br>APDRQ: 0.72 |
| Vojtechova, 2020 (121)<br><br>Prospective cohort study<br><br>2012 - 2016 | 16 endoscopists | Screening or abnormal FOBT (gFOBT/FIT)<br>1614 COL | ADR | Spearman's correlation coefficient was used to assess PDR/ADR for each endoscopist.<br><br>Overall (mean): 58.8%<br><br>ADR significantly correlated with PDR: r=0.82 (p<0.001)<br><br>APDRQ: 0.7233 |
| Sastra Lozano, 2019 (128)<br><br>Retrospective cohort study<br><br>January 1st, 2011-December 31st, 2014 | 14 endoscopists | Screening<br><br>12,482 COL | ADR | Pearson's correlation test was performed to analyze whether the endoscopists' diagnoses of polyps were associated with the histopathologic result of adenoma.<br><br>Overall (mean): 32.78 (SD ± 8.54)<br><br>ADR significantly correlated with PDR: r=0.927 (p<0.01)<br><br>They grouped the endoscopists into high and low PDR groups and counted the PCCRCs. G1 (nine PCCRC, 69.2%) vs. G2 (four PCCRC, 30.8%), p<0.02. A significantly higher PCCRC rate was observed in the group of endoscopists with a lower PDR (p<0.02). |
| **SSPDR (sessile serrated polyp detection rate)**<br>**CSSDR** (number of colonoscopies with at least one CSSP divided by the total number of colonoscopies) | | | | |

| Study | Endoscopist number/ factors | Indication for colonoscopy/ Number of colonoscopies/ patients | Gold standard | Results |
|---|---|---|---|---|
| **PSPDR** (number of colonoscopies with at least one serrated polyp detected in the proximal colon, either exclusively or in both the proximal and distal segments, divided by the total number of colonoscopies performed by the endoscopist) | | | | |
| Zessner-Spitzenberg, 2023 (111)<br><br>Retrospective cohort<br><br>January 2013-December 2020 | 308 endoscopists | Screening<br><br>229 729 COL | ADR | The association between ADR and PSPDR was used to analyze the extent of correlation by Spearman's rank coefficient of all dynamically calculated values<br><br>Overall (mean):10.6% (SD=7.95%)<br><br>ADR correlated with PSPDR: r=0.70 (95% CI, 0.70-0.71) |
| van Toledo, 2022 (109)<br><br>Retrospective cohort<br><br>January 2014-December 2020 | 441 endoscopists | Abnormal FIT<br><br>277 555 COL | ADR | The Spearman correlation coefficient was calculated to analyze the correlation between PSPDR and ADR.<br><br>Median PSPDR was 11.9% (IQR 8.3–15.8)<br><br>ADR significantly correlated with PSDPR (r=0.59; p<0·0001) |
| Park, 2020 (106)<br><br>Retrospective cohort study<br><br>May 2013 – December 2016 | 30 endoscopists | Screening or surveillance<br><br>26 627 COL | ADR | Pearson's correlation test was used to analyze the correlation between quality indicators. Correlation coefficients of relationships were analyzed using Steiger's z-test.<br><br>Overall (mean): 6.1% (95% CI, 5.1-7.1%); (median): 5.4 (IQR 3.7-7.1%)<br><br>ADR significantly correlated with CSSDR: r=0.47 (p<0.01) |
| Anderson, 2017 (127)<br><br>Prospective cohort study<br><br>Multicentre<br><br>April 2009 to December 2014 | 77 endoscopists | Screening and surveillance<br><br>45,996 COL | ADR | Non-parametric Spearman correlations coefficients between screening PSPDR, CSSDR and ADR.<br><br>Overall (mean): CSSDR: 5.8%<br>Overall (mean) PSPDR: 10.6%<br><br>Screening ADR significantly correlated with CSSDR: r=0.69 (p<0.0001)<br>Screening ADR significantly correlated with PSPDR: r=0.79 (p<0.0001)<br>Surveillance ADR significantly correlated with CSSDR: r=0.74 (p<0.0001)<br>Surveillance ADR significantly correlated with PSPDR: r=0.78 (p<0.0001) |

| Study | Endoscopist number/ factors | Indication for colonoscopy/ Number of colonoscopies/ patients | Gold standard | Results |
|---|---|---|---|---|
| **High Risk Adenoma Detection Rate (HRADR)** Calculated by dividing the total number of patients with at least one of the following three criteria: (1) any sized TVA or VA or adenoma with HGD, (2) adenoma ≥10 mm in size or (3) presence of three or more adenomas of any size, by the total number of patients undergoing screening colonoscopy<br>**Advanced adenoma detection rate (AADR):** Calculated by dividing the total number of advanced adenoma (>10mm in size, have villous histology or high-grade dysplasia) by the total number of screening colonoscopies done by one endoscopist.<br>**Advanced adenoma detection rate (AADR-2):** Calculated by dividing the total number of patients having one or more AA or three or more adenomas of any size by a total number of screening colonoscopies done by one endoscopist. | | | | |
| Wisse, 2022 (110)<br><br>Retrospective cohort<br><br>2014-2016 | 311 endoscopists | FIT +<br><br>103,900 COL | ADR | The correlation between HRADR and ADR was assessed with the Spearman correlation coefficient. The strength of the association was evaluated using linear regression models.<br><br>Overall (median) HRADR: 39.7%<br><br>ADR correlated with HRADR: r=0.52, p=NR |
| Wadhwa 2020 (122)<br>Retrospective chart review<br><br>January 1, 2012 -August 31, 2014 | 32 endoscopists | Screening and surveillance<br><br>4158 COL | ADR | Linear regression analysis was performed to assess the relationship between the various detection rates and ADR. A p<0.05 was considered statistically significant.<br><br>Overall (mean) HRADR: 8.0 ± 5.7% (range: 0 and 23%)<br>Males (mean) HRADR: 10.2 (SD± 8.6%)<br>Females (mean) HRADR: 6.1 (SD± 6.0%)<br><br>Variability was higher in HRADR (CV=72) than ADR (CV=41).<br><br>ADR was not significantly correlated with HRADR: r=0.57 (95% CI,0.40–0.70) p=NR<br><br>For every 10% increase in HRADR, the average ADR increased by 11%.<br><br>In women, HRADR of 4% (95% CI, 1,14) corresponded to ADR of 20% and in men, HRADR of 7% (95% CI, 1, 20) corresponded to ADR of 30% |
| Penz, 2020 (107)<br><br>Retrospective cohort study<br><br>2007 - 2010 | 262 endoscopists<br><br>Divided all endoscopists into quintiles based on the ADR. | Screening<br><br>218,193 COL | ADR | Spearman's rank-order was used to evaluate the correlation among endoscopists' ADRs and HRADRs. Results were compared between endoscopists with <25% and ≥25% ADRs. Statistical significance was defined by p≤0.05.<br><br>Overall (mean) HRADR: 7.72% (95% CI, 7.19-8.25)<br><br>ADR was significantly correlated with HRADR: r=0.51 (p<0.001) |

| Study | Endoscopist number/ factors | Indication for colonoscopy/ Number of colonoscopies/ patients | Gold standard | Results |
|---|---|---|---|---|
| | | | | Endoscopists with an ADR <25%, (mean) HRADR: 6.33% (95% CI, 5.77-6.90)<br>Endoscopists with an ADR ≥25% (mean) HRADR: 9.85% (95% CI, 8.97-10.74) |
| Abdelfatah 2017 (113)<br><br>Retrospective cohort study<br><br>October 2007 - October 2012 | 6 endoscopists | Screening<br><br>2116 COL | ADR | The ADR was calculated for each endoscopist. Spearman's rank-order correlation was then used to evaluate the relationship of ADR with AADR and AADR-2.<br><br>Overall (mean) HRADR: 4.2% (range: 3-5.7%)<br>Overall (mean) HRADR-2: 6.4% (range: 3.7-9.9%)<br><br>ADR not significantly correlated with AADR r=0.53 (95% CI, -0.49 to 0.94, p=0.31)<br>ADR significantly correlated with AADR-2 r=0.82 (95% CI, 0.10 to 0.98, p=0.04) |
| Park, 2016 (119)<br><br>Retrospective and prospective cohort study<br><br>December 2007 - November 2008<br>and<br>May 2010 - February 2011 | 28 endoscopists | Screening<br><br>1142 patients | ADR<br>APC | Pearson correlation was used to evaluate the relationship of ADR with HRADR and HRADR-2. Statistical significance was defined as a p value<0.05.<br><br>Overall (mean) HRADR: 10.98% (SD ±8.68%)<br>Overall (mean) HRADR-2: 14.90% (SD± 9.43%)<br><br>ADR significantly correlated with AADR: r=0.60 (p=0.001)<br>APC significantly correlated with AADR: r=0.65 (p<0.001)<br><br>There was no difference between the correlation coefficients of ADR-HRADR-1 and APC-HRADR-1 (0.60 versus 0.65, p=0.28).<br><br>ADR significantly correlated with AADR-2: r=0.64 (p<0.001)<br>APC significantly correlated with AADR-2: r=0.77 (p<0.001) |
| **Nonadvanced ADR** (total number of adenomas that does not meet advanced adenoma criteria over the total number of procedures done by one endoscopist) | | | | |
| Penz, 2020 (107)<br><br>Retrospective cohort study<br><br>2007 - 2010 | 262 endoscopists<br><br>Divided all endoscopists into quintiles based on the ADR. | Screening<br><br>218 193 COL | ADR | Spearman's rank-order was used to evaluate the correlation among endoscopists' ADRs and NAADRs. Results were compared between endoscopists with <25% and ≥25% ADRs. Statistical significance was defined by p≤0.05.<br><br>Overall (mean) NAADR:15.31% (95% CI, 14.36-16.27)<br><br>ADR was significantly correlated with NAADR: r=0.49 (p<0.001)<br><br>Endoscopists with an ADR <25%, (mean) NAADR: 10.84% (95% CI, 10.07-11.61)<br>Endoscopists with an ADR ≥25% (mean) NAADR: 22.22% (95% CI, 20.97-23.46) |

| Study | Endoscopist number/ factors | Indication for colonoscopy/ Number of colonoscopies/ patients | Gold standard | Results |
|---|---|---|---|---|
| Abdelfatah 2017 (113)<br><br>Retrospective cohort study<br><br>October 2007 - October 2012 | 6 endoscopists | Screening<br><br>2116 COL | ADR | The ADR and NAADR were calculated for each endoscopist. Spearman's rank-order correlation was then used to evaluate the relationship between ADR and the NAADR for each endoscopist.<br><br>Overall (mean) NAADR: 21% (range: 11.7-29%)<br><br>ADR significantly correlated with NAADR: r=0.99 (95% CI, 0.95 – 0.99, p=0.0001) |
| **Adenomas per positive participant (APP)** Calculated by dividing the total number of adenomas by the total number of colonoscopies with at least single adenoma detected. | | | | |
| Wisse, 2022 (110)<br><br>Retrospective cohort<br><br>2014-2016 | 311 endoscopists | FIT +<br><br>103,900 COL | ADR | The correlation between APP and ADR was assessed with the Spearman correlation coefficient. The strength of the association was evaluated using linear regression models.<br><br>Overall (median) APP: 2.48 (range: 1.5-6.6)<br><br>ADR correlated with APP: r=0.53 (p=NR) |
| Aniwan, 2021 (100)<br><br>Retrospective cohort<br><br>Jan 2007 - June 2018 | 47 endoscopists<br><br>Endoscopist ADRs classified as acceptable (25%-29%), high (30%-39%) and aspirational (≥ 40%) | Screening<br><br>7339 COL | ADR<br>HRADR | Categorical variables and continuous variables were compared using the chi-squared test and independent t test, respectively.<br><br>APP modelled as a categorical variable: ADR ≥40% (vs. <40%) =2.1 (0.3 to 3.9), p=0.02<br><br>There was a significant difference in the proportions having a high APP among the three ADR groups. An APP higher than the cutoff value of 2.0 was found in 18% of endoscopists with acceptable ADR, in 44% with high standard ADR, and in 72% with aspirational ADR (p=0.02).<br><br>Endoscopists with aspirational ADR (≥40%) and high APP performance (≥2) had on average a 5.3 percentage points higher HRADR (95% CI, 3.0 – 7.6; p<0.01) |
| Gessl, 2019 (116)<br><br>Retrospective cohort study | 202 endoscopists | Screening<br><br>44,142 COL | ADR<br>HRADR | Spearman correlation analysis was performed for the association between APP with ADR, and HRADR.<br><br>Overall (mean) APP: 1.54 (±3.1)<br><br>ADR significantly correlated with APP: r=0.36 (p<0.01)<br>HRADR significantly correlated with APP: r=0.19 (p<0.01) |

| Study | Endoscopist number/ factors | Indication for colonoscopy/ Number of colonoscopies/ patients | Gold standard | Results |
|---|---|---|---|---|
| Jan 2016 - Sept 2017 | | | | |
| Abdelfatah 2017 (113)<br><br>Retrospective cohort study<br><br>October 2007 - October 2012 | 6 endoscopists | Screening<br><br>2116 COL | ADR | The ADR and APP were calculated for each endoscopist. Spearman's rank-order correlation was then used to evaluate the relationship between ADR and APP for each endoscopist.<br><br>Overall (mean) APP: 1.6 (range: 1.3-1.8)<br><br>ADR not significantly correlated with APP: r=0.66 (95% CI, -0.28 to 0.96, p=0.16) |
| Aniwan, 2016 (114)<br><br>Cross-sectional study<br><br>August 2014–June 2015 | 4 endoscopists | Screening<br><br>200 patients; 400 COL | AMR | To assess the quality of the colonoscopy as determined by the AMR, the APP was calculated for each endoscopist and compared to the AMR using Pearson's correlation coefficients.<br><br>Overall (mean) APP: 2.16 (range: 1.91-2.43)<br><br>AMR strongly inversely correlated with the APP: r =−0.99 (p<0.01) |
| Han, 2021 (102)<br><br>Prospective cross-sectional study<br><br>July 2018 – June 2020 | 8 endoscopists | Screening<br><br>742 COL | ADR<br>AMR | One-way analysis of variances and chi-square tests were used for the continuous and categorical variables. To assess the quality of the colonoscopy, endoscopists' APP were compared to AMR and ADR using the Spearman correlation coefficients. A two-sided p-value<0.05 was considered significant.<br><br>Overall (mean) APP: 1.69 ±0.36<br><br>The APP range was 0.62 to 2.30; p=0.038.<br><br>ADR not significantly inversely correlated with APP: r=-0.048 (p=0.935)<br>AMR not significantly inversely correlated with APP: r=-0.357 (p=0.389) |
| **Adenomas per Colonoscopy (APC)** (total number of adenomas over the total number of screening colonoscopies done by one endoscopist) | | | | |
| Wisse, 2022 (110)<br><br>Retrospective cohort<br><br>2014-2016 | 311 endoscopists | FIT +<br><br>103,900 colonoscopies | ADR | The correlation between APC and ADR was assessed with the Spearman correlation coefficient. The strength of the association was evaluated using linear regression models.<br><br>Overall (median) APC: 1.74 (range: 0.9-4.7)<br><br>ADR correlated with APC: r=0.64, p=NR |

| Study | Endoscopist number/ factors | Indication for colonoscopy/ Number of colonoscopies/ patients | Gold standard | Results |
|---|---|---|---|---|
| Han, 2021 (102)<br><br>Prospective cross-sectional study<br><br>July 2018 – June 2020 | 8 endoscopists | Screening<br><br>742 COL | ADR<br>AMR | One-way analysis of variances and chi-square tests were used for the continuous and categorical variables. To assess the quality of the colonoscopy, endoscopists' APC were compared to AMR and ADR using the Spearman correlation coefficients. A two-sided p-value<0.05 was considered significant.<br><br>Overall (mean) APC: 0.98<br><br>ADR not significantly correlated with APC: r=0.571 (p=0.151)<br>AMR not significantly inversely correlated with APC: r=-0.095 (p=0.840) |
| Gessl, 2019 (116)<br><br>Retrospective cohort study<br><br>Jan 2016 - Sept 2017 | 202 endoscopists | Screening<br><br>44,142 COL | ADR<br>HRADR | Differences of characteristics between groups were analyzed by unpaired t-tests or chi-square tests. Spearman correlation analysis was performed for the association between ADR, HRADR and APC.<br><br>Overall (mean) APC: 0.35 SD ±0.19<br><br>ADR significantly correlated with APC: r=0.94 (p<0.01)<br>HRADR significantly correlated with APC: r=0.46 (p<0.01) |
| Aniwan, 2016 (114)<br><br>Cross-sectional study<br><br>August 2014–June 2015 | 4 endoscopists | Screening<br><br>200 patients<br>400 COL | AMR | To assess the quality of the colonoscopy as determined by the AMR, the APC was calculated for each endoscopist and compared to the AMR using Pearson's correlation coefficients.<br><br>Overall (mean) APC: 1.05 (range: 0.84-1.18)<br><br>AMR not significantly correlated with the APC: r =−0.82 (p=0.18) |
| Abdelfatah, 2017 (113)<br><br>Retrospective cohort study<br><br>October 2007 - October 2012 | 6 endoscopists | Screening<br><br>2116 COL | ADR | The ADR and APC were calculated for each endoscopist. Spearman's rank-order correlation was then used to evaluate the relationship between ADR and APC for each endoscopist.<br><br>APC was 25.5% (range: 14.7-34.7%)<br><br>ADR significantly correlated with APC: r=0.99 (95% CI, 0.89 – 0.99); p=0.0002. |
| Park, 2016 (119) | 28 endoscopists | Screening<br><br>1142 patients | ADR<br>HRADR-1<br>HRADR-2 | A descriptive analysis was performed using means and SDs for continuous measures and percentages for categorical measures. Pearson correlation was used to evaluate the relationship between ADR-HRADR, APC-HRADR and ADR-APC. Steiger's |

| Study | Endoscopist number/ factors | Indication for colonoscopy/ Number of colonoscopies/ patients | Gold standard | Results |
|---|---|---|---|---|
| Retrospective and prospective cohort study<br><br>December 2007 - November 2008<br><br>and<br><br>May 2010 - February 2011 | | | | z-test was used to compare correlation coefficient of ADR-HRADR and APC-HRADR. Statistical significance was defined as a p value<0.05.<br><br>Overall (mean) ADR: 37.29% (SD± 12.51%) (range: 16.67 to 66.67%)<br>Overall (mean) APC: 0.65 (SD± 0.29%) (range: 0.22 to 1)<br><br>ADR significantly correlated with APC: r=0.82 (p<0.001)<br>HRADR-1 significantly correlated with APC: r=0.65 (p<0.001)<br>HRADR-2 significantly correlated with APC: r=0.77 (p<0.001) |
| **ADR-Plus** (additional adenomas found after the first adenoma per colonoscopy) | | | | |
| Han, 2021 (102)<br><br>Prospective cross-sectional study<br><br>July 2018 – June 2020 | 8 endoscopists | Screening<br><br>742 COL | ADR<br>AMR | One-way analysis of variances and chi-square tests were used for the continuous and categorical variables. To assess the quality of the colonoscopy, endoscopists' ADR-plus were compared to AMR and ADR using the Spearman correlation coefficients. A two-sided p-value<0.05 was considered significant.<br><br>Overall (mean) ADR-plus: 0.40<br><br>ADR not significantly correlated with ADR-Plus: r=0.238 (p=0.582)<br>AMR not significantly correlated with ADR-Plus: r=-0.262 (p=0.536) |
| Abdelfatah 2017 (113)<br><br>Retrospective cohort study<br><br>October 2007 - October 2012 | 6 endoscopists | Screening<br><br>2116 COL | ADR | The ADR and ADR-plus were calculated for each endoscopist. Spearman's rank-order correlation was then used to evaluate the relationship between ADR and ADR-plus for each endoscopist.<br><br>Overall (mean) ADR-Plus: 0.6 (range: 0.3-0.8)<br><br>ADR significantly correlated with ADR-Plus: r=0.85 (95% CI, 0.98; p=0.047) |
| Aniwan, 2016 (114)<br><br>Cross-sectional study | 4 endoscopists | Screening<br><br>200 patients; 400 COL | AMR | To assess the quality of the colonoscopy as determined by the AMR, the ADR-plus was calculated for each endoscopist and compared to the AMR using Pearson's correlation coefficients.<br><br>Overall (mean) ADR-plus: 0.565 (range: 0.40-0.66)<br><br>AMR not significantly inversely correlated with the ADR-plus: r=−0.93 (p=0.07) |

| Study | Endoscopist number/ factors | Indication for colonoscopy/ Number of colonoscopies/ patients | Gold standard | Results |
|---|---|---|---|---|
| August 2014- June 2015 | | | | |
| **CRC-ADR** (ADR in first surveillance colonoscopy following surgical resection of CRC) | | | | |
| Tjaden, 2018 (120)<br><br>Retrospective and prospective cohort study<br><br>Retrospective: 2006 – 2012<br><br>Prospective: 2013 - 2016 | 15 endoscopists<br><br>Endoscopists were dichotomized into high-quality screening defined by ADR ≥25% vs. low-quality screening defined by <25%. | Screening<br><br>3 031 COL | ADR | Categorical variables and continuous variables were calculated and compared by two-sided Fisher's exact test and two-sided t-test with p value ≤ 0.05. In Pearson's correlation, 0.3<r<0.7 represented moderate correlation and r > 0.7 was considered strong correlation.<br><br>Overall (mean) CRC-ADR: 29.1%.<br><br>ADR significantly correlated with CRC-ADR: r=0.74 (p=0.002)<br><br>High quality S-ADR similar to high quality in CRC-ADR: S-ADR 33.4% (SD= 5.9%) vs. CRC-ADR 37.7 (SD= 8%) p=0.22<br><br>LQD had similar S-ADR and CRC-ADR: 20.2% vs. 20.1% (p=0.99) |

**Abbreviations:** ADR, adenoma detection rate; AMR, adenoma miss rate; APC, adenomas per colonoscopy; APP, adenomas per positive participant; CI, confidence interval; COL, colonoscopies; CRC, colorectal cancer; CRC-ADR, colorectal cancer adenoma detection rate; CRSPDR, clinically relevant serrated polyp detection rate; CSSDR, clinically significant serrated polyp detection rate; CSSP, clinically significant serrated polyps; CV, coefficient of variation; FIT, fecal immunochemical test; FOBT, fecal occult blood test; HR, high risk; HRADR, high-risk adenoma detection rate; IQR, interquartile range; LQD, low-quality detectors; NAADR, nonadvanced adenoma detection rate; PCCRC, post-colonoscopy colorectal cancer; PDR, polyp detection rate; PSPDR, proximal serrated polyp detection rate; S-ADR, screening adenoma detection rate; SSPDR: sessile serrated polyp detection rate, SD, standard deviation; SPDR, serrated polyp detection rate.

**Definitions:**

**Adenoma detection rate (ADR)**: Calculated by dividing the total number of patients with at least one histologically confirmed adenoma, by the total number of patients undergoing screening or surveillance procedures.

**Adenoma miss rate (AMR):** Calculated as the number of adenomas missed in the first colonoscopy divided by the total number of adenomas detected during both the first and second colonoscopies.

**PDR:** calculated as the number of participants with ≥ 1 polyp including adenoma detected during the first colonoscopy divided by the number of first colonoscopies

**High risk adenoma detection rate (HRADR):** Calculated by dividing the total number of patients with at least one of the following three criteria: (1) any sized TVA or VA or adenoma with HGD, (2) adenoma ≥ 10 mm in size or (3) presence of three or more adenomas of any size, by the total number of patients undergoing screening colonoscopy.

**Advanced adenoma detection rate (advanced-ADR):** Calculated by dividing the total number of advanced adenoma (>10mm in size, have villous histology or high-grade dysplasia) by the total number of screening colonoscopies done by one endoscopist.

**Advanced adenoma detection rate (advanced-ADR-1):** Calculated by dividing the total number of patients having one or more AAs by a total number of screening colonoscopies done by one endoscopist.

**Advanced adenoma detection rate (advanced-ADR-2):** Calculated by dividing the total number of patients having one or more AAs or three or

more adenomas of any size by a total number of screening colonoscopies done by one endoscopist.
**Nonadvanced adenomas detection rate (nonadvanced-ADR):** Calculated by dividing the total number of adenomas that does not meet any of the advanced adenoma mentioned features by the total number of procedures done by one endoscopist.
**Adenoma per colonoscopy (APC):** Calculated by dividing the total number of adenomas by the total number of screening colonoscopies done by one endoscopist.
**Adenomas per positive participant (APP):** Calculated by dividing the total number of adenomas by the total number of patients with at least single adenoma detected by one endoscopist.
**Adenoma detection rate-plus (ADR-Plus):** Calculated by the mean number of adenomas found after the first adenoma in procedures in which one or more adenomas detected by one endoscopist.
**CRC-ADR:** Calculated by dividing the total number of patients with at least one histologically confirmed adenoma, by the total number of patients undergoing first surveillance colonoscopy for each endoscopist.
**CSSP:** Sessile serrated adenomas/polyps or traditional serrated adenomas; hyperplastic polyps (HP) measuring ≥5 mm and proximal to the splenic flexure; or HP measuring ≥10 mm anywhere in the colon.
**CSSDR:** The number of colonoscopies with at least one CSSP divided by the total number of colonoscopies.

## Table 4.21. Study Characteristics – Withdrawal Times -4 RCTs, 9 Cohort.

| Study | Design/ Study period/ Jurisdiction | Data Source | Definition | Number of Patients/ Colonoscopies/ Endoscopists | Indication for Colonoscopy | Age | Aims | Outcomes |
|---|---|---|---|---|---|---|---|---|
| Desai, 2023 (131) | RCT<br><br>Multi centre<br><br>March 2018-June 2022 | 3 academic tertiary care facilities in Kansas City, Missouri, Indianapolis, Indiana, and Cleveland, Ohio | A clean inspection time among all colonoscopies in which the times required to clean bowel segments and for polyp resection were excluded from the total procedure time | 1142 pts<br><br>13 endoscopists | Screening or diagnosis | 50-80 years<br>62.3 ± 8.9 years (mean± SD) | To examine the relationship of WT and ADR and to assess whether a longer examination time would yield a higher ADR. | ADR<br>SDR HRADR<br>APC |
| Zhao, 2023 (132) | RCT<br><br>Multi-centre<br><br>March 2021-December 2021 | 11 tertiary hospitals | The designated 6-/9-minuteWT was equally divided into 3 parts (two-thirds minutes) for each segment withdrawal, with actual WTs recorded. The reinsertion time and related time for biopsy or polypectomy was subtracted from WT. | 733 participants<br><br>15 endoscopists | Screening | 40-75 years | To determine the effect of a mean 9-minute WT on AMR and ADR | AMR<br>AAMR<br>ADR<br>AADR |

| Study | Design/ Study period/ Jurisdiction | Data Source | Definition | Number of Patients/ Colonoscopies/ Endoscopists | Indication for Colonoscopy | Age | Aims | Outcomes |
|---|---|---|---|---|---|---|---|---|
| Mangas-Sanjuan, 2022 (138) | Retrospective study<br><br>Multi-centre<br><br>February 2016-Decemer 2017 | 13 centers in Spain (nested within the QUALISCOPIA project) | Considered only in procedures without biopsy or therapy and calculated as the time from achievement of cecal intubation until the colonoscope was extracted through the anus | 12,932 colonoscopies<br><br>96 endoscopists | Screening or diagnosis | 40-80 years<br><br>41.9 ± 9.8 years (mean ± SD) | To analyze procedure- and endoscopist-related factors associated with detection of colorectal lesions and whether these factors have a similar influence in the context of different colonoscopy indications: abnormal FIT and post-polypectomy surveillance colonoscopies | ADR<br>APCR<br>HRADR SDR<br>SPPCR |
| Sekiguchi, 2022 (140) | Retrospective cohort<br><br>Multi-centre<br><br>March 2014-December 2020 | Colonoscopy procedures were performed in 33 hospitals in 18 regions of Sweden | Time required to withdraw the scope from the cecum to the anus, not including time required for polypectomy; divided into ≥ 6 and < 6 min | 16,552 colonoscopies<br><br>142 endoscopists | Screening or diagnosis | ≥ 60 years<br><br>61 (median, range:60-65) | To investigate lesion detection rates during colonoscopies and the associated factors in the SCREEning of Swedish COlons (SCREESCO) study | CRC DR<br>ADR<br>HRADR<br>SDR |
| Zhao, 2022 (133)<br><br>China | RCT<br><br>Multicentre<br><br>January 2018 – July 2019 | 12 endoscopy centres in China | The length of time taken to remove the colonoscope once the cecum or terminal ileum has been reached. The time for biopsy and polypectomy excluded from the WT | 1027 patients<br><br>6 minutes: 513<br>9 minutes: 514 | Screening, surveillance, or diagnosis | Outpatients aged 40–85 years | To determine whether a 9-minute WT is superior to the 6-minute standard regarding ADR. | ADR<br>PDR<br>APC<br>HRADR<br>SDR<br>Rate of CRC<br>Adverse events<br>Adverse events |

| Study | Design/ Study period/ Jurisdiction | Data Source | Definition | Number of Patients/ Colonoscopies/ Endoscopists | Indication for Colonoscopy | Age | Aims | Outcomes |
|---|---|---|---|---|---|---|---|---|
| Coghlan, 2020 (130)<br><br>Argentina | RCT<br><br>Single centre<br><br>February 2013 – June 2014 and April 2016 – October 2016 | Hospital Universitario Austral | The colonoscopy withdrawal was timed from the moment of cecal intubation until the extraction of the colonoscope through the anus, excluding time to remove polyps. | 1149 patients<br><br>573 fixed WT, 576 conventional WT<br><br>6 endoscopists | Screening | 50-75 years<br><br>57 ± 6 years (mean ± SD) | To find ways to reduce the number of lesions missed in the proximal segments of the colon assessing the difference in ADR between two colonoscopic withdrawal timed techniques (fixed time – specified # min in each segment vs. conventional withdrawal time – 6 mins for whole colon). | ADR |
| Shiha, 2021 (142)<br><br>UK | Retrospective study<br><br>Multicentre<br><br>January 2016 – December 2019<br><br>Sheffield Teaching Hospitals | Electronic Document and Records Management System (EDMS) was used for data retrieval including the WT and the presence of polyps. Extracted data from NED (National Endoscopy Database) using EDMS. | WT is the time spent cautiously inspecting the colonic folds while withdrawing the scope. | 8783 COL<br><br>25 endoscopists | Diagnosis | NR | To assess whether WT changed since the introduction of NED (to be used to ensure high-quality service and monitoring) and whether WT affected PDR | PDR |
| Choi, 2021 (134) | Retrospective study | Seoul National University | The WT was defined as the time the scope arrived at the cecum | 5721 cases<br><br>16 endoscopists | Screening or surveillance | 50-75 years | To evaluate the effects of bowel preparation, | ADR<br>PDR |

| Study | Design/ Study period/ Jurisdiction | Data Source | Definition | Number of Patients/ Colonoscopies/ Endoscopists | Indication for Colonoscopy | Age | Aims | Outcomes |
|---|---|---|---|---|---|---|---|---|
| Korea | Single centre<br><br>September 2015 – August 2016 | Hospital Healthcare System Gangnam Center electronic medical records | to the time the scope was removed from the anus, excluding the time elapsed during biopsy/ polyp removal. | | | 58.6 ± 6.3 years (mean ± SD) | according to the BBPS, and WT on ADR and PDR in the adequate bowel preparation group. | |
| Jung, 2019 (136)<br><br>Korea | Prospective observational study<br><br>Multicentre<br><br>October 2015 – February 2017 | 10 university hospitals<br><br>All pathology specimens were reviewed by board-certified GI pathologists at each hospital. | Measured the colonoscopy withdrawal times by segment and for the entire colonoscopy, excluding the time for biopsy and polyp removal and to clean and suction retained fluid. | 724 patients<br><br>12 endoscopists | Screening or surveillance | 50-80 years<br><br>59.9 ± 9.8 years (mean ± SD) | To examine the relationship between withdrawal time and ADR/PDR in individual colonic segments to determine the appropriate withdrawal times for the right-sided, proximal, and left-sided colon segments. | ADR<br>PDR<br>SDR<br>APC<br>Sessile polyps<br>Flat polyps |
| Patel, 2018 (139)<br><br>USA | Retrospective observational study<br><br>Single centre<br><br>January 2014 – August 2015 | NorthShore University Health System<br><br>Data extracted from clinical enterprise data warehouse Used natural language processing (NLP) tool. | NPL notes were validated using randomly selected subsets of notes with manual annotation.<br><br>Withdrawal time was defined as the time of cecal intubation to the time of colonoscope removal from the anus. The mean withdrawal time was calculated from colonoscopy examinations without biopsies or polypectomies performed. | 31,558 COL 31,061 patients<br><br>42 endoscopists | Screening or diagnosis | 50-75 years<br><br>59.4 ± 7.0 years (mean ± SD) | To identify a functional threshold withdrawal time associated with both increased PSP-DR and ADR, which may serve in the future as a quality measure of colonoscopy performance. | ADR<br>PSP-DR |

| Study | Design/ Study period/ Jurisdiction | Data Source | Definition | Number of Patients/ Colonoscopies/ Endoscopists | Indication for Colonoscopy | Age | Aims | Outcomes |
|---|---|---|---|---|---|---|---|---|
| Kashiwagi, 2017 (137)<br><br>Japan | Retrospective observational cohort study<br><br>Single centre<br><br>April 2015 – March 2016 | Keio University Hospital<br><br>Extracted data from electronic colonoscopy databases (Olympus Medical System) | WT was defined as the time taken to withdraw the colonoscopy from the cecal to the anus and recorded as the nearest whole time in unit of one minute.<br><br>Only complete colonoscopies during which no polyps were removed or biopsied were included in analysis to remove the impact of biopsy or therapeutic maneuvers on the procedure duration | 1008 participants for CRC screening<br><br>880 divided into 2 groups:<br>626 no polyp detected<br>254 polyp detected<br><br># Endoscopists -NR | Screening | NR<br><br>57.9 ± 11.6 years (mean ± SD) | To analyze the predicting factors with PDR as a surrogate for ADR by using comprehensive health checkup data, and assess the correlation between PDR per each colonic segment and WT, and factors influencing WT. | PDR |
| Choung, 2016 (135)<br><br>South Korea | Cross-sectional study<br><br>Single centre<br><br>June 15, 2012 – August 16, 2012 | Chonbuk National University Hospital Endoscopy Centre<br><br>Assistant nurse recorded the WT times and checked time-delaying factors during the procedure. | None.<br>WT was defined as the time period from cecal identification to the time when the colonoscopy was withdrawn across the anus. | 665 patients<br><br>12 gastroenterologists | Screening | 50-75 years<br><br>59.2 years (mean) | To evaluate if withdrawal time is a useful index in spite of differences in gastroenterologists' ability and if there are other quality indicators of colonoscopy. | ADR<br>PPR<br>CIR |
| Shaukat, 2015 (141) | Retrospective study | Minnesota Cancer | Ascertainment was done by randomly | 76,810 COL<br><br>51 endoscopists | Screening | ≥50 years | To study the relationships between withdrawal | Interval cancers<br>ADR |

| Study | Design/ Study period/ Jurisdiction | Data Source | Definition | Number of Patients/ Colonoscopies/ Endoscopists | Indication for Colonoscopy | Age | Aims | Outcomes |
|---|---|---|---|---|---|---|---|---|
| USA | Multicentre<br><br>January 2004 – December 2014 | Surveillance System<br><br>Extracted data from the electronic medical record (NextGen System) | selecting 1% of all database records and performing manual chart review of the colonoscopy and pathology reports. Agreement between extracted data and information in the chart was 99%. Mean withdrawal time for a physician was measured from the time the endoscopist announced he or she was starting to withdraw until removal of the colonoscope from the patient in examinations where no polyps were found. | | | 58 ± 7.8 years (mean ± SD) | time, ADR, and the incidence of subsequent CRC in a community gastroenterology practice. | |

**Abbreviations:** ADR, adenoma detection rate; APC, adenomas per colonoscopy; BBPS, Boston Bowel Preparation Scale; COL, colonoscopies; CRC, colorectal cancer; CWT, colonoscopy withdrawal time; EDMS, Electronic Document and Records Management System; FIT, faecal immunochemical test; NED, National Endoscopy Database; PDR, polyp detection rate; PSPDR, proximal serrated polyp detection rate; RCT, randomized controlled trial; SD, standard deviation; SPDR, serrated lesion detection rate; WT, withdrawal time; USA, United States of America.

## Table 4.22. Withdrawal Times Validation Tables.

| Study | Aims | Age of Inclusion | Withdrawal Time | Benchmarking/targeting |
|---|---|---|---|---|
| Rees, 2016 (39)<br><br>SR | To provide supporting evidence for new indicators and standards, and to demonstrate the value and importance of each of the measures. | > 18 years | 14 studies | Minimum: mean WT of 6 min for negative procedures.<br>Aspirational: mean WT of 10 min for negative procedures.<br>WTs should be routinely recorded and audited. |

| Study | Aims | Age of Inclusion | Withdrawal Time | Benchmarking/targeting |
|---|---|---|---|---|
| Desai, 2023 (131)<br><br>RCT<br><br>Multi centre<br><br>March 2018-June 2022 | To examine the relationship of WT and ADR and to assess whether a longer examination time would yield a higher detection rate | 50-80 years<br><br>62.3 ± 8.9 years (mean± SD) | Screening: median WT = 9.0 minutes (IQR, 3.3): ADR =49.6%,<br>• Surveillance: median WT= 9.3 minutes (IQR, 4.3): ADR = 63.9%. ADR increased with WT from 6 minutes to 13 minutes, but not after (50.4% vs 76.6%, p < .01)<br>• For each 1-minute increase in WT, there was 6% higher odds of detecting an additional patient with an adenoma (OR, 1.06; 95% CI, 1.02-1.10; p=0.004). | None |
| Zhao, 2023 (132)<br><br>RCT<br><br>Multi-centre<br><br>March 2021-December 2021 | To determine the effect of a mean 9-minute WT on AMR and ADR | 40-75 years | 9 min WT first vs 6 min WT first<br>AMR: 14.5 vs. 36.6%, p<0.001<br>AAMR: 5.3% vs. 46.9%. p<0.001<br>Rate of shortening surveillance interval: 7.7% vs. 16.1 % p<0.001 | Nine-minute WT deserves to be incorporated into the current panel of indicators to optimize colonoscopy quality. |
| Mangas-Sanjuan, 2022 (138)<br><br>Multi-centre<br><br>February 2016-Decemer 2017 | To analyze procedure- and endoscopist-related factors associated with detection of colorectal lesions and whether these factors have a similar influence in the context of different colonoscopy indications: abnormal FIT and post-polypectomy surveillance colonoscopies | 40-80 years<br><br>41.9 ± 9.8 years (mean ± SD) | WT was associated with higher ADR and SDR (p<0.001)<br>WT: median 8 min (25-75th percentile 6-10 min)<br><br>Multivariate analysis of WT associations:<br><br>ADR: OR 1.39 (95% CI,1.34-1.43, p<0.001)<br>APCR: β =0.146 (95% CI, 0.128-0.164) p< 0.001)<br>HRADR: OR=1.36 (95% CI, 1.30-1.41, p<0.001)<br>SDR: OR=1.17 (95% CI, 1.13-1.22, p<0.001)<br>SPPCR: β=0.0181(95% CI, 0.145-0.216. p<0.001) | None |
| Sekiguchi, 2022 (140)<br><br>Multi-centre<br><br>March 2014-December 2020 | To investigate lesion detection rates during colonoscopies and the associated factors in the SCREEning of Swedish COlons (SCREESCO) study | ≥ 60 years<br><br>61 (median, range:60-65) | WT ≥ 6 min: ADR= 38.9%<br>WT ≤ 6 min: ADR= 21.6% p<0.001 | None |
| Zhao, 2022 (133)<br><br>RCT | To determine whether a 9-minute WT is superior to the 6-minute standard regarding ADR. | Outpatients aged 40–85 years | Overall:<br>ADR: 6 min vs. 9 min WT: 27.1% vs. 36.6%, p=0.001<br>RR=1.35 (95% CI, 1.13-1.62) | Recommended: prolonging WT from 6 minutes to 9 minutes |

| Study | Aims | Age of Inclusion | Withdrawal Time | Benchmarking/targeting |
|---|---|---|---|---|
| Multi-centre<br><br>January 2018 – July 2019 | | 6 minutes: 56.5 ± 9.6 years (mean ± SD)<br><br>9 minutes: 56.8 ± 9.8 years (mean ± SD) | ADR for Screening and Surveillance: NS<br>ADR Diagnosis: 6 vs. 9 min: 24.4% vs. 35.2%, p=0.02<br><br>Overall:<br>PDR: 6 vs. 9 min WT: 47.8% vs. 58%, p=0.001<br>APC: 6 vs. 9 min WT: 0.4 (± 0.7) vs. 0.5 (± 0.7), p=0.008<br><br>No significant difference for overall rate of CRC, HRADR, SDR, satisfaction, discomfort, or adverse events. | |
| Coghlan, 2020 (130)<br><br>RCT<br><br>Single centre<br><br>February 2013 – June 2014 and April 2016 – October 2016 | To find ways to reduce the number of lesions missed in the proximal segments of the colon assessing the difference in ADR between two colonoscopic withdrawal timed techniques.<br><br>Group A: fixed WT: minimum of 2 min in the cecum and ascending colon, 1 min in the transverse colon, and no less than 3 min in the left colon and rectum<br><br>Group B: conventional WT: at least 6 minutes | 50 -75 years<br><br>57 ± 6 years (mean ± SD) | Group A WT (mean): 7 min (SD=2)<br>Group B WT (mean): 7 min (SD=1), p=0.16<br><br>Overall ADR (mean): 41%<br>Group A ADR (mean): 42.1%<br>Group B ADR (mean): 39.8%, p=0.43<br><br>Correlation between WT and presence of any:<br>colonic lesions:<br>cOR=1.20 (CI 95%, 1.09 – 1.30), p=0.001<br>aOR=1.17 (CI 95% 1.07 – 1.28), p=0.001<br><br>proximal lesions:<br>cOR=1.17 (CI 95% 1.07 – 1.27), p=0.001<br>aOR=1.15 (CI 95% 1.05 – 1.26), p=0.002<br><br>serrated lesions:<br>cOR=1.17 (CI 95% 1.04 – 1.30), p=0.01<br>aOR=1.17 (CI 95% 1.04 – 1.31), p=0.01 | None |
| Shiha, 2021 (142)<br><br>Retrospective study<br><br>Multicentre<br><br>January 2016 – December 2019 | To assess whether WT changed since the introduction of National Endoscopy Database (NED) and whether WT affected PDR. | NR | PreNED WT (mean): 7.66 min (SD ±2.44)<br>PostNED WT (mean): 9.25 min (SD ±2.16), p=0.0001<br><br>PreNED ADR (mean): 29.9%<br>PostNED ADR (mean): 28.3%, p=0.64<br><br>Positive correlation between WT and ADR in PreNED (r=0.38, p=0.05) and PostNED (r=0.50, p=0.01)<br><br>72% of endoscopists (18/25) had WT >6 min in PreNED vs. 100% (25/25) in PostNED | None |
| Choi, 2021 (134) | To evaluate the effects of bowel preparation, | 50-75 years | WT (mean): 8.2 ± 3.0 min | None |

| Study | Aims | Age of Inclusion | Withdrawal Time | Benchmarking/targeting |
|---|---|---|---|---|
| Retrospective study<br><br>Single centre<br><br>September 2015 – August 2016 | according to the BBPS, and WT on ADR and PDR in the adequate bowel preparation group. | 58.6 ± 6.3 years (mean ± SD) | Associations:<br>WT (min) and ADR:<br>(univariate) OR, 1.04; (95% CI 1.02–1.06, p<0.001)<br>(multivariate) OR=1.05; (95% CI, 1.02-1.07), p=0.002<br><br>WT (min) and PDR:<br>(univariate) OR, 1.09 (95% CI, 1.06-1.12), p<0.001<br>(multivariate) OR, 1.05 (95% CI, 1.02-1.07), p=0.002 | |
| Jung, 2019 (136)<br><br>Prospective observational study<br><br>Multicentre<br><br>October 2015 – February 2017 | To examine the relationship between withdrawal time and ADR/PDR in individual colonic segments. | 50-80 years<br><br>59.9 ± 9.8 years (mean ± SD) | WT (mean):<br>right-sided colon: 3.1 ± 1.9 min<br>proximal colon: 5.3 ± 2.6 min<br>left-sided colon: 3.8 ± 2.0 min<br>whole colon: 9.1 ± 3.7 min<br><br>Times derived by statistical significance of ADR and PDR<br>Right-sided colon segment: ≥2 vs. <2 minutes:<br>ADR (33.2% vs. 13.7%, p<0.001),<br>PDR (41.1% vs. 16.7%, p<0.001),<br>SDR (13.9% vs. 3.6%, p<0.001),<br>APC (0.52 ± 0.04 vs. 0.20 ± 0.04, p<0.001)<br>Sessile (0.22 ± 0.56 vs. 0.59 ± 1.08, p<0.001)<br><br>Proximal colon segment: ≥4 vs. <4 minutes:<br>ADR (47.4% vs. 18.5%, p<0.001),<br>PDR (56.0% vs. 24.2%, p<0.001),<br>SDR (19.0% vs. 7.7%, p<0.001),<br>APC (0.90 ± 0.07 vs. 0.30 ± 0.05, p<0.001)<br>Sessile (0.37 ± 0.84 vs. 0.97 ± 1.45, p<0.001)<br>Flat (0.04 ± 0.26 vs. 0.13 ± 0.47, p=0.006)<br><br>Left-sided colon segment: ≥3 vs. <3 minutes:<br>ADR (32.9% vs. 14.6%, p<0.001),<br>PDR (48.4% vs. 18.6%, p<0.001),<br>APC (0.51 ± 0.04 vs. 0.20 ± 0.04, p<0.001)<br>Sessile (0.19 ± 0.51 vs. 0.67 ± 1.02, p<0.001) | Colonoscopy withdrawal times of at least 2 minutes in the right side of the colon, 4 minutes in the proximal colon, and 3 minutes in the left side of the colon. |
| Patel, 2018 (139)<br><br>Retrospective observational study | To identify a functional threshold withdrawal time associated with both increased PSP-DR and ADR, which may serve in the future as a | 50-75 years<br><br>59.4 ± 7.0 years (mean ± SD) | WT (mean): 9.08 (SD ± 3.33 min)<br>WT (median): 7 mins (25%)<br><br>ADR (mean): 35.7% (SD ± 9.5);<br>significantly correlated with WT: r=0.76, p≤0.001 | Recommended that negative colonoscopy withdrawal time of greater than 11 min be used as a threshold in future guidelines if PSP-DR is not met. |

| Study | Aims | Age of Inclusion | Withdrawal Time | Benchmarking/targeting |
|---|---|---|---|---|
| Single centre<br><br>January 2014 – August 2015 | quality measure of colonoscopy performance.<br><br>Examined the detection difference of increasing withdrawal time, by each additional incremental full minute starting at 6 min. | | PSPDR (mean): 10.4% (SD± 5.4);<br>significantly correlated with WT: r=0.42, p=0.043<br><br>The 11-minute mark was when there were meaningful differences in detection rates.<br><br>Comparing WT <11 vs. ≥11 min:<br>ADR: 31.5% vs.44.0%; OR, 1.65 (95% CI, 1.09-2.51)<br>PSP-DR: 8.6% vs.13.9; OR, 1.81 (95% CI, 1.06-3.08)<br>(16 vs. 8 endoscopists) | |
| Kashiwagi, 2017 (137)<br><br>Retrospective observational cohort study<br><br>Single centre<br><br>April 2015 – March 2016 | To analyze the predicting factors with PDR as a surrogate for ADR by using comprehensive health checkup data, and assess the correlation between PDR per each colonic segment and WT, and factors influencing WT. | NR<br><br>57.9 ± 11.6 years (mean ± SD) | Overall WT (mean): 5.5 ± 2.0 min (range: 1 – 23)<br><br>WT was significantly associated with polyp detection<br>5.2 ± 1.9 vs. 6.1 ± 2.3 min: OR 1.217 (95% CI, 1.127, 1.314, p=0.000)<br><br>PDR increased with WT time: from 3 min to 9 min<br>correlation: r= 0.989 (p=0.000)<br><br>WT ≥ 6 min had a higher PDR than WT <6 min in all of five segments, especially in transverse (2.3 times, p=0.004) and sigmoid colon (2.1 times, p=0.001) | Recommends taking more time up to 9 min of WT. |
| Choung, 2016 (135)<br><br>Cross-sectional study<br><br>Single centre<br><br>June 15, 2012 – August 16, 2012 | To evaluate if withdrawal time is a useful index despite differences in endoscopists' ability and if there are other quality indicators of colonoscopy.<br>Experienced group (n=6) = over 1000 colonoscopies, confirmed board-certified after training: Under experienced group (n=6) = less than 1000 colonoscopies, in fellowship training | 50-75 years<br><br>59.2 years (mean) | Overall:<br>ADR (mean): 49.7% (range 27-68%)<br>WT (mean): 8.45 (SD=6.64) min<br>ADR and WT correlation: (r=0.401, p=0.360)<br><br>Experienced endoscopists vs. under-experienced endoscopists:<br><br>ADR (mean):55.8% vs. 42.9%, p=0.048<br>WT (mean): 6.83 vs. 6.53 min, p=0.185<br>Correlation: (r=-0.152, p=0.584) vs. (r= 0.827, p=0.005) | Maintaining a withdrawal time for more than 6 minutes is important particularly for under-experienced endoscopists. |

| Study | Aims | Age of Inclusion | Withdrawal Time | Benchmarking/targeting |
|---|---|---|---|---|
| Shaukat, 2015 (141)<br><br>Retrospective study<br><br>Multicentre<br><br>January 2004 – December 2009 | To study the relationships between withdrawal time, ADR, and the incidence of subsequent CRC in a community gastroenterology practice. | ≥50 years<br><br>58 ± 7.8 years (mean ± SD) | WT (mean): 8.3 min (SD ±2.8) (range: 3.9 – 14.4)<br><br>Annual WT (mean): 8.6 min (SD ±1.7)<br>The physicians' annual WT and ADRs were positively related: 3.6% increase in ADR per minute increase in WT (95% CI,2.4-4.8; p<0.0001)<br><br>Comparing WT <6 minutes vs. >6 minutes (threshold selected based on recent guidelines), the CRC incidence rate ratio was 2.3 (95% CI, 1.5-3.5, p<0.0001)<br><br>Noted a nonlinear relationship between withdrawal time and interval CRC. Starting at a WT of 8.0 minutes, the CRC incidence rate increased as the physician's withdrawal time decreased. | None<br>Suggests that the incidence of interval CRC was lowest and relatively constant when a physician's annual mean withdrawal time was ≥ 8 minutes. |

**Abbreviations:** ADR, adenoma detection rate; APC, adenomas per colonoscopy; aOR, adjusted odds ratio; BBPS, Boston Bowel Preparation Scale; COL, colonoscopies; CRC, colorectal cancer; CWT, colonoscopy withdrawal time; EDMS, Electronic Document and Records Management System; NED, National Endoscopy Database; PDR, polyp detection rate; PSP-DR, proximal serrated polyp detection rate; RCT, randomized controlled trial; SD, standard deviation; WT, withdrawal time.

## Table 4.25. Study Characteristics – Cecal Intubation Rate.

| Study | Design/ Study period/ Jurisdiction | Data Source | Definition | Number of Patients/ Colonoscopies/ endoscopists | Indication for Colonoscopy | Age of Inclusion | Aim | Outcomes |
|---|---|---|---|---|---|---|---|---|
| Vemulapalli, 2020 (144)<br><br>USA | Retrospective cohort<br><br>Single centre<br><br>September 2002 – December 2018 | Endoscopic quality programs in Indiana University Hospital and associated outpatient endoscopy units Extracted data from Provation (ProVation Medical) | Cecal intubation defined as fully intubating the cecal caput, with identification of the appendiceal orifice, and or the terminal ileum, and allowing full examination of the medial wall of the cecum | 54,083 procedures<br><br>16 endoscopists | All colonoscopies | >18 years<br><br>Mean: 55.6 years | To investigate stability of CIRs over time. | CIR |

**Abbreviations:** CIR, cecal intubation rate.

**Table 4.26. Cecal Intubation Rate Validation Table.**

| Study | Aim | Indication for colonoscopy | Participants age | CIR results | Benchmarking/targeting |
|---|---|---|---|---|---|
| Rees, 2016 (39)<br><br>SR | To provide supporting evidence for new indicators and standards, and to demonstrate the value and importance of each of the measures. | All colonoscopies | >18 years | 32 studies | Minimal unadjusted cecal intubation 90%. Endoscopists should aspire to achieve 95% unadjusted cecal intubation. Photographic documentation of cecal intubation should be obtained with images taken of clear cecal landmarks or of terminal ileum. |
| Vemulapalli, 2020 (144)<br><br>Retrospective cohort<br><br>Single centre<br><br>September 2002 – December 2018 | To investigate stability of CIRs over time and to determine whether continuous measurement of CIR is useful in high performers.<br><br>Cases need not be counted if they were aborted for inadequate preparation or if there was no intent to reach the cecum. | All colonoscopies, excluding those with poor preparation and those where intent was not to reach the cecum.<br><br>Sensitivity analysis includes those with poor bowel preparation. | >18 years<br><br>Mean: 55.6 years | Overall (Adjusted) CIR (mean): 99.4%<br><br>Unadjusted CIR (mean): 98%<br><br>None of the 16 physicians had a CIR <96.6% in any year<br><br>Sensitivity analysis CIR (mean): 98% | Physicians with CIR ≥99% need to have only 84 examinations reviewed to establish CIR is >95% within ± 3%.<br><br>Supports target of ≥95% unadjusted. |

**Abbreviations:** CIR, cecal intubation rate. Unadjusted: rate not adjusted for bowel preparation or impassable strictures.

**Table 4.27. Study Characteristics – Bowel Preparation.**

| Study | Design/ Study period/ Jurisdiction | Data Source | Ascertainment | Number of Patients/ Colonoscopies/ endoscopists | Indication for Colonoscopy | Age | Aims | Outcomes |
|---|---|---|---|---|---|---|---|---|
| Kastenburg, 2018 (147) | Review of bowel preparation quality scales | NR | NR | Summarized and compared validated scales Aronchick Scale; the BBPS; Ottawa Bowel Preparation Scale; the Harefield Cleansing Scale; Chicago Bowel Preparation Scale | NA | NA | To summarize and discuss currently available bowel preparation quality scales and highlight the benefits of using a reliable and validated scale in both clinical practice and clinical trials of bowel preparation agents. | |

| Study | Design/ Study period/ Jurisdiction | Data Source | Ascertainment | Number of Patients/ Colonoscopies/ endoscopists | Indication for Colonoscopy | Age | Aims | Outcomes |
|---|---|---|---|---|---|---|---|---|
| Sulz, 2016 (146) | Systematic review | Pubmed up to November 2014 | Review and data extraction of each study was performed by two authors, discrepancies were resolved after discussion | 27 studies:<br>21 comparative studies, 6 repeat -colonoscopy studies | NR | NR | To summarize the effects of bowel preparation on detection of adenomas, advanced adenomas and colorectal cancer | ADR<br>HRADR<br>CRC |
| Pantelon Sanchez, 2022 (150) | Prospective study (nested in a multicenter RCT)<br><br>Multi-centre<br><br>January 2017 - June 2018 | Research electronic data capture (REDCap) was used to collect and manage data collected | The pathologic reports were used for histological assessment. | >1000 COL<br>651 pts | Screening, diagnostic, surveillance | 18-85 years<br><br>Median, 63.3 years (53.5-69.9 years) | To assess the prevalence of missed neoplastic lesions in patients with inadequate BP detected in an early repeat colonoscopy | ADR<br>HRADR<br>SPDR<br>AMR |
| Kimpel, 2022 (155) | Qualitative descriptive study<br><br>Single centre<br><br>June 2018 – June 2019<br><br>Vanderbilt University Medical Center | Survey or interview REDCap electronic data capture tools | Coding was performed by two trained coders.<br>Each transcript was independently coded twice and reviewed by coders to reach consensus for any disagreements. | 59 patients<br><br>Number of endoscopists: NR | NR | ≥18 years<br><br>Mean: 58.2 years (SD=11.8, range=29-82 years) | To explore patients' experiences of inadequate-quality bowel preparation for a colonoscopy; pre-endoscopy education and scheduling; colonoscopy preparation; procedure setting; emotional responses to the process; and unexpected need for a repeat procedure and preparation. | Anxiety<br>Verbal instruction clarity<br>Written instruction clarity<br>Amount of laxative consumed |
| Zhou, 2021 (153) | Prospective, observational study<br><br>Single centre<br><br>May 11, 2020 - August 10, 2020 | Withdrawal videos were collected and divided into three colon segments which were then reviewed by three | For internal and external video validation, the videos were processed into 1 frame per second. Each frame was evaluated by | 616 patients<br><br>Number of endoscopists: NR | Screening, diagnostic, surveillance | 18 – 75 years<br><br>Mean: 53 years (SD=12.45 years) | To investigate whether there was a statistically inverse relationship between the e-BBPS score and the ADR, and to determine the threshold of e-BBPS score for adequate bowel preparation in colonoscopy screening. | ADR<br>PDR |

| Study | Design/ Study period/ Jurisdiction | Data Source | Ascertainment | Number of Patients/ Colonoscopies/ endoscopists | Indication for Colonoscopy | Age | Aims | Outcomes |
|---|---|---|---|---|---|---|---|---|
| | Endoscopy Center of Wuhan University | endoscopists who recorded their BBPS scores independently to compare them with the e-BBPS score. | the three endoscopists, and only when two or more endoscopists came to a consensus was the image eligible in the corresponding category. | | | | Non-proprietary system. | |
| Choi, 2021 (134) | Prospective, observational study<br><br>Single centre<br><br>September 2015 – August 2016<br><br>Seoul National University Hospital Healthcare System Gangnam Center | Scored by endoscopist. All the endoscopists were educated until they showed high concordance rates in bowel preparation scoring and follow-up plans | None. | 5721 COL<br><br>16 endoscopists | Screening (10.7%)<br>Surveillance (89.3%) | 50 – 75 years<br><br>Mean: 58.6 years (SD=6.3 years) | To evaluate the effects of bowel preparation, according to the BBPS, and CWT on ADR and PDR in the adequate bowel preparation group. | ADR<br>PDR |
| Guo, 2019 (148) | Cross-sectional study<br><br>Single centre<br><br>June 1, 2016 – October 31, 2016 | Demographic and procedural data for each patient were collected at time of colonoscopy. | None. | 5798 COL<br><br>42 endoscopists | Screening, surveillance, and diagnostic (84.7%)<br><br>Therapeutic purposes (15.3%) | ≥18 years<br><br>Mean: 61.4 years (SD=10.3 years) | To investigate the quality of bowel preparation segmentally and its effect on ADR and HRADR at corresponding bowel segments. | ADR<br>HRADR |

| Study | Design/ Study period/ Jurisdiction | Data Source | Ascertainment | Number of Patients/ Colonoscopies/ endoscopists | Indication for Colonoscopy | Age | Aims | Outcomes |
|---|---|---|---|---|---|---|---|---|
| | Bejing Friendship Hospital | | | | | | | |
| Clark, 2016 (154) | Prospective study<br><br>Single centre<br><br>January 2014 – February 2015<br><br>West Haven Veterans Affairs Medical Center | Characteristics of all polyps were prospectively recorded | All pathologists providing histologic diagnoses were trained in gastrointestinal pathology and were blinded to preparation quality. | 794 patients<br><br>4 endoscopists | Screening (51.7%) Surveillance (48.3%) | 50-75 years<br><br>Mean: 65 years (IQR=57-67 years) | To determine proportions of patients in whom SSPs were detected at different levels of bowel preparation quality, using common validated scoring systems. | SSP |
| Wong, 2016 (152) | Prospective study<br><br>Single centre<br><br>2008 - 2014<br><br>CRC screening program in Hong Kong | The endoscopists rated the quality of bowel preparation during the procedure using the terms included ‘‘excellent,’’ ‘‘good,’’ ‘‘fair,’’ and ‘‘poor’’ | None. | 5470 participants | Screening | 50-70 years<br><br>Mean: 57.71 years (SD=4.88 years) | To evaluate the factors independently associated with the quality of bowel preparation in a large CRC screening population. | ADR<br>HRADR<br>Covariates of BBPS<br>WT<br>CIR |
| Jain, 2015 (149) | Prospective observational cohort study<br><br>Single centre<br><br>2014 | A research associate was present during each procedure to record the BBPS reported by the endoscopist in | None. | 360 participants | Screening | Mean: 59.2 years | To determine HRADR in relation to segmental and composite BBPS’s during colonoscopy. | HRADR |

| Study | Design/ Study period/ Jurisdiction | Data Source | Ascertainment | Number of Patients/ Colonoscopies/ endoscopists | Indication for Colonoscopy | Age | Aims | Outcomes |
|---|---|---|---|---|---|---|---|---|
| | The Brooklyn Hospital Centre | each segment during the procedure | | | | | | |
| Tholey, 2015 (151) | Retrospective observational study<br><br>Single centre<br><br>August 31, 2011 – September 1, 2012<br><br>Thomas Jefferson University | An electronic endoscopic database to identify excellent and good bowel preparation colonoscopies. | Investigators reviewed the pathology report located within the hospital's inpatient electronic medical record. | 5113 COL | Screening (32%)<br>Surveillance (36%)<br>Symptoms (32%) | ≥18 years<br><br>Mean: 59.6 years (SD=12.3 years) | To determine whether Excellent bowel cleansing is superior to Good for the detection of adenomas. | ADR<br>HRADR<br>SSP<br>CRC |

**Abbreviations:** HRADR, advanced adenoma detection rate; ADR, adenoma detection rate; BBPS, Boston Bowel Preparation Scale; COL, colonoscopies; CIR, cecal intubation rate; CRC, colorectal cancer; CWT, colonoscopy withdrawal time; IQR, interquartile range; NA, not applicable; NR, not reported; PDR, polyp detection rate; REDCap, Research Electronic Data Capture; SD, standard deviation; SPDR, serrated polyp detection rate; SSP, sessile serrated polyps; WT, withdrawal time.

## Table 4.28. Bowel Preparation Validation Tables.

| Study | Aims | Age of Inclusion | Bowel Preparation | Benchmarking/targeting |
|---|---|---|---|---|
| Rees, 2016 (39)<br><br>SR | The aim of this paper is to provide supporting evidence for these new indicators and standards, and to demonstrate the value and importance of each of the measures. | NA | 9 studies | Bowel preparation of at least adequate quality to be achieved in 90% of patients.<br>Aspirational: bowel preparation of at least adequate quality to be achieved in 95% of patients.<br>Aspirational: easy to use, validated national bowel preparation scale should be developed. |
| Kastenburg, 2018 (147) | To summarize and discuss currently available bowel preparation quality scales and highlight the benefits of | NA | Compared scales based on quality, colon segment cleansing vs. whole colon, need for washing and | The Boston bowel preparation scale is recommended as the |

| Study | Aims | Age of Inclusion | Bowel Preparation | Benchmarking/targeting |
|---|---|---|---|---|
| | using a reliable and validated scale in both clinical practice and clinical trials of bowel preparation agents. | | suctioning, and reliability (including interrater reliability) and validity data.<br><br>BBPS has been validated in colon segments, scoring is conducted after withdrawal and after all flushing and suctioning of fluid have been completed, has been validated in many studies, has good reliability and interrater reliability. | current standard for use in clinical practice.<br><br>A total BBPS score of ≥ 6 and/or all segment scores ≥ 2 may serve as a threshold or standard to recommend a 10 -year follow-up |
| Sulz, 2016 (146) | To summarize the effects of bowel preparation on ADR, HRADR, CRCDR<br>Reported bowel preparation quality was transformed to the Aronchick scale with its qualities "excellent", "good", "fair", "poor", and "insufficient"<br>or<br>"optimal" (good/excellent), vs. "suboptimal" (fair/poor/insufficient)<br>or<br>"adequate" (good/excellent/fair) vs. "inadequate" (poor/insufficient) | NR | Inadequate vs. adequate bowel preparation<br>ADR: OR, 0.53; 95% CI, 0.46–0.62, p<0.001)<br>HRADR: OR, 0.74; 95% CI, 0.62–0.87, p<0.001<br><br>Suboptimal vs. Optimal bowel preparation:<br>ADR: OR, 0.81; 95% CI, 0.74–0.89, p<0.001<br>HRADR: OR, 0.94; 95% CI, 0.87–1.01, p=0.33 | None |
| Pantelon Sanchez, 2022 (150) | To assess the prevalence of missed neoplastic lesions in patients with inadequate BP detected in an early repeat colonoscopy | 18-85 years<br><br>Median, 63.3 years (53.5-69.9 years) | Total BBPS score, mean (index COL vs. repeat COL): 2.3 (1.8 SD) vs. 7.1 (1.3 SD)<br><br>Proximal colon BBPS score, mean (index COL vs. repeat COL): 0.7 (0.6 SD) vs. 2.3 (0.4 SD)<br><br>Distal colon BBPS score, mean (index COL vs. repeat COL): 0.9 (0.7 SD) vs. 2.4 (0.5 SD)<br><br>On index colonoscopy:<br>ADR: 22% (95% CI, 18.1-26.3%)<br>AADR:7.5% (95% CI 5.2-10.5%)<br>SPDR: 13.6% (95% CI 2-4.1%)<br>DCRC: 0.5% (95% CI,0.1-2%)<br><br>On repeat colonoscopy:<br>ADR: 45.3% (95% CI, 40.5–50.1%)<br>AADR:10.9% (95% CI 8.1–14.3%)<br>SPDR: 14.3% (95% CI 10.9–17.7%)<br>DCRC: 1% (95% CI,0.2-2.5%) | Adequate BP was defined as BBPS segment scores ≥2 for all three segments of the colon |

| Study | Aims | Age of Inclusion | Bowel Preparation | Benchmarking/targeting |
|---|---|---|---|---|
| Kimpel, 2022 (155) | To explore patients' experiences of inadequate-quality bowel preparation for a colonoscopy; pre-endoscopy education and scheduling; colonoscopy preparation; procedure setting; emotional responses to the process; and unexpected need for a repeat procedure and preparation. | ≥18 years<br><br>Mean: 58.2 years (SD=11.8, range=29-82 years) | Inadequate (N=33) vs. adequate (N=26):<br>Experience of anxiety (0-100, N=57): 50 vs. 23, p=0.032 | Developed a framework that organizes main experiential themes and subthemes.<br>Themes:<br>Preparation<br>Implementation<br>Successful outcomes<br>Unsuccessful outcome<br>➢ Response<br>➢ Decision to repeat<br><br>With the context of prior experience, peer influences, understanding the purpose of the colonoscopy and anxious anticipation influencing all of the themes. |
| Zhou, 2021 (153) | To investigate whether there was a statistically inverse relationship between the e-BBPS (automated BBPS) score and the ADR, and to determine the threshold of e-BBPS score for adequate bowel preparation in colonoscopy screening. | 18 – 75 years<br><br>Mean: 53 years (SD=12.45 years) | Significant inverse correlation between e-BBPS score and ADR: r=-0.976, p<0.01<br><br>Scores and ADR:<br>e-BPPS 1 -ADR: 28.57%<br>e-BPPS 2 -ADR: 28.68%<br>e-BPPS 3: ADR: 26.79%<br>e-BPPS 4: ADR: 19.19%<br>e-BPPS 5: ADR: 17.57%<br>e-BPPS 6: ADR: 17.07%<br>e-BPPS 7: ADR: 14.81%<br>e-BPPS 8: ADR: 0%<br><br>Those with a e-BBPS score <3 had significantly higher ADR and PDR than those with a score>3:<br>ADR: 28.03% vs. 15.93%; OR, 0.43, 95% CI, 0.28–0.66, p<0·001<br>PDR: 65.32% vs. 44.44%; OR, 0.36, 95% CI, 0.25–0.52, p<0·001 | The e-BBPS score of 3 was defined as the threshold to achieve an ADR of more than 25% and was applied to analyze lesion detection rate difference. |
| Choi, 2021 (134) | To evaluate the effects of bowel preparation, according to the BBPS, and CWT on ADR and PDR in the adequate bowel preparation group. | 50 – 75 years<br><br>Mean: 58.6 years (SD=6.3 years) | Good BBPS=6,7 vs. Excellent BBPS =8,9<br>ADR:47.3% vs. 45.0%, p=0.035<br>PDR: 73.7% vs. 69.5%, p=0.004 | BBPS score ≥6 was defined as adequate bowel preparation.<br>For categorical analysis, a BBPS score of 6 or 7 was |

| Study | Aims | Age of Inclusion | Bowel Preparation | Benchmarking/targeting |
|---|---|---|---|---|
| | | | | defined as good and a score of 8 or 9 was defined as excellent bowel preparation |
| Guo, 2019 (148) | To investigate the quality of bowel preparation segmentally and its effect on ADR and HRADR at corresponding bowel segments. | ≥18 years<br><br>Mean: 61.4 years (SD=10.3 years) | Total BBPS score: ADR and HRADR<br>BBPS ≤3: ADR:11.9%; HRADR:3.0%<br>BPPS 4: ADR: 15.4%; HRADR:6.5%<br>BPPS 5: ADR: 20.8%; HRADR:5.5%<br>BPPS 6: ADR: 21.8%; HRADR:8.0%<br>BPPS 7: ADR: 27.8%; HRADR:9.5%<br>BPPS 8: ADR: 28.2%; HRADR:14.2%<br>BPPS 9: ADR: 32.6%; HRADR:17.1%<br>Increasing trend was significant for both ADR, p<0.001; and HRADR p<0.001<br><br>Bowel bubble score: the lower the BBS score (less bubbles) the higher the ADR and HRADR<br><br>When comparing BBPS of individual segment higher score of BBPS shows significantly higher ADR and HRADR (p<0.05) | None |
| Clark, 2016 (154) | To determine proportions of patients in whom SSPs were detected at different levels of bowel preparation quality, using modified Aronchick scale and the BBPS. | 50-75 years<br><br>Mean: 65 years (IQR=57-67 years) | Using the BBPS, the SSPDR in the right colon increased with increasing BBSP segment score.<br>BBSP score for the right colon segment:<br>BBSP 3: SSPDR=9.5% (95% CI, 6.3-13.8) referent<br>BBSP 2: SSPDR=4.7% (95% CI, 2.8-7.4), aOR, 0.50 (95% CI, 0.26-0.94)<br>BBSP 1: SSPDR=1.9% (95% CI, 0.2-6.8), aOR, 0.21 (95% CI, 0.05-0.92) | Should attain optimal preparation quality (Aronchick scale of excellent/good or BBPS segment score of 3), especially in the right colon. |
| Wong, 2016 (152) | To evaluate the factors independently associated with the quality of bowel preparation in a large CRC screening population. | 50-70 years<br><br>Mean: 57.7 years (SD=4.9 years) | Poorer bowel preparation was associated with longer CIR and WT (both p<0.001)<br><br>Compared to excellent bowel preparation:<br>Good:<br>ADR: aOR, 0.354 (95% CI, 0.270–0.464) p<0.001<br>HRADR: aOR, 0.388 (95% CI, 0.220–0.685) p=0.001<br>ADR ≥ 5mm: aOR, 0.428 (95% CI, 0.295–0.621) p<0.001<br>HRADR ≥ 5mm: aOR, 0.363 (95% CI, 0.205–0.643) p=0.001<br>Fair or Poor:<br>ADR: aOR, 0.406 (95% CI, 0.303–0.545) p<0.001<br>HRADR: aOR =0.504 (95% CI, 0.274–0.929) p=0.03<br>ADR ≥ 5mm: aOR, 0.619 (95% CI, 0.420–0.911) p=0.02 | None |

| Study | Aims | Age of Inclusion | Bowel Preparation | Benchmarking/targeting |
|---|---|---|---|---|
| | | | HRADR ≥ 5mm: aOR, 0.497 (0.269–0.918) p=0.03 | |
| Jain, 2015 (149) | To determine HRADR in relation to segmental and composite BBPS's during colonoscopy. | Mean: 59.2 years | Group 0: BBPS 0-3 (poor)<br>Group 1: BBPS 4-6 (suboptimal)<br>Group 2: BBSP 7-9 (adequate)<br><br>HRADR showed a linear trend through Group-0 to 2; with an HRADR of 3.8%, 14.8% and 16.7% respectively.<br><br>HRADR differences:<br>Group 0 and 2 (3.8% vs. 16.7%, p<0.05),<br>Group 1 and 2 (14.8% vs. 16.7%, p<0.05)<br>Group 0 and 1 (3.8% vs. 14.8%, p<0.05) | None |
| Tholey, 2015 (151) | To determine whether Excellent bowel cleansing is superior to Good for the detection of adenomas in their own scale.<br><br>Hypothesized the superiority of Excellent cleansing would be established if ADR were at least 15% higher as compared with Good. Assuming an overall ADR=30%, with Adequate preparations comprised of 70% Good and 30% Excellent, ~4400 colonoscopies were necessary to find a 1.15 RR between groups with 82% power using a 2-sided α=0.05 | ≥18 years<br><br>Mean: 59.6 years (SD=12.3 years) | ADR differences:<br>Excellent and Good (26% vs. 29%)<br>OR (Excellent): 0.97 (0.85, 2.22), P=0.618<br><br>APC differences:<br>Excellent and Good (0.437 vs. 0.499)<br>IRR (Excellent): 0.98 (0.90, 1.07), P=0.705<br><br>HRADR differences:<br>Excellent and Good (0.076 vs. 0.056), IRR 1.368 (1.092, 1.715), P=0.0065<br>SSPs=0.029 vs. 0.019; IRR 1.656 (1.141, 2.403), p=0.0079 | None |

**Abbreviations:** ADR, adenoma detection rate; APC, adenomas per colonoscopy; aOR, adjusted odds ratio; BBPS, Boston Bowel Preparation Scale; BBS, bowel bubble scale; CI, confidence interval; CIR, cecal intubation rate; CRC, colorectal cancer; CWT, colonoscopy withdrawal time; HRADR, High-risk adenoma detection rate; IRR, incident rate ratio; IQR, interquartile range; N, number; NA, not applicable; NR, not reported; NS, not significant; OR, odds ratio; PDR, polyp detection rate; RR, relative risk; SD, standard deviation; SR, systematic review; SSP, sessile serrated polyps; vs., versus; WT, withdrawal time.

**Table 4.29. Study Characteristics – Retroflexion and Second Forward Look on Right Side of Colon.**

| Study | Design/ Study period/ Jurisdiction | Data Source | Ascertainment | Number of Patients/ Colonoscopies/ Endoscopists | Indication for Colonoscopy | Age of Inclusion | Aims | Outcomes |
|---|---|---|---|---|---|---|---|---|
| Desai, 2019 (156)<br><br>USA, UK, Italy | SR (of RCTs and prospective controlled studies)<br><br>Up to January 30, 2018 | PubMed, Medline, Embase, Web of Science, and Cochrane databases | Data of interest were extracted and verified by 3 independent reviewers. | 2,608 patients<br><br>1882 second forward view<br><br>726 retroflexion | Standard colonoscopy | NR<br><br>Mean: 58.3 years; (range, 54.9-62.3) | To assess and compare the yield of second forward view and retroflexion examinations for detection of right-sided adenomas. | AMR<br>Right-sided ADR |
| Ai, 2017 (157)<br><br>China | SR (of RCTs and prospective cohort studies)<br><br>Up to January 2017 | PubMed, Embase, and Cochrane registry of controlled trials | Data of interest was extracted by 1 author and checked for accuracy by another. | 4155 patients | Screening, surveillance or diagnostic | NR<br><br>Mean: approx. 60 years | To assess the results of a second examination of the right side of the colon with forward-view or retroflexion colonoscopy performed immediately after the initial examination. | Right sided ADR<br>PDR |
| Yang, 2022 (160) | Prospective single-center RCT | Collected during procedures | - | 840 patients<br><br>420 retroflexion<br><br>420 control<br><br>3 endoscopists | Screening, surveillance, or diagnostic | 18-80 years<br><br>Retroflexion: (mean): 51.1 (SD=11.9)<br><br>Control: (mean): 50.8 (SD=12.4) | To determine the impact of the second examination of the proximal colon on ADR compared with standard examination | ADR<br>PDR<br>WT<br>BBPS |
| Noagles. 2021 (158)<br><br>Spain | Prospective<br><br>Single centre<br><br>March-June 2017 | Collected during procedures | - | 463 patients<br><br>6 endoscopists | Screening, surveillance, bleeding, diarrhea | >18 years<br><br>Median: 59 years (Range, 22-87) | To assess the additional adenoma detection rate with the RCR attempt | AMR<br>RCR success rate<br>Factors associated with RCR success and safety |
| Nunez Rodriguez, 2020 (159) | RCT<br><br>Multicentre | Collected during procedures | - | 648 patients | Abnormal FIT (>20 ug/g) | 50-69 years | To determine whether retroflexion improved the ADR in the right | AMR<br>RCR success rate |

| Study | Design/ Study period/ Jurisdiction | Data Source | Ascertainment | Number of Patients/ Colonoscopies/ Endoscopists | Indication for Colonoscopy | Age of Inclusion | Aims | Outcomes |
|---|---|---|---|---|---|---|---|---|
| Spain | June-September 2017 | | | 316 proximal retroflexion<br><br>332 forward view<br><br>5 endoscopists | | | colon compared with a forward view in the FIT-based CRC screening programme | Adverse events<br>Change in surveillance recommendations<br>predictors of failed retroflexion |

**Abbreviations:** ADR, adenoma detection rate; AMR, adenoma miss rate; CRC, colorectal cancer; FIT, fecal immunochemical testing; PDR, polyp detection rate; RCR, right colon retroflexion; RCT, randomized controlled trial; SR, systematic review; UK, United Kingdom; USA, United States of America.

**Table 4.30. Retroflexion and Second Forward Look on Right Side of Colon: Validation Tables -3 Systematic Reviews, 2 Studies.**

| Study | Aim / Definition | Indication for colonoscopy | Age of Inclusion | Retroflexion results | Benchmarking/targeting |
|---|---|---|---|---|---|
| Rees, 2016 (39)<br><br>SR | To provide supporting evidence for new indicators and standards, and to demonstrate the value and importance of each of the measures. | All colonoscopies | >18 years | 10 studies -all rectal retroflexion<br>-4 case studies<br>-4 cohort studies<br>-1 flexible sigmoidoscopy<br>-1 unfound | Rectal examination or omission should be recorded in 100% of cases.<br>Rectal retroflexion should be performed in 90% of cases. |
| Desai, 2019 (156)<br><br>SR and Meta-analysis<br><br>5 studies | To assess and compare the yield of SFV and RCR examinations for detection of right-sided adenomas compared to SC<br><br>-4 studies with data on AMR and SFV<br><br>-3 studies with data on AMR and RCR<br><br>-3 studies with SFV and RCR | Standard colonoscopy | NR<br><br>Mean: 58.3 years; (range: 54.9-62.3) | Second examination (SFV or RCR) vs. SC<br><br>R-ADR<br>SFV vs. SC, 33.6% vs. 26.7%; (n=4)<br>Pooled risk difference: 9% (95% CI, 3-15%; $p<0.01$, $I^2=71\%$ $p=0.02$)<br><br>RCR vs. SC, 28.4% vs. 22.7%; (n=3)<br>Pooled risk difference: 6% (95% CI, 3-9%; $p<0.01$)<br><br>R-AMR Pooled estimate:<br>SFV vs. SC: 13.3% (95% CI, 6.6-20%) (n=4)<br>RCR vs. SC: 8.1% (95% CI, 3.7-12.5%) (n=3)<br><br>R-AMR<br>SFV vs. RCR: (n=3) | None |

| Study | Aim / Definition | Indication for colonoscopy | Age of Inclusion | Retroflexion results | Benchmarking/targeting |
|---|---|---|---|---|---|
| | | | | 7.3% vs. 6.3%; p=0.21<br>Pooled OR:1.2 (95% CI,0.9 -1.61, I2= 0%, p=0.42) | |
| Ai, 2018 (157)<br><br>SR and Meta-analysis<br><br>5 studies | To assess the results of a SFV or RCR compared to SC.<br><br>-5 studies with data on AMR and SFV<br><br>-2 studies with data on AMR and RCR | Screening, surveillance, or diagnostic | NR<br><br>Mean: approx. 60 years | Combined examinations (RCR and SFV) vs. SC:<br><br>R-ADR: 28.8% vs. 24.1% (p<0.001) (n=6)<br>Pooled OR: 1.34 (95% CI, 1.13–1.59, $I^2$=61% p=0.02)<br><br>R-PDR: 33.8% vs. 27.6% (p<0.001) (n=5)<br>Pooled OR: 1.37 (95% CI, 1.17–1.61, $I^2$=58%, p=0.05)<br><br>RCR vs. SC R-ADR: 25.4% vs. 22.3% (p=0.002) (n=4)<br>Pooled OR: 1.19 (95% CI, 1.06–1.33, $I^2$=12% p=0.33)<br><br>SFV vs. SCR R-ADR: 46.0% vs. 33.5% (p<0.001) (n=2)<br>Pooled OR:1.76 (95% CI, 1.40–2.22, $I^2$=0%, p=0.64)<br><br>RCR vs. SC R-PDR: 32.6% vs. 27.4% (p<0.001), (n=4)<br>Pooled OR: 1.29 (95% CI, 1.16–1.43, $I^2$=22%, p=0.28<br><br>Not enough data for SFV PDR. | None |
| Yang, 2022 (160)<br><br>RCT<br><br>Single Centre<br><br>June 2021-June 2022 | To determine the impact of the second examination of the proximal colon on ADR compared with standard examination (one inspection) | Screening, surveillance, or diagnostic | 18-80 years<br><br>Retroflexion: (mean): 51.1 (SD=11.9)<br><br>Control: (mean): 50.8 (SD=12.4) | Proximal colon ADR intervention vs. control: (35.7% vs. 25.2%, p=0.001)<br><br>Left-sided colon ADR intervention vs. control: (18.8% vs. 17.6%, p=0.655)<br><br>Whole-colon ADR intervention vs. control: (44.0% vs. 34.0%, p=0.003)<br><br>AMR of proximal colon: 33.9 % (80/236) | This simple and reliable technique should be considered during a routine colonoscopy |

| Study | Aim / Definition | Indication for colonoscopy | Age of Inclusion | Retroflexion results | Benchmarking/targeting |
|---|---|---|---|---|---|
| | | | | Proximal colon PDR intervention vs. control: (55.0% vs 41.2%, p=0.001)<br><br>Whole-colon PDR intervention vs. control: (67.6% vs 60.2%, p=0.026)<br><br>One patient in retroflexion group with post-polypectomy bleeding requiring endoscopic hemostasis. | |
| Noagles. 2021 (158)<br><br>Nonrandomized Prospective Consecutive Series<br><br>Single centre<br><br>March -June 2017 | To assess the additional adenoma detection rate with the right colon retroflexion attempt.<br><br>Compared retroflexion to second forward view (retroflexion was second exam) | Screening, surveillance, bleeding, diarrhea | >18 years<br><br>Median: 59 years (range, 22-87) | RCR was successful in 431/463 colonoscopies (93.1%).<br><br>AMR: 6.7% colonoscopies (95% CI 5.01–9.98; OR 0.07 95% CI 0.05–0.09, NNT:15)<br><br>Total number of additional polyps: 40<br><br>Histology of the additional lesions:<br>Adenoma with low-grade dysplasia in 29/40 (72.5%), adenoma with high-grade dysplasia in 3/40 (7.5%),<br>sessile serrated lesions in 7/40 (17.5%), inflammatory polyp in 1/40 (2.5%)<br><br>Additional adenoma detection contributed to modify the colonoscopy surveillance interval in 25 patients (5.4%)<br><br>No adverse events occurred. | According to previous descriptive studies, we defined an additional ADR of 5%. |
| Nunez Rodriguez, 2020 (159)<br><br>RCT<br><br>Multicentre<br><br>June-September 2017 | To determine whether proximal retroflexion improved the ADR in the right colon compared with a second forward view in the FIT-based CRC screening programme<br><br>Patients were randomized to second right colon examination using proximal | Abnormal FIT | 50-69 years<br><br>Retroflexion (mean): 59.7 (SD ±4.6)<br><br>Second forward view (mean): 60.6 (SD ±5.8) | Overall:<br>• ADR (mean): 61%<br>• AMR (mean) 19%<br><br>Second Examination:<br>• Proximal retroflexion success rate: 83%<br>• AMR 11%<br><br>Proximal retroflexion vs. SFV:<br>• ADR on second withdrawal: 9% vs. 12%, p=0.21<br>• WT: 8.79±3.32 min vs. 9.44±5.27 min, p= 0.07 | None |

| Study | Aim / Definition | Indication for colonoscopy | Age of Inclusion | Retroflexion results | Benchmarking/targeting |
|---|---|---|---|---|---|
| | retroflexion or forward view. | | | • AMR:17% vs. 20%, p= 0.28<br>• High grade adenomas: 2.5% vs. 17%, p<0.05<br><br>In 15.6% of patients (RCR: 17%, SFV: 14.5%) in whom lesions were detected during the second pass, endoscopic follow-up was modified by reducing the time of the next colonoscopy<br><br>No adverse events were found. | |

**Abbreviations:** ADR, adenoma detection rate; AMR, adenoma miss rate; CIR, cecal intubation rate; COL, colonoscopies; CI, confidence interval; FIT, fecal immunochemical testing; NNT, number needed to treat; OR, odds ratio; PDR, polyp detection rate; R-ADR -right sided ADR; RCT, randomized controlled trial; RCR, right colon retroflexion; R-PDR -right sided PDR; SFV, second forward view, SC, standard colonoscopy; SD, standard deviation; SR, systematic review; WT, withdrawal time.

### Table 4.31. PICI (successful cecal intubation, some measure of comfort, and some level of use of midazolam) and TIIR Data Tables.

| Clinical Indicator | Study | Participants | Objective /methods | Results | Comments |
|---|---|---|---|---|---|
| Performance Indicator of Colonic Intubation (PICI) | Nass, 2021 (162)<br><br>Retrospective Cohort<br><br>Impact of sedation on the Performance Indicator of Colonic Intubation | 107,328 colonoscopies Dutch screening program for ages 55-75 yrs<br><br>Jan 2016-Jan 2018<br><br>FIT<br><br>Performed by 387 endoscopists, 376 of whom performed more than 20 colonoscopies | Determine the association between PICI and adenoma detection rate (ADR).<br>Unadjusted CIR was used<br>Comfort during colonoscopy was reported as the nurse-assessed modified Gloucester Comfort Scale (GCS)<br><br>An adenoma was defined as an advanced adenoma when one of the following criteria was fulfilled: 1) tubulovillous or villous histologic characteristics; 2) high-grade dysplasia; 3) adenoma of ≥10 mm.<br><br>Proximal serrated polyps were classified as hyperplastic polyps, | • Mean CIR=97% (SD=2.0), mean ADR 63.7% (SD=8.4), mean HRADR 34.0% (SD=6.1) and pSPDR 9.7% (SD=5.1)<br>• GCS 1-3 reported in 95.6%<br>• Sedation in 70.3% median dose was 5.0 (IQR 2.5-5 mg)<br>• Adequate PICI was achieved in 46.1%<br>• ADR was marginally higher for colonoscopies during which adequate PICI was achieved compared with colonoscopies without adequate PICI (64.8% vs. 63.6%; p<0.001), (OR, 1.16, 95% CI, 1.12 - 1.20).<br>• Not for advanced adenoma detection (OR, 1.03, 95% CI=1.00-1.06; p=0.65) or detection of proximal serrated polyp (OR, 1.04, 95% CI; 0.99-1.10; p=0.14)<br>• The ADR was higher in colonoscopies with cecal intubation, a GCS of 1 – 3, and administration of ≤5 mg midazolam compared with colonoscopies where this was not achieved (65.3% vs. 55.3%; p<0.001). | Adequate PICI was defined as successful cecal intubation, GCS score of 1 – 3 (no to mild discomfort) and use of ≤2.5 mg midazolam.<br><br>The maximum dose of 2 mg midazolam used by Valori et al. was adjusted to 2.5 mg for practical reasons. In the Netherlands, in low-risk patients it is common practice to start with administration of half a 5mg ampoule of midazolam instead of titration per mg.<br><br>PICI appeared to be heavily dependent on sedation practice. Because of wide variation in sedation practice between individual endoscopists and countries, the |

| Clinical Indicator | Study | Participants | Objective /methods | Results | Comments |
|---|---|---|---|---|---|
| | | | sessile serrated lesions, or traditional serrated lesions, located at or proximally to the splenic flexure. | • With a cut off of 5 mg midazolam, median dose in this Dutch population, adequate PICI was achieved in 95,410 colonoscopies (88.9%).<br>• In colonoscopies with inadequate PICI, inadequacy was due to higher sedation doses in 87.8%. | benefit of PICI as a quality indicator is limited. |
| Performance Indicator of Colonic Intubation (PICI) | Lund, 2019 (161)<br><br>Retrospective Cohort<br><br>The performance indicator of colonic intubation (PICI) in a FIT-based colorectal cancer screening program 2019 | Included 6749 screening colonoscopies performed at 3 units between July 1, 2015, to June 30, 2017 In Central Denmark Region within 60 days after an abnormal FIT-test Ages 50-74 yrs old | They aimed to (i) measure the variation of PICI between endoscopists and colonoscopy units; (ii) to assess the correlation between the individual components of PICI; and (iii) to evaluate the association between PICI and commonly used performance indicators.<br><br>Colonoscopies performed by endoscopists with a volume of <30 procedures in the study period were excluded<br>53 endoscopists included<br><br>Reported results in quartiles | • The overall PICI was 78.7% with substantial variation between endoscopists (40.0–91.9%) and units (72.6–82.0%).<br>• The CIR ranged from 88.5–94.1%, PDR from 45.2–59.1%, PRR from 92.3–96.8%, and mean WT from 10.1–15.4 minutes between units.<br>• CIR was significantly correlated with patient-experienced comfort (r=0.49, n=73, p<0.0001)<br>• CIR was not correlated with use of sedation dosage ≤ 2 mg midazolam (r=-0.0195, n=73, p=0.87).<br>• Endoscopists with a PICI between 79.9% and 84.3% (quartile 3) had the highest ADRx (p=0.04) (Only significant result)<br>• There was no clear pattern for improvement in ADR, ADRx, PRR and WT by increasing PICI quartiles | PICI defined as the percentage of colonoscopies achieving cecal intubation with use of ≤2 mg midazolam and no/minimal/mild patient-experienced discomfort on Gloucester comfort scale.<br><br>ADR was defined as the percentage of colonoscopies in which at least one conventional adenoma was identified and removed.<br><br>ADRx was defined as ADR, but including traditional serrated adenomas and sessile serrated adenomas/polyps with dysplasia. |
| Performance Indicator of Colonic Intubation (PICI) | Valori, 2018 (163)<br><br>Retrospective cohort<br><br>A new composite measure of colonoscopy: the Performance Indicator of Colonic | 20 085 colonoscopies reported in the 2011 UK national audit. (Over a 2-week period) For all COL - not just screening COL<br><br>FOBT | This study determined the diagnostic validity of the PICI measure compared to cecal intubation rate and polyp detection, or CIR + comfort alone.<br><br>PICI compared to CIR, CIR + Comfort score 1-3 and PDR>1 | • PICI was achieved in 54.1% of procedures.<br>• PICI was associated with a significantly higher likelihood of detecting one or more polyps, compared with procedures with no achievement of PICI (OR, 1.44 (95% CI, 1.35–1.53)<br>• for detecting two or more polyps (OR, 1.45, 95% CI, 1.34-1.57)<br>• not statistically significant for finding cancer (OR, 1.14, 95% CI, 0.98-1.32)<br><br>PICI identified factors affecting performance more frequently than single measures such as | Achievement of PICI was defined as the proportion of all procedures in the audit that achieved cecal intubation AND ≤ 2 mg AND a nurse assessed comfort score of 1–3 ("comfortable" to "mild discomfort") on the Gloucester comfort scale<br><br>(PICI% =all 3 above /all procedures) |

| Clinical Indicator | Study | Participants | Objective /methods | Results | Comments |
|---|---|---|---|---|---|
| | Intubation (PICI) | | | CIR and polyp detection, or CIR + comfort alone.<br>Using multivariate analysis, they looked at 25 variables.<br>• 17 of the 25 subgroups of the unit, training, and endoscopist variables showed statistically significant ORs for the likelihood of achieving PICI.<br>• Unit accreditation, the presence of magnetic imagers in the unit, greater annual volume, fewer years' experience, and higher training/trainer status were associated with higher PICI rates.<br>• Older age, male sex, adequate bowel preparation, and an abnormal fecal occult blood test as indication were associated with a higher PICI.<br>• Whereas: 8/25 for CIR alone, 8/25 for CIR + Comfort level 1-3 and 4/25 for PDR >1 | PICI provides a simpler picture of performance of colonoscopic intubation than separate measures of CIR, comfort, and sedation. It is associated with more factors that are amenable to change that might improve performance and with higher likelihood of polyp detection. |
| Terminal ileum intubation rate (TIIR) | Leiman, 2020 (164)<br><br>Retrospective cohort study<br><br>Terminal ileum (TI) intubation is not associated with colonoscopy quality measures | Examined 7799 average-risk screening colonoscopies performed at an academic health system between July 2016 and October 2017.<br><br>Patient ages 52-64 yrs<br><br>- 5 sites<br>-28 endoscopists | Aimed to determine whether TI intubation during screening colonoscopy is associated with colonoscopy quality measures or identifies subclinical pathology<br><br>Patients were excluded if inadequate prep or had >1 COL during the study period. Physicians were excluded if they had<50 eligible COL during the study period or incomplete quality measure data | • The median TIIR was 37.0%, with a range of (2–93%).<br>• The average PDR=58.9 (57.8, 60.0), ADR= 43.1 (42.0, 44.2) and SSPDR=7.6 (7.0, 8.2)<br>• There were no significant differences in the PDR, ADR, or SSPDR in cases with or without TI intubation<br>• In a random 10% sample of cases with TI intubation, no clinically significant pathology was found.<br>• The cecal intubation time was significantly shorter in cases with TI intubation compared with those without (median and interquartile range: 6 (4, 10) vs. 5 (4, 8); p<0.0001).<br>• Only BMI (p=0.0003), insertion time (p<0.0001), and withdrawal time (p=0.04) were significantly associated with TI intubation | |

**Abbreviations:** HRADR, advanced adenoma detection rate; ADR, adenoma detection rate; ADRx, adenoma detection rate extended; BMI, body mass index; CI, confidence interval; CIR, cecal intubation rate; COL, colonoscopy; FIT, fecal immunochemical test; FOBT, fecal occult blood test; GCS, Gloucester Comfort Scale; IQR, interquartile range; OR, odds ratio; PDR, polyp detection rate; PICI, Performance Indicator of Colonic Intubation; PRR, polyp retrieval rate; pSPDR,

proximal serrated polyp detection rate; SD, standard deviation; SSPDR, sessile serrated polyp detection rates; TI, terminal ileum; TIIR, terminal ileum intubation rate; WT, withdrawal time; yrs, years.

**Table 4.32. Study Characteristics –Incomplete Resection.**

| Study | Design/ Study period/ Jurisdiction | Data Source | Number of Patients/ Colonoscopies/ endoscopists | Indication for Colonoscopy | Age | Aims | Outcomes |
|---|---|---|---|---|---|---|---|
| Alsayid, 2021 (165)<br><br>USA | Retrospective cohort<br><br>January 2006 - October 2018<br><br>Single centre | Electronic medical records/ Endoscopy reports of patients | 337 patients<br><br>6 endoscopists | Tubular adenoma on index colonoscopy | Mean=60.5 (SD: 9.6) | To compare the rate of metachronous adenoma attributable to incomplete resection in polyps 6 to 9 mm versus polyps 10 to 20 mm | SMAR-IR: calculated by subtracting the risk rate of metachronous adenoma in a segment without adenoma on index examination from the risk rate of metachronous adenoma in a segment with adenoma on index examination<br><br>Segmental metachronous advanced neoplasia rate |

**Abbreviations:** SD, standard deviation; SMAR-IR, segmental metachronous adenoma rate attributable to incomplete resection; USA, United States of America.

**Table 4.33. Incomplete Resection Validation Tables.**

| Study | Aims | Age of Inclusion | Incomplete resection | Benchmarking/targeting |
|---|---|---|---|---|
| Alsayid, 2021 (165)<br><br>Retrospective cohort<br><br>January 2006 - October 2018<br><br>Single centre | To compare the rate of metachronous adenoma attributable to incomplete resection in polyps 6 to 9 mm versus polyps 10 to 20 mm | NR | 146 patients had a TA 10 to 20 mm in size and 191 patients a TA 6 to 9 mm in size as the most advanced lesion<br><br>For cases in which an index 10- to 20-mm TA was resected, the SMAR in segments with adenoma was 21.0% and in segments without adenoma 9.6%, the SMAR-IR was 11.4% (95% confidence interval, 4.5-18.3).<br><br>For cases in which an index 6- to 9-mm TA was resected, the SMAR in segments with adenoma was 22.0% and in segments without adenoma 8.8%, the SMAR-IR was 13.2% (95% CI, 7.2-19.4).<br><br>Among 6 endoscopists, the SMAR-IR ranged between 7.0% and 15.5% for polyps 6 to 20 mm<br><br>Incomplete resection of neoplasia appears to be a significant risk factor for metachronous neoplasia in 6- to 9-mm lesions as well as larger ones | 54% of all adenomas could potentially be attributed to incomplete resection in TAs 10 to 20 mm and 60% of all adenomas could potentially be attributed to incomplete resection in TAs 6 to 9 mm. More than half of the metachronous adenomas might potentially occur because of incomplete resection in both groups.<br><br>SMAR-IR appears to occur in lesions 6 to 9 mm in size at a significant rate, and monitoring of lesions of this size should be considered. |

**Abbreviations:** CI, confidence interval; NR, not reported; SMAR, segmental metachronous adenoma rate; SMAR-IR, segmental metachronous adenoma rate attributable to incomplete resection; TA, tubular adenoma.

## Appendix 5: GRADE and ISFU tables

**GRADE (Grading of Recommendations Assessment, Development and Evaluation) Table**

**ISFU (Importance, Scientific acceptability, Feasibility, Usability and Comparison) Framework**

**Importance to measure and report:** Extent to which the specific measure focus is evidence based; important to making gains in healthcare quality; and important to improving health outcomes.

**Scientific acceptability:** Extent to which the measure produces consistent (reliable) and credible (valid) results about the quality of care.

**Feasibility:** Extent to which the specifications, including measure logic, require data that are readily available or could be captured without undue burden and can be implemented for performance measurement

**Usability and use:** Extent to which potential audiences are using or could use performance results for both accountability and performance improvement.

**Comparison to related or competing measures:** If a measure meets the above criteria and there are endorsed or new related measures or competing measures, the measures are compared to address harmonization and/or selection of the best measure.

**PCCRC**

**Table 5.1. PCCRC: GRADE Table.**

| Quality Assessment | | | | | | | | | | Quality | Importance |
|---|---|---|---|---|---|---|---|---|---|---|---|
| No. of studies | Design | Risk of Bias | Inconsistency | Indirectness | Imprecision | Large Effect | Dose-response | No plausible confounding | Other | | |
| **Post Colonoscopy CRC** | | | | | | | | | | | |
| 16<br>1<br>1 | Cohort<br>Case/control<br>SR | Low<br>Low<br>Low | No serious inconsistency | No serious indirectness | No serious imprecision | n/a | n/a | n/a | - | +++ | High |

**Abbreviations:** CRC, colorectal cancer; n/a, not applicable; no., number; PCCRC, post-colonoscopy colorectal cancer; SR, systematic review.

**Table 5.2. PCCRC: ISFU Table.**

| Indicator | Number of studies | GRADE evaluation | ISFU Criteria | | | | |
|---|---|---|---|---|---|---|---|
| | | | Importance to measure and report | Scientific acceptability of measure properties | Feasibility | Usability and use | Comparison to related or competing measures |
| PCCRC | 1 SR<br>1 case-control<br>16 cohort studies | Moderate | High importance | PCCRC is well defined and precisely specified so it can be implemented consistently<br><br>Monitoring allows for identification of clinically meaningful differences in performance in specific circumstances (e.g., sufficiently large sample to measure rates) | May be feasible to report as a performance measure at the provincial, regional, facility and individual level<br><br>Required linkages (e.g., to cancer registries and across facilities) may limit feasibility<br><br>Measurement and interpretation in high-risk populations pose challenges | Likely useful for performance improvement<br><br>Data lags may limit usability<br><br>Used to calculate rates if sample size is sufficiently large, otherwise can be used for practice audit<br><br>It may be confusing to users if different time periods for practice audit and rate calculations are used | Key measure of the ability of colonoscopy to detect and prevent colorectal cancer<br><br>Important to the patient |

**Abbreviations:** GRADE, Grading of Recommendations, Assessment, Development and Evaluation; ISFU, importance, scientific acceptability, feasibility, usability, and comparison to related/competing measures; PCCRC, post-colonoscopy colorectal cancer; SR, systematic review.

## Adverse events

**Table 5.3. Adverse events: GRADE Table.**

| Quality Assessment | | | | | | | | | | Quality | Importance |
|---|---|---|---|---|---|---|---|---|---|---|---|
| No. of studies | Design | Risk of Bias | Inconsistency | Indirectness | Imprecision | Large Effect | Dose-response | No plausible confounding | Other | | |
| **Overall adverse events** | | | | | | | | | | | |
| 12 | Cohort | Moderate | No serious inconsistency | No serious indirectness | No serious imprecision | n/a | n/a | n/a | - | +++ | High |
| **Perforations** | | | | | | | | | | | |
| 2<br>18 | SR<br>cohort | Moderate | No serious inconsistency | No serious indirectness | No serious imprecision | n/a | n/a | n/a | - | +++ | High |
| **Post-polypectomy bleeding rate** | | | | | | | | | | | |
| 3<br>17 | SR<br>cohort | Moderate | No serious inconsistency | No serious indirectness | No serious imprecision | n/a | n/a | n/a | - | +++ | High |
| **Mortality** | | | | | | | | | | | |
| 2<br>13 | SR<br>cohort | Moderate | No serious inconsistency | No serious indirectness | No serious imprecision | n/a | n/a | n/a | - | ++ | Moderate |
| **Unplanned admissions** | | | | | | | | | | | |
| 7 | Cohort | Moderate | No serious inconsistency | No serious indirectness | No serious imprecision | n/a | n/a | n/a | - | ++ | Low |

**Abbreviations:** GRADE, Grading of Recommendations, Assessment, Development and Evaluation; n/a, not applicable; no., number; SR, systematic review.

**Table 5.4. Overall Adverse events: ISFU Table.**

| Indicator | Number of studies | GRADE evaluation | ISFU Criteria | | | | |
|---|---|---|---|---|---|---|---|
| | | | Importance to measure and report | Scientific acceptability of measure properties | Feasibility | Usability and use | Comparison to related or competing measures |
| Overall adverse events | 12 cohort studies | Low | Important (especially for patients)<br><br>Higher | There is face validity to this indicator. However, there is little comparison in studies to a gold standard (e.g., chart review)<br><br>Lack of consensus as to what adverse events ought to be included for this composite measure | Required linkages (i.e., to track adverse events presenting to another facility) may limit feasibility<br><br>Systematically measuring this indicator at the provincial, regional, or facility level is likely possible | Not suitable for targeted performance improvement<br><br>Data lags may limit usability | Important to the patient |

**Abbreviations:** GRADE, Grading of Recommendations, Assessment, Development and Evaluation; ISFU, importance, scientific acceptability, feasibility, usability, and comparison to related/competing measures; QI, quality indicator.

**Table 5.5. Perforations: ISFU Table.**

| Indicator | Number of studies | GRADE evaluation | ISFU Criteria | | | | |
|---|---|---|---|---|---|---|---|
| | | | Importance to measure and report | Scientific acceptability of measure properties | Feasibility | Usability and use | Comparison to related or competing measures |
| Perforation rate | 2 SRs<br>18 cohort studies | Low | High<br>Important to have a measure to monitor intraprocedural care and endoscopist technical skills | There is face validity to this indicator. However, studies do not often compare to a gold standard (e.g., chart review)<br><br>Lack of consensus about the appropriate time frame to measure after colonoscopy<br><br>Lack of consensus about whether there should be a separate target for FIT vs. other indications<br><br>Lack of consensus about whether there should be a separate target by type of therapeutic procedure (e.g., ESD) | Required linkages (i.e., to track adverse events presenting to another facility) may limit feasibility<br><br>Systematically measuring this indicator at the provincial, regional, or facility level is likely possible | Likely useful for performance improvement | Important to the patient |

**Abbreviations:** EMR, endoscopic mucosal resection; ESD, endoscopic submucosal dissection; FIT, fecal immunochemical test; GRADE, Grading of Recommendations, Assessment, Development and Evaluation; ISFU, importance, scientific acceptability, feasibility, usability, and comparison to related/competing measures; SR, systematic review; vs, versus.

**Table 5.6. Post-colonoscopy bleeding: ISFU Table.**

| Indicator | Number of studies | GRADE evaluation | ISFU Criteria | | | | |
|---|---|---|---|---|---|---|---|
| | | | Importance to measure and report | Scientific acceptability of measure properties | Feasibility | Usability and use | Comparison to related or competing measures |
| Post polypectomy bleeding rate | 3 SRs<br>17 cohort studies | Low | High<br>Important to have a measure to monitor intraprocedural care and endoscopist technical skills | There is face validity to this indicator. However, studies do not often compare to a gold standard (e.g., chart review)<br><br>Lack of consensus about the appropriate time frame to measure after colonoscopy<br><br>Lack of consensus about which indicator should be used to measure overall bleeding rate vs. post-polypectomy<br><br>Lack of consensus about whether there should be a separate target for FIT vs. other indications | Required linkages (i.e., to track adverse events presenting to another facility) may limit feasibility<br><br>Systematically measuring this indicator at the provincial, regional, or facility level is possible | Likely useful for performance improvement | Important to the patient |

**Abbreviations:** FIT, fecal immunochemical test; GRADE, Grading of Recommendations, Assessment, Development and Evaluation; ISFU, importance, scientific acceptability, feasibility, usability, and comparison to related/competing measures; SR, systematic review; vs, versus.

**Table 5.7. Mortality Rate: ISFU Table.**

| Indicator | Number of studies | GRADE evaluation | ISFU Criteria | | | | |
|---|---|---|---|---|---|---|---|
| | | | Importance to measure and report | Scientific acceptability of measure properties | Feasibility | Usability and use | Comparison to related or competing measures |
| Mortality | 2 SRs<br>13 cohort studies | Low | Important | There is face validity to this indicator. However, studies do not often compare to a gold standard (e.g., chart review)<br><br>Lack of consensus about the best way to measure mortality: 30 day all-cause; excess mortality (e.g., abnormal FIT vs. normal FIT); colonoscopy specific death | Required linkages (i.e., to track adverse events presenting to another facility) may limit feasibility<br><br>Excess mortality or colonoscopy- related death might be less feasible to measure due to data lags, effort, chart review, phoning people. | Likely useful for performance improvement, however feasibility issues limit its use. | Important to the patient |

**Abbreviations:** FIT, fecal immunochemical test; GRADE, Grading of Recommendations, Assessment, Development and Evaluation; ISFU, importance, scientific acceptability, feasibility, usability, and comparison to related/competing measures; SR, systematic review; vs, versus.

**Table 5.8. Unplanned Admissions: ISFU Table.**

| Indicator | Number of studies | GRADE evaluation | ISFU Criteria | | | | |
|---|---|---|---|---|---|---|---|
| | | | Importance to measure and report | Scientific acceptability of measure properties | Feasibility | Usability and use | Comparison to related or competing measures |
| Unplanned admissions | 7 cohort studies | Low | Low | Not all unplanned admissions will be directly related to the colonoscopy | Required linkages (e.g., to track adverse events presenting to another facility) may limit feasibility | Could be useful for performance improvement | May be important to the patient |

**Abbreviations:** GRADE, Grading of Recommendations, Assessment, Development and Evaluation; ISFU, importance, scientific acceptability, feasibility, usability, and comparison to related/competing measures.

## Patient Outcomes

**Table 5.9. Patient Outcomes: GRADE Table.**

| Quality Assessment | | | | | | | | | | Quality | Importance |
|---|---|---|---|---|---|---|---|---|---|---|---|
| No. of studies | Design | Risk of Bias | Inconsistency | Indirectness | Imprecision | Large Effect | Dose-response | No plausible confounding | Other | | |
| **Pain and Comfort** | | | | | | | | | | | |
| 3 | Cross-sectional/ validation | NA | NA | NA | NA | NA | NA | NA | NA | - | Very |
| 1 | SR | Moderate | NA | NA | NA | NA | NA | NA | NA | Moderate | Very |
| **Satisfaction with the whole process** | | | | | | | | | | | |
| 6 | Cross-section/ validation | NA | NA | NA | NA | NA | NA | NA | NA | - | Very |

**Abbreviations:** GRADE, Grading of Recommendations, Assessment, Development and Evaluation; ISFU, importance, scientific acceptability, feasibility, usability, and comparison to related/competing measures; NA, not applicable; no., number; SR, systematic review.

**Table 5.10. Patient Pain and Comfort: ISFU Table.**

| Indicator and Number of studies | GRADE evaluation | ISFU Criteria | | | | |
|---|---|---|---|---|---|---|
| | | Importance to measure and report | Scientific acceptability of measure properties | Feasibility | Usability and use | Comparison to related or competing measures |
| Comfort and pain with the procedure<br>1 SR<br>3 studies<br>3 questionnaires, see below for study specific details | N/A | High<br>Important to have a measure to monitor intraprocedural care and endoscopist technical skills | Patient comfort and pain may be correlated with other quality indicators.<br>Sedation practices vary across endoscopy units and patient comfort is impacted by the degree of sedation. | Systematically measuring this indicator at the provincial or regional level would be challenging at a unit level for every procedure<br>However, short audits of this indicator are feasible at the facility level. Some units may be able to report this on a consistent basis given the appropriate IT/infrastructure | Could be used to improve patient care<br>Sedation may impair a patient's ability to recall discomfort or affect experience of discomfort. Variation in sedation practice across endoscopy units and/or providers may limit ability to compare scores. Interpretation of scores should take variation in sedation practice into account<br>Measuring pain and comfort is only appropriate for cases using conscious sedation<br>An unintended consequence of measuring pain and comfort using this indicator might be to promote over sedation | Important to the patient, to ensure procedure completeness and to optimize attendance at colonoscopy<br>Best assessment tools based on the ISFU criteria:<br>• SPECS<br>• NAPCOMs<br>• Both are nurse reported, limited patient input into development |
| PRO-STEP | | | Only measured reliability; Had poor to acceptable reliability but no validity measures.<br>Patients involved in development<br>Results are for all endoscopies; no stratification by procedure type. | | • 6 questions<br>• Patient reported | |
| SPECS | | | Had excellent reliability and acceptable validity.<br>Results are specific to colonoscopy.<br>Measured against patient self-reported VAS. | | • 3 questions<br>• Nurse reported | |
| NAPCOMS | | | Had excellent reliability and acceptable validity.<br>Results are specific to colonoscopy.<br>Measured against patient rating of comfort. | | • 3 domains; 5 questions<br>• Nurse reported<br>• Accounts for level of consciousness and tolerability | |

**Abbreviations:** GRADE, Grading of Recommendations, Assessment, Development and Evaluation; ISFU, importance, scientific acceptability, feasibility, usability, and comparison to related/competing measures; IT, information technology; NAPCOMs, Nurse-assisted Patient Comfort Score; PRO-STEP, Patient-reported scale for tolerability of endoscopic procedures; SPECS, St. Paul's Endoscopy Comfort Scale; VAS, visual analogue scale.

**Table 5.11. Patient Satisfaction: ISFU Table.**

| Indicator and Number of studies | GRADE evaluation | ISFU Criteria | | | | |
|---|---|---|---|---|---|---|
| | | Importance to measure and report | Scientific acceptability of measure properties | Feasibility | Usability and use | Comparison to related or competing measures |
| Satisfaction with the process<br><br>6 studies<br>4 questionnaires, see below for study specific details | N/A | High | Patient satisfaction may be correlated with other quality indicators.<br>Sedation practices vary across endoscopy units and patient satisfaction is impacted by the degree of sedation. | Systematically measuring patient satisfaction would be challenging at the provincial and regional level. However, short audits of this indicator could be feasible.<br><br>Response rates from patients may be a challenge.<br><br>It can be a low cost and low effort to institute with the appropriate technology available. | Could be used to improve patient care<br><br>Variation in sedation practices across units of analysis may limit comparisons. However, within an institution, conducting surveys and acting on the results is expected to be valuable | Important to the patient<br><br>Best assessment tools based on the ISFU criteria: CSSQP |
| CEST | | | Had good reliability.<br>Results specific to colonoscopy.<br>Patients involved in development. | | • 30 questions<br>• Patient reported<br>• Has an open-ended comment section | |
| ENDOPREM | | | Results specific to colonoscopy.<br>Patients involved in development. | | • 68 questions<br>• Patient reported<br>• Has an open-comment section | |
| CSSQP | | | Had excellent reliability and acceptable validity.<br>Results specific to colonoscopy.<br>Patients involved in development. | | • 15 questions<br>• Patient reported<br>• Has an open-ended comment section to generate new areas for improvement<br>• Fewer items than GESQ | |
| GESQ | | | Had excellent reliability measured, but not much data on validity.<br>Results are for all endoscopy<br>Reported on in three studies. Mostly assessing translations into different languages<br>Patients involved in development | | • 21 questions<br>• Patient reported<br>• Used in different contexts | |

**Abbreviations:** CSSQP, Colonoscopy Satisfaction and Safety Questionnaire based on patients' experiences; GESQ, gastrointestinal endoscopy satisfaction questionnaire; GRADE, Grading of Recommendations, Assessment, Development and Evaluation; ISFU, importance, scientific acceptability, feasibility, usability, and comparison to related/competing measures.

## Adenoma Detection Rate

**Table 5.12. ADR: GRADE Table.**

| Quality Assessment | | | | | | | | | | Quality |
|---|---|---|---|---|---|---|---|---|---|---|
| **No. of studies** | **Design** | **Risk of Bias** | **Inconsistency** | **Indirectness** | **Imprecision** | **Large Effect** | **Dose-response** | **No plausible confounding** | **Other** | |
| **Adenoma detection rate** | | | | | | | | | | |
| 1<br>23 | SR<br>Cohort | Moderate | No serious inconsistency | No serious indirectness | No serious imprecision | n/a | n/a | n/a | - | ++ |
| **Polyp detection rate** | | | | | | | | | | |
| 4 | Cohort | Moderate | No serious inconsistency | No serious indirectness | No serious imprecision | n/a | n/a | n/a | - | ++ |
| **Sessile serrated polyp detection rate (includes CSSDR and PSPDR)** | | | | | | | | | | |
| 4 | Cohort | Moderate | No serious inconsistency | No serious indirectness | No serious imprecision | n/a | n/a | n/a | - | + |
| **High risk adenoma detection rate** | | | | | | | | | | |
| 5 | Cohort | Moderate | No serious inconsistency | No serious indirectness | No serious imprecision | n/a | n/a | n/a | - | ++ |
| **Nonadvanced ADR** | | | | | | | | | | |
| 2 | Cohort | Moderate | No serious inconsistency | No serious indirectness | No serious imprecision | n/a | n/a | n/a | - | + |
| **Adenomas per participant** | | | | | | | | | | |
| 6 | Cohort | Moderate | No serious inconsistency | No serious indirectness | No serious imprecision | n/a | n/a | n/a | - | ++ |
| **Adenomas per colonoscopy** | | | | | | | | | | |
| 6 | Cohort | Moderate | No serious inconsistency | No serious indirectness | No serious imprecision | n/a | n/a | n/a | - | ++ |
| **Adenoma detection rate plus** | | | | | | | | | | |
| 3 | Cohort | Moderate | No serious inconsistency | No serious indirectness | No serious imprecision | n/a | n/a | n/a | - | + |
| **CRC-Adenoma detection rate (ADR in first surveillance colonoscopy following surgical resection of CRC)** | | | | | | | | | | |
| 1 | Cohort | Moderate | No serious inconsistency | No serious indirectness | No serious imprecision | n/a | n/a | n/a | - | + |

**Abbreviations:** ADR, adenoma detection rate; CRC, colorectal cancer; CSSDR, clinically significant sessile polyp detection rate; GRADE, Grading of Recommendations, Assessment, Development and Evaluation; n/a, not applicable; no., number; PSPDR, proximal serrated polyp detection rate; SR, systematic review.

**Table 5.13. ADR: ISFU Table.**

| Indicator | Number of studies | GRADE evaluation | Importance to measure and report | Scientific acceptability of measure properties | Feasibility | Usability and use | Comparison to related or competing measures |
|---|---|---|---|---|---|---|---|
| ADR | 1 SR<br>6 studies | Low - Moderate | High importance | Strong validation against PCCRC and PCCRC-related death.<br><br>Benchmarks exist relative to PCCRC. Some evidence to suggest different benchmarks are warranted for abnormal FIT vs. other colonoscopy indications.<br><br>May be a ceiling effect. | Challenges related to linking pathology to colonoscopy may pose feasibility issues.<br><br>Measurement at facility level may be more feasible than regional and higher levels because of the lack of jurisdictional pathology databases.<br><br>Natural language processing may make this easier to measure in the future. | Direct evidence of an association with colonoscopy quality.<br><br>Evidence suggests that improving ADR is possible with endoscopy education initiatives.<br><br>Improvement in ADR is associated with reduction in PCCRC. | Often used as a gold standard that other measures are compared against.<br><br>Few studies comparing ADR to other indicators against another gold standard i.e., PCCRC. |

**Abbreviations:** ADR, adenoma detection rate; FIT, fecal immunochemical test; GRADE, Grading of Recommendations, Assessment, Development and Evaluation; ISFU, importance, scientific acceptability, feasibility, usability, and comparison to related/competing measures; PCCRC, post-colonoscopy colorectal cancers; SR, systematic review.

**Table 5.14. Other Additional Indicators Related to Adenoma Detection Rate: ISFU Table.**

| Indicator | Number of studies | GRADE evaluation | ISFU Criteria | | | | |
|---|---|---|---|---|---|---|---|
| | | | Importance to measure and report | Scientific acceptability of measure properties | Feasibility | Usability and use | Comparison to related or competing measures |
| PDR | 4 cohort studies | Low | High importance | Validated against PCCRC and ADR<br><br>Strongly correlated with ADR. | No need for pathology data in order to measure.<br><br>Feasible to measure at facility, regional and provincial levels. | Direct evidence of an association with colonoscopy quality.<br><br>No data to indicate that improving PDR is possible or that improvement leads to a change in colonoscopy quality.<br><br>PDR can be used as a proxy for ADR assuming a ratio of approximately two-thirds.<br><br>Concerns about the potential for manipulation. | Easier to measure than ADR.<br><br>Potential for manipulation and variation in relationship to ADR limits usefulness. |
| SSPDR<br><br>(CSSDR and PSPDR) | 4 cohort studies | Low | High importance | Validated against ADR and PCCRC.<br><br>Moderate-strongly correlated to ADR. | Challenges related to linking pathology to colonoscopy may pose feasibility issues.<br><br>Measurement at facility level may be more feasible than regional and higher levels because of the lack of jurisdictional pathology databases.<br><br>Natural language processing may make this easier to measure in the future. | Direct evidence of an association with colonoscopy quality.<br><br>No data to indicate that improving SSPDR is possible or that improvement leads to a change in colonoscopy quality. | Possible complementary measure to ADR as it targets a separate precancerous lesion. |
| HRADR | 5 cohort studies | Low | Important | Validated against ADR.<br><br>Moderately correlated with ADR. | Challenges related to linking pathology to colonoscopy may pose feasibility issues.<br><br>Measurement at facility level may be more feasible than regional and higher levels because of the lack of jurisdictional pathology databases. | Indirect evidence of an association with colonoscopy quality. | Measures most clinically significant precancerous lesions. |

| Indicator | Number of studies | GRADE evaluation | ISFU Criteria | | | | |
|---|---|---|---|---|---|---|---|
| | | | Importance to measure and report | Scientific acceptability of measure properties | Feasibility | Usability and use | Comparison to related or competing measures |
| | | | | | Natural language processing is less able to capture number of adenomas.<br><br>Requires additional effort to distinguish from ADR. | | |
| NAADR | 2 cohort studies | Low | Less Important | Validated against ADR.<br><br>Modertae-strongly correlated with ADR. | Challenges related to linking pathology to colonoscopy may pose feasibility issues.<br><br>Measurement at facility level may be more feasible than regional and higher levels because of the lack of jurisdictional pathology databases.<br><br>Natural language processing is less able to capture number of adenomas.<br><br>Requires additional effort to distinguish from ADR. | Indirect evidence of an association with colonoscopy quality. | Unclear if there is additional benefit over ADR given the additional effort required to compute. |
| APP | 6 cohort studies | Low | Less Important | Validated against ADR and AMR.<br><br>The correlations are not consistent (variable strength of association and not always significant) | Challenges related to linking pathology to colonoscopy may pose feasibility issues.<br><br>Measurement at facility level may be more feasible than regional and higher levels because of the lack of jurisdictional pathology databases.<br><br>Natural language processing is less able to capture number of adenomas. | Limited evidence of an association with colonoscopy quality. | Addresses a "one and done" phenomenon, a concern with ADR. |
| APC | 6 cohort studies | Low | Important | Validated against ADR and AMR.<br><br>Moderate-strongly correlated to ADR. | Challenges related to linking pathology to colonoscopy may pose feasibility issues.<br><br>Measurement at facility level may be more feasible than regional and | Indirect evidence of an association with colonoscopy quality. | Addresses a "one and done" phenomenon, a concern with ADR. |

| Indicator | Number of studies | GRADE evaluation | ISFU Criteria | | | | |
|---|---|---|---|---|---|---|---|
| | | | Importance to measure and report | Scientific acceptability of measure properties | Feasibility | Usability and use | Comparison to related or competing measures |
| | | | | Correlations to AMR not significant. | higher levels because of the lack of jurisdictional pathology databases.<br><br>Natural language processing is less able to capture number of adenomas. | | |
| ADR plus | 3 cohort studies | Low | Less Important | Validated against ADR and AMR.<br><br>The correlations are not consistent (variable strength of association and not always significant) | Challenges related to linking pathology to colonoscopy may pose feasibility issues.<br><br>Measurement at facility level may be more feasible than regional and higher levels because of the lack of jurisdictional pathology databases.<br><br>Natural language processing is less able to capture number of adenomas. | Indirect evidence of an association with colonoscopy quality. | Addresses a "one and done" phenomenon, a concern with ADR. |
| CRC ADR | 1 cohort study | Low | Less Important | Validated against ADR.<br><br>Strongly correlated to ADR. | Applies to a small sub population of patients having colonoscopy.<br><br>Challenges related to linking pathology to colonoscopy may pose feasibility issues.<br><br>Measurement at facility level may be more feasible than regional and higher levels because of the lack of jurisdictional pathology databases.<br><br>Natural language processing may make this easier to measure in the future. | Indirect evidence of an association with colonoscopy quality. | Of limited use compared to ADR |

**Abbreviations:** ADR, adenoma detection rate; AMR, adenoma miss rate; APC, adenomas per colonoscopy; APP, adenomas per positive participant; CRC ADR, colorectal cancer adenoma detection rate; CSSDR, Clinically significant serrated polyp detection rate; GRADE, Grading of Recommendations, Assessment, Development and Evaluation; HRADR, high-risk adenoma detection rate; ISFU, importance, scientific acceptability, feasibility, usability, and comparison to related/competing measures; NAADR, nonadvanced adenoma detection rate; PCCRC, post-colonoscopy colorectal cancers; PDR, polyp detection rate; SSPDR, sessile serrated polyp detection rate.

## Withdrawal Time

**Table 5.15. Withdrawal Time: GRADE Table.**

| Quality Assessment | | | | | | | | | | Quality | Importance |
|---|---|---|---|---|---|---|---|---|---|---|---|
| No. of studies | Design | Risk of Bias | Inconsistency | Indirectness | Imprecision | Large Effect | Dose-response | No plausible confounding | Other | | |
| **Withdrawal Time** | | | | | | | | | | | |
| 1<br>4<br>9 | SR<br>RCT<br>Cohort | Low | No serious inconsistency | No serious indirectness | No serious imprecision | n/a | n/a | n/a | - | ++ | High |

**Abbreviations:** GRADE, Grading of Recommendations, Assessment, Development and Evaluation; n/a, not applicable; no., number; RCT, randomized controlled trial; SR, systematic review.

**Table 5.16. Withdrawal Time: ISFU Table.**

| Indicator | Number of studies | GRADE evaluation | ISFU Criteria | | | | |
|---|---|---|---|---|---|---|---|
| | | | Importance to measure and report | Scientific acceptability of measure properties | Feasibility | Usability and use | Comparison to related or competing measures |
| Withdrawal Time | 4 RCT<br>9 cohort studies | Low | High importance | Validated in a single study against PCCRC. Remainder of studies compared to ADR.<br><br>Using ADR as the reference is less desirable than PCCRC as mostly low-risk lesions may be detected as WT increases.<br><br>A benchmark of eight minutes was established relative to PCCRC. | Not possible to measure at the jurisdictional level but could be measured at the facility level.<br><br>Unclear if routinely reported in endoscopy reports, making use of NLP less feasible. | Direct evidence of an association with colonoscopy quality.<br><br>Lacking evidence that an increase in withdrawal time leads to an improvement in quality.<br><br>Susceptible to gaming.<br><br>Not routinely available in administrative data. | Unclear if there is additional benefit over ADR, especially given potential for gaming and limitations in data availability.<br><br>However, ADR and WT, interpreted together, may provide important complementary information. |

**Abbreviations:** ADR, adenoma detection rate; GRADE, Grading of Recommendations, Assessment, Development and Evaluation; ISFU, importance, scientific acceptability, feasibility, usability, and comparison to related/competing measures; NLP, natural language processing; PCCRC, post-colonoscopy colorectal cancer; WT, withdrawal time.

## Cecal Intubation Rate

**Table 5.17. Cecal Intubation Rate: GRADE Table.**

| Quality Assessment | | | | | | | | | | Quality | Importance |
|---|---|---|---|---|---|---|---|---|---|---|---|
| No. of studies | Design | Risk of Bias | Inconsistency | Indirectness | Imprecision | Large Effect | Dose-response | No plausible confounding | Other | | |
| **Cecal Intubation Rate** | | | | | | | | | | | |
| 1<br>1 | SR<br>Cohort | Low | No serious inconsistency | No serious indirectness | No serious imprecision | n/a | n/a | n/a | - | ++ | High |

**Abbreviations:** GRADE, Grading of Recommendations, Assessment, Development and Evaluation; n/a, not applicable; no., number; SR, systematic review.

**Table 5.18. Cecal Intubation Rate: ISFU Table.**

| Indicator | Number of studies | GRADE evaluation | ISFU Criteria | | | | |
|---|---|---|---|---|---|---|---|
| | | | Importance to measure and report | Scientific acceptability of measure properties | Feasibility | Usability and use | Comparison to related or competing measures |
| Cecal Intubation Rate | 1 SR<br>1 cohort | Low | High importance | Validated against PCCRC and ADR. | May be feasible to report as a performance measure at the regional, provincial, facility and individual level.<br><br>Unadjusted CIR is more feasible to report. | High reported rates of cecal intubation in multiple jurisdictions may limit usefulness for performance improvement.<br><br>Some data to suggest use of a higher benchmark than is currently recommended. | Important validated measure but high endoscopist performance may make less relevant. |

**Abbreviations:** ADR, adenoma detection rate; CIR, cecal intubation rate; GRADE, Grading of Recommendations, Assessment, Development and Evaluation; ISFU, importance, scientific acceptability, feasibility, usability, and comparison to related/competing measures; PCCRC, post-colonoscopy colorectal cancers.

## Bowel Preparation

### Table 5.19. Bowel Preparation: GRADE Table.

| Quality Assessment | | | | | | | | | | Quality | Importance |
|---|---|---|---|---|---|---|---|---|---|---|---|
| No. of studies | Design | Risk of Bias | Inconsistency | Indirectness | Imprecision | Large Effect | Dose-response | No plausible confounding | Other | | |
| **Bowel Preparation** | | | | | | | | | | | |
| 3<br>1<br>8<br>1 | SR<br>Review<br>Cohort<br>Cross-sectional | Low | No serious inconsistency | No serious indirectness | No serious imprecision | n/a | n/a | n/a | - | ++ | High |

**Abbreviations:** GRADE, Grading of Recommendations, Assessment, Development and Evaluation; n/a, not applicable; no., number; RCT, randomized controlled trial; SR, systematic review.

### Table 5.20. Bowel Preparation: ISFU Table.

| Indicator | Number of studies | GRADE evaluation | ISFU Criteria | | | | |
|---|---|---|---|---|---|---|---|
| | | | Importance to measure and report | Scientific acceptability of measure properties | Feasibility | Usability and use | Comparison to related or competing measures |
| Bowel Preparation | 2 SR<br>1 review<br>8 cohort<br>1 cross-sectional | Low | High importance | Validated against ADR, HRADR, SSP and CIR and important patient outcomes.<br><br>BBSP is reliable, validated and has established benchmarks. Other reasonably validated scales include the Aronchick and Ottawa scale.<br>Some evidence to support threshold of poor/inadequate bowel preparation vs. other.<br>Some evidence to support more stringent right colon bowel preparation scores to detect SSPs. | Measurement at facility level may be more feasible than at regional and higher levels.<br><br>Use of validated scales in usual clinical practice may be cumbersome.<br><br>Unlikely to be used in a standardized fashion in routine reporting, making use of NLP less feasible. | Indirect evidence of an association with colonoscopy quality.<br><br>Lack of endoscopist ownership for bowel preparation quality may make it less actionable. | Key measure for colonoscopy quality.<br><br>Important to the patient.<br><br>No other similar measures. |

**Abbreviations:** HRADR, high-risk adenoma detection rate; ADR, adenoma detection rate; BBSP, Boston Bowel Preparation Scale; CIR, cecal intubation rate; GRADE, Grading of Recommendations, Assessment, Development and Evaluation; ISFU, importance, scientific acceptability, feasibility, usability, and comparison to related/competing measures; NLP, natural language processing; SSP, sessile serrated polyps; vs., versus.

## Retroflexion

**Table 5.21. Retroflexion: GRADE Table.**

| Quality Assessment | | | | | | | | | | Quality | Importance |
|---|---|---|---|---|---|---|---|---|---|---|---|
| No. of studies | Design | Risk of Bias | Inconsistency | Indirectness | Imprecision | Large Effect | Dose-response | No plausible confounding | Other | | |
| **Retroflexion** | | | | | | | | | | | |
| 3<br>2<br>1 | SR<br>RCT<br>Cohort | Low | No serious inconsistency | No serious indirectness | No serious imprecision | n/a | n/a | n/a | - | ++ | Moderate |

**Abbreviations:** GRADE, Grading of Recommendations, Assessment, Development and Evaluation; n/a, not applicable; no., number; RCT, randomized controlled trial; SR, systematic review.

**Table 5.22. Retroflexion: ISFU Table.**

| Indicator | Number of studies | GRADE evaluation | ISFU Criteria | | | | |
|---|---|---|---|---|---|---|---|
| | | | Importance to measure and report | Scientific acceptability of measure properties | Feasibility | Usability and use | Comparison to related or competing measures |
| Re-examination of the right colon (either RCR or SFV) | 3 SR<br>2 RCT<br>1 cohort study | Moderate | Important | Re-examination of right-sided colon validated against AMR and R-ADR.<br><br>Method of re-examination not important. | Not possible to measure at the jurisdictional level but could be measured at the facility level.<br><br>Unclear if routinely reported in endoscopy reports, making use of NLP less feasible. | Indirect evidence of an association with colonoscopy quality. | Addresses the issue of missed right sided neoplasia. |
| Rectal retroflexion | 1 SR | Low | Important | Rectal retroflexion has been shown to lead to small improvements in adenoma detection | Not possible to measure at the jurisdictional level but could be measured at the facility level.<br><br>Unclear if routinely reported in endoscopy reports, making use of NLP less feasible. | Indirect evidence of an association with colonoscopy quality. | |

**Abbreviations:** AMR, adenoma miss rate; GRADE, Grading of Recommendations, Assessment, Development and Evaluation; ISFU, importance, scientific acceptability, feasibility, usability, and comparison to related/competing measures; NLP, natural language processing; R-ADR, right-sided ADR; RCR, right colon retroflexion; SFV, second forward view.

## PICI and TIIR

**Table 5.23. PICI and TIIR: GRADE Table.**

| Quality Assessment | | | | | | | | | Quality | Importance |
|---|---|---|---|---|---|---|---|---|---|---|
| **No. of studies** | **Design** | **Risk of Bias** | **Inconsistency** | **Indirectness** | **Imprecision** | **Large Effect** | **Dose-response** | **No plausible confounding** | | |
| **Performance Indicator of Colonic Intubation (PICI)** | | | | | | | | | | |
| 3 | Observational studies | Low/ Moderate | Serious* | No serious indirectness | Serious** | n/a | n/a | None | + | Low/ moderate |
| **Terminal ileum intubation rate (TIIR)** | | | | | | | | | | |
| 1 | Observational study | Moderate | n/a | No serious indirectness | Serious (Large range) | none | none | none | + | Low |

*Inconsistency -different tests for COL indication -FOBT and FIT; different levels of sedation between studies
**Imprecision -not sure, in terms of PICI achieved 46.1, 78.7 (wide variation), 54.1 -then yes, but all have PICI associated with ADR
**Abbreviations:** ADR, adenoma detection rate; COL, colonoscopy; FIT, fecal immunochemical test; FOBT, fecal occult blood test; GRADE, Grading of Recommendations, Assessment, Development and Evaluation; n/a, not applicable; no., number; PICI, performance indicator of colonic intubation; TIIR, terminal ileum intubation rate.

**Table 5.24. PICI and TIIR: ISFU Table.**

| Indicator | Number of studies | GRADE evaluation | ISFU Criteria | | | | |
|---|---|---|---|---|---|---|---|
| | | | Importance to measure and report | Scientific acceptability of measure properties | Feasibility | Usability and use | Comparison to related or competing measures |
| PICI | 3 cohort studies | Low | Addresses concern with CIR, with respect to safety and patient comfort<br><br>New colonoscopy quality construct | Associated with ADR in most studies<br><br>PICI correlated with:<br>-unit accreditation,<br>-the presence of magnetic imagers in the unit,<br>-greater annual volume,<br>-fewer years' experience,<br>-higher training/trainer status<br><br>No data on risk adjustment, clinically important difference, issues with data sources or missing data. | CIR, sedation level, and comfort should be measured regardless.<br><br>PICI cannot be measured in units where propofol is routinely used<br><br>PICI varies on sedation level and may not be comparable across or within endoscopy units with different sedation practices<br><br>May be feasible to report at the unit level but it may challenge across a region or provincially as their patient comfort or sedation measure is not in the health administrative data | Takes into consideration of safety and comfort.<br><br>Could be used to improve patient care. | Is CIR enough?<br><br>It adds another dimension to CIR. |

**Abbreviations:** ADR, adenoma detection rate; CIR, cecal intubation rate; GRADE, Grading of Recommendations, Assessment, Development and Evaluation; ISFU, importance, scientific acceptability, feasibility, usability, and comparison to related/competing measures; PICI, Performance Indicator of Colonic Intubation.

**Table 5.25. TIIR: ISFU Table.**

| Indicator | Number of studies | GRADE evaluation | ISFU Criteria | | | | |
|---|---|---|---|---|---|---|---|
| | | | Importance to measure and report | Scientific acceptability of measure properties | Feasibility | Usability and use | Comparison to related or competing measures |
| TIIR | 1 cohort study | Low | Low importance<br>(Not associated with quality indicators or indication of additional pathology) | No significant differences in the PDR, ADR, or SSPDR in cases with or without TI intubation.<br><br>No additional pathology. | Quite feasible | Unlikely to change quality of patient care | Does not appear to add anything beyond CIR |

**Abbreviations:** ADR, adenoma detection rate; CIR, cecal intubation rate; GRADE, Grading of Recommendations, Assessment, Development and Evaluation; ISFU, importance, scientific acceptability, feasibility, usability, and comparison to related/competing measures; PDR, polyp detection rate; PICI, Performance Indicator of Colonic Intubation; SSPDR, sessile serrated polyp detection rates; TI, terminal ileum; TIIR, terminal ileum intubation rate.

## Polyp Management

**Table 5.26. Incomplete resection: GRADE Table.**

| Quality Assessment | | | | | | | | | | Quality | Importance |
|---|---|---|---|---|---|---|---|---|---|---|---|
| No. of studies | Design | Risk of Bias | Inconsistency | Indirectness | Imprecision | Large Effect | Dose-response | No plausible confounding | Other | | |
| **Retroflexion** | | | | | | | | | | | |
| 1<br>1 | SR<br>Cohort | Low | No serious inconsistency | No serious indirectness | No serious imprecision | n/a | n/a | n/a | - | ++ | Moderate |

**Abbreviations:** GRADE, Grading of Recommendations, Assessment, Development, and Evaluation; n/a, not applicable; no., number; SR, systematic review.

**Table 5.27. Incomplete Resection: ISFU Table.**

| Indicator | Number of studies | GRADE evaluation | ISFU Criteria | | | | |
|---|---|---|---|---|---|---|---|
| | | | Importance to measure and report | Scientific acceptability of measure properties | Feasibility | Usability and use | Comparison to related or competing measures |
| SMAR-IR | 1 cross-sectional study | Low | Less important | Not validated.<br><br>An approach to measuring incomplete resection has been reported. | Potentially feasible at the facility level more than at regional and higher levels. | No association with colonoscopy quality reported.<br><br>Has face validity as incomplete resection is a cited cause for PCCRCs. | No other similar measures. |

**Abbreviations:** GRADE, Grading of Recommendations, Assessment, Development and Evaluation; ISFU, importance, scientific acceptability, feasibility, usability, and comparison to related/competing measures; PCCRC, post-colonoscopy colorectal cancers; SMAR-IR, segmental metachronous adenoma rate attributable to incomplete resection.

## Appendix 6: Quality Assessment tables

**Table 6.1. AGREE II (Appraisal of Guidelines for Research and Evaluation) Instrument Scores.**

| Guideline | Domain 1: Scope and Purpose | Domain 2: Stakeholder Involvement | Domain 3: Rigor of Development | Domain 4: Clarity of Presentation | Domain 5: Applicability | Domain 6: Editorial Independence |
|---|---|---|---|---|---|---|
| UK Key Performance Indicators and Quality Assurance Standards, Rees 2016 | 56% | 58% | 52% | 53% | 21% | 50% |

**Table 6.2. ROBIS (Risk of Bias in Systematic Reviews) Quality Assessment Scores.**

| Study | Domain 1: Study Eligibility Criteria | Domain 2: Identification and Selection of studies | Domain 3: Data Collection and Study Appraisal | Domain 4: Synthesis and Findings | Overall Risk of Bias in the Review |
|---|---|---|---|---|---|
| Rees, 2016 | Unclear | Unclear | Unclear | Low | Unclear |
| **PCCRC** | | | | | |
| Kang, 2021 | Low | Moderate | Low | Low | Low |
| **Rate of Surgical Resection** | | | | | |
| De Neree tot Babbeerich, 2019 | Low | Moderate | Low | Low | Low |
| Thorlacius, 2019 | Low | Moderate | Low | Low | Low |
| Hassan, 2016 | Low | Low | Low | Low | Low |
| **Adverse events** | | | | | |
| Kothari 2019 | Low | Low | High | High | High |
| Takamaru 2020 | Unclear | Low | High | High | High |
| Jaruvongvanic 2017 | Low | Low | Low | Low | Low |
| Reumkens 2016 | Low | Low | High | Low | Low |
| **Retroflexion** | | | | | |
| Desai, 2019 | Low | Low | Low | Low | Low |
| Ai, 2018 | Low | Low | Low | Low | Low |
| **Bowel Preparation** | | | | | |
| Katenburg, 2018 | Low | Unclear | Unclear | Low | Unclear |
| Sulz, 2016 | Low | Low | Low | Low | Low |

**Abbreviation:** PCCRC, post-colonoscopy colorectal cancer

**Table 6.3. Risk of Bias in Randomized Controlled Trials.**

| Study | Domain 1: Randomization Process | Domain 2: Deviation from Intervention | Domain 3: Missing Outcome Data | Domain 4: Measurement of Outcome | Domain 5: Reported Result | Overall Risk of Bias |
|---|---|---|---|---|---|---|
| **Withdrawal Time** | | | | | | |
| Desai, 2023 | Low | Low | Low | Low | Low | Low |
| Zhao, 2023 | Low | Low | Low | Low | Low | Low |
| Zhao, 2022 | Low | Low | Low | Moderate | Low | Low |
| Coghlan, 2019 | Low | Low | Low | Moderate | Low | Low |
| **Retroflexion** | | | | | | |
| Yang, 2022 | Low | Low | Moderate | Low | Low | Moderate |
| Nunez Rodriguez, 2020 | Low | Moderate | Low | Moderate | Low | Moderate |

**Table 6.4. ROBINS (Risk of Bias in Case-Control Studies) Quality Assessment Scores.**

| Study | Domain 1: Bias due to confounding | Domain 2: Bias due to selection of participants | Domain 3: Bias in measurement of interventions | Domain 4: Bias due to departure of interventions | Domain 5: Bias due to missing data | Domain 6: Bias in measure ment of outcomes | Domain 7: Bias in selection of the reported results | Overall Risk of Bias |
|---|---|---|---|---|---|---|---|---|
| **PCCRC** | | | | | | | | |
| Tollivoro, 2019 | Low | Low | Low | Low | Low | Low | Low | Low |

**Abbreviation:** PCCRC, post-colonoscopy colorectal cancer

**Table 6.5. ROBINS (Risk of Bias in Non-randomized Studies) Quality Assessment Scores.**

| Study | Domain 1: Bias due to confounding | Domain 2: Bias due to selection of participants | Domain 3: Bias in measurement of interventions | Domain 4: Bias due to departure of intervent ions | Domain 5: Bias due to missing data | Domain 6: Bias in measure ment of outcomes | Domain 7: Bias in selection of the reported results | Overall Risk of Bias |
|---|---|---|---|---|---|---|---|---|
| **Rate of Surgical Resection** | | | | | | | | |
| Parker, 2023 | Moderate | Low | Low | Low | Low | Moderate | Low | Moderate |
| Chaoui, 2022 | Moderate | Low | Low | Low | Low | Moderate | Low | Moderate |
| Chiba, 2022 | Moderate | Moderate | Moderate | Low | Low | Moderate | Low | Moderate |
| Mandic, 2022 | Low | Low | Low | Moderate | Low | Moderate | Low | Moderate |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Tidehag 2022 | Low | Low | Low | Low | Low | Moderate | Low | Moderate |
| Zammit 2022 | Moderate | Moderate | Low | Moderate | Low | Moderate | Low | Moderate |
| Wickham, 2022 | Moderate | Low | Low | Low | Low | Low | Low | Moderate |
| Patel, 2021 | Moderate | Low | Low | Low | Low | Low | Low | Moderate |
| Qu, 2021 | Moderate | Moderate | Low | Low | Low | Low | Low | Moderate |
| Spychalski, 2021 | Moderate | Moderate | Low | Low | Low | Low | Low | Moderate |
| Vu, 2021 | Moderate | Low | Low | Low | Low | Low | Low | Moderate |
| Yu, 2021 | Moderate | Low | Low | Low | Low | Low | Low | Moderate |
| Azevedo, 2020 | Moderate | Moderate | Low | Low | Low | Low | Low | Moderate |
| Bosch, 2020 | Moderate | Moderate | Low | Low | Low | Low | Low | Moderate |
| Moon, 2020 | Moderate | Moderate | Low | Low | Low | Moderate | Low | Moderate |
| Rodrigues, 2020 | Moderate | Moderate | Low | Low | Low | Serious | Low | Serious |
| Li, 2019 | Moderate | Moderate | Low | Low | Low | Low | Low | Moderate |
| Peery, 2018 | Moderate | Low | Low | Low | Low | Low | Low | Moderate |
| **PICI and TIIR** | | | | | | | | |
| Nass 2021 Retrospective | Moderate | Low | Low | Low | Low | Moderate | Low | Moderate |
| Lund 2019 Retrospective | Moderate | Low | Low | Low | Moderate | Moderate | Moderate | Moderate |
| Valori 2018 Retrospective | Moderate | Low | Low | Low | Low | Moderate | Low | Moderate |
| Leiman, 2020 Retrospective | Moderate | Low | Low | Low | Low | Moderate | Low | Moderate |
| **PCCRC** | | | | | | | | |
| Waldmann, 2022 | Moderate | Low | Low | Low | Low | Low | Low | Moderate |
| Aerts, 2021 | Moderate | Serious | Low | Low | Low | Low | Low | Moderate |
| Dossa, 2021 | Low | Low | Low | Low | Low | Low | Low | Low |
| Anderson, 2020 | Moderate | Low | Low | Low | Low | Low | Low | Moderate |
| Forseberg, 2020 | Moderate | Low | Low | Low | Low | Low | Low | Moderate |
| Burr, 2019 | Moderate | Low | Low | Low | Low | Low | Low | Moderate |
| Chen, 2019 | Moderate | Moderate | Low | Low | Low | Low | Low | Moderate |
| Cheung, 2019 | Moderate | Low | Low | Low | Low | Low | Low | Moderate |
| Macken, 2019 | Moderate | Low | Low | Low | Low | Low | Moderate | Moderate |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Pedersen, 2019 | Moderate | Low | Low | Low | Low | Low | Low | Moderate |
| Murthy, 2018 | Moderate | Low | Low | Low | Low | Low | Low | Low |
| Nakada, 2017 | Moderate | Low | Low | Low | Low | Low | Low | Moderate |
| Govindarajan, 2016 | Moderate | Low | Low | Low | Low | Low | Low | Moderate |
| Stoffel, 2016 | Moderate | Low | Low | Low | Low | Low | Low | Moderate |
| Hilsden, 2015 | Moderate | Low | Low | Low | Low | Low | Low | Moderate |
| **Adverse events** | | | | | | | | |
| Benazzato, 2021 | Moderate | Moderate | Low | Low | Low | Low | Low | Moderate |
| Kim 2021 | Moderate | Low | Low | Low | Low | Low | Low | Moderate |
| Kooyker, 2021 | Moderate | Low | Low | Low | Low | Low | Low | Moderate |
| Passat, 2021 | Moderate | Low | Low | Low | Low | Low | Low | Moderate |
| Tomaszewski, 2021 | Moderate | Low | Low | Low | Low | Low | Low | Moderate |
| Yoshida, 2021 | Moderate | Low | Low | Low | Low | Low | Low | Moderate |
| Casusada-calo, 2020 | Low | Low | Low | Low | Low | Low | Low | Low |
| Garg, 2020 | Moderate | Low | Low | Low | Low | Low | Low | Moderate |
| Kobiela, 2020 | Moderate | Low | Low | Low | Low | Low | Low | Moderate |
| Laanani, 2019 | Moderate | Low | Low | Low | Low | Low | Low | Moderate |
| Vanaclocha-Espi, 2019 | Moderate | Low | Low | Low | Low | Low | Low | Moderate |
| Derbyshire, 2018 | Moderate | Low | Low | Low | Low | Low | Low | Moderate |
| Hoff, 2017 | Moderate | Low | Low | Low | Low | Low | Low | Moderate |
| Denis 2021 | Moderate | Low | Low | Low | Low | Moderate | Low | Moderate |
| Rutter 2014 | Moderate | Low | Low | Low | Low | Low | Low | Moderate |
| Saraste 2016 | Moderate | Low | Low | Low | Low | Low | Low | Moderate |
| Gupta 2011 | Moderate | Low | Low | Low | Low | Low | Low | Moderate |
| Arana-Arri 2018 | Moderate | Low | Low | Low | Low | Low | Low | Moderate |
| Mikkelsen 2018 | Moderate | Low | Low | Low | Low | Low | Low | Moderate |
| Tepes 2017 | Moderate | Low | Low | Low | Moderate | Low | Low | Moderate |
| **ADR** | | | | | | | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Zessner-Spitzenberg, 2023 | Moderate | Low | Low | Low | Low | Low | Low | |
| Zorzi 2023 | Moderate | Low | Low | Low | Low | Moderate | Low | Moderate |
| Schottinger, 2022 | Low | Low | Low | Low | Low | Low | Low | Low |
| Schwarz, 2022 | Moderate | Low | Low | Low | Low | Low | Low | Modetate |
| van Toledo, 2022 | Moderate | Low | Low | Low | Low | Low | Low | Moderate |
| Wisse, 2022 | Moderate | Low | Low | Low | Low | Low | Low | Moderate |
| Aniwan, 2021 | Moderate | Low | Low | Low | Low | Low | Low | Moderate |
| Gingold, 2021 | Moderate | Serious | Low | Low | Low | Low | Low | Serious |
| Han, 2021 | Moderate | Low | Low | Low | Moderate | Low | Low | Moderate |
| Kaltenbach, 2021 | Moderate | Low | Low | Low | Low | Low | Low | Moderate |
| Murphy, 2021 | Moderate | Low | Low | Low | Low | Low | Low | Moderate |
| Buerger, 2020 | Moderate | Low | Low | Low | Low | Low | Low | Moderate |
| Leite, 2020 | Moderate | Low | Low | Low | Low | Low | Low | Moderate |
| Park, 2020 | Moderate | Low | Low | Low | Low | Low | Low | Moderate |
| Penz, 2020 | Moderate | Low | Low | Low | Low | Low | Low | Moderate |
| Vojtechova, 2020 | Moderate | Low | Low | Low | Low | Low | Low | Moderate |
| Wadhwa 2020 | Moderate | Low | Low | Low | Low | Low | Low | Moderate |
| Yamaguchi, 2020 | Moderate | Moderate | Low | Low | Low | Moderate | Low | Moderate |
| Gessl, 2019 | Moderate | Low | Low | Low | Low | Low | Low | Moderate |
| Hilsden, 2019 | Moderate | Low | Low | Low | Low | Low | Low | Moderate |
| Sastra Lozano 2019 | Moderate | Moderate | Low | Low | Low | Low | Low | Moderate |
| Murchie, 2018 | Moderate | Low | Low | Low | Low | Low | Low | Moderate |
| Tjaden, 2018 | Moderate | Low | Low | Low | Low | Low | Low | Moderate |
| Yoon, 2018 | Moderate | Moderate | Low | Low | Low | Low | Low | Moderate |
| Abdelfatah 2017 | Moderate | Low | Low | Low | Low | Low | Low | Moderate |
| Anderson, 2017 | Moderate | Low | Low | Low | Low | Low | Low | Moderate |
| Cubiella, 2017 | Moderate | Low | Low | Low | Low | Low | Low | Moderate |
| Kaminski, 2017 | Moderate | Low | Low | Low | Low | Low | Low | Moderate |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Aniwan, 2016 | Moderate | Serious | Low | Low | Low | Moderate | Low | Serious |
| Hilsden, 2016 | Moderate | Moderate | Low | Low | Low | Low | Low | Moderate |
| Park, 2016 | Moderate | Low | Low | Low | Low | Low | Low | Moderate |
| **Withdrawal Time** | | | | | | | | |
| Mangas-Sanjuan, 2022 | Moderate | Low | Low | Low | Low | Low | Low | Moderate |
| Sekiguchi, 2022 | Moderate | Low | Moderate | Low | Low | Low | Low | Moderate |
| Shiha, 2021 | Moderate | Low | Low | Low | Low | Low | Low | Moderate |
| Choi, 2021 | Moderate | Low | Low | Low | Low | Low | Low | Moderate |
| Jung, 2019 | Moderate | Low | Low | Low | Low | Low | Low | Moderate |
| Patel, 2018 | Low | Low | Low | Low | Low | Low | Low | Low |
| Shaukat, 2015 | Moderate | Moderate | Low | Low | Low | Low | Low | Moderate |
| Kashiwagi, 2017 | Moderate | Low | Low | Low | Low | Low | Low | Moderate |
| Choug, 2016 | Moderate | Low | Low | Low | Low | Low | Low | Moderate |
| **Retroflexion** | | | | | | | | |
| Noagles, 2021 | Moderate | Serious | Low | Low | Low | Low | Low | Serious |
| **Cecal Intubation Rate** | | | | | | | | |
| Vemulapalli 2020 | Moderate | Moderate | Low | Low | Low | Low | Low | Moderate |
| **Bowel Preparation** | | | | | | | | |
| Pantelon Sanchez 2022 | Moderate | Low | Moderate | Low | Low | Moderate | Low | Moderate |
| Zhou, 2021 | Moderate | Low | Low | Low | Low | Moderate | Low | Moderate |
| Choi, 2021 | Moderate | Moderate | Low | Low | Low | Moderate | Moderate | Moderate |
| Guo, 2019 | Serious | Moderate | Low | Low | Low | Moderate | Low | Serious |
| Clark, 2016 | Moderate | Low | Low | Low | Low | Low | Low | Moderate |
| Wong, 2016 | Serious | Moderate | Low | Low | Low | Serious | Moderate | Serious |
| Jain, 2015 | Serious | Moderate | Low | Low | Low | Moderate | Low | Serious |
| Tholey, 2015 | Serious | Moderate | Moderate | Low | Low | Moderate | Moderate | Serious |

**Abbreviations:** ADR, adenoma detection rate; PCCRC, post-colonoscopy colorectal cancer; PICI, performance indicator of colonic intubation; TIIR, terminal ileum intubation rate

[For retroflexion] * Note: The order of procedures favoured towards better detection for right colon retroflexion.

**Table 6.6. Joanna Briggs Institute Critical Appraisal Checklist for Analytical Cross-Sectional Studies Quality Assessment Scores.**

| Study | Domain 1: Bias due to selection of participants | Domain 2: Bias in measurement of interventions | Domain 3: Bias due to confounding | Domain 4: Bias in measurement of outcomes | Overall Risk of Bias |
|---|---|---|---|---|---|
| **Rate of Surgical Resection** | | | | | |
| Spychalski, 2021 | Low | Low | Moderate | Low | Low |
| Vu, 2021 | Low | Low | Low | Low | Low |
| Yu, 2021 | Low | Low | Low | Low | Low |
| Azevedo, 2020 | Low | Low | Low | Low | Low |
| Li, 2019 | Low | Low | Low | Low | Low |
| Peery, 2018 | Low | Low | Low | Low | Low |
| **Patient Outcomes** | | | | | |
| *Patient Comfort and Pain during procedure* | | | | | |
| Forbes, 2021 | Yes | Yes | NA | NA | NA |
| Telford, 2020 | Yes | Yes | NA | NA | NA |
| Rostom, 2013 | Yes | Yes | NA | NA | NA |
| Klein, 2010 | Yes | Yes | NA | NA | NA |
| *Patient Satisfaction with the whole process/visit* | | | | | |
| Veldhuijzen, 2020 | Yes | Yes | NA | NA | NA |
| Brotons, 2019 | Yes | Yes | NA | NA | NA |
| Yoon, 2018 | Yes | Yes | Yes | Yes | NA |
| Hutchings, 2015 | Yes | Yes | NA | NA | NA |
| **Bowel Preparation** | | | | | |
| Kimpel, 2022 | Low | Low | Low | Low | Low |
| **Polyp Management – Incomplete Resection** | | | | | |
| Alsayid, 2021 | Low | Moderate | Low | Low | Low |

## Appendix 7: ISFU framework

| | Criterion | Sub-criteria |
|---|---|---|
| **Importance to measure and report** | Extent to which the specific measure focus is evidence-based, important to making significant gains in healthcare quality, and improving health outcomes for a specific high priority aspect of healthcare where there is variation in or overall, less-than-optimal performance.<br>The extent to which the indicators capture key aspects of care that require improvement.<br>*Measures must be judged to meet all sub-criteria to pass this criterion and be evaluated against the remaining criteria* | a. Evidence base -The measure focus is evidence-based:<br>• Health outcome: a rationale supports the relationship of the health outcome to processes or structures of care.<br>• A systematic assessment and grading of the quantity, quality, and consistency of the evidence that the measured structure, process or intermediate clinical outcome leads to a desired health outcome.<br>b. Performance gap -Demonstration of quality problems and opportunity for improvement<br>c. High priority -A high priority aspect of healthcare. |
| **Scientific acceptability** | Extent to which the measure, as specified, produces consistent (reliable) and credible (valid) results about the quality of care when implemented.<br>*Measures must be judged to meet the sub-criteria for both reliability and validity to pass this criterion and be evaluated against the remaining criteria.* | a. Reliability -The measure is well defined and precisely specified so it can be implemented consistently and allows for comparability.<br>b. Validity –measure specifications are consistent with the evidence (face validity); correlated with other measure; adequate discrimination and calibration; scoring allows for statistical significance and clinically meaningful differences in performance; compares with other methods and ensures results are not biased from missing data<br>c. Disparities-If disparities in care have been identified, measure specifications, scoring, and analysis allow for identification of disparities through stratification of results. |
| **Feasibility** | Extent to which the specifications, including measure logic, required data that are readily available or could be captured without undue burden and can be implemented for performance measurement. | a. For clinical measures, the required data elements are routinely generated and used<br>b. The required data elements are available in electronic sources, or a credible path to electronic collection is specified.<br>c. Demonstration that the data collection strategy can be implemented |
| **Usability and use** | Extent to which potential audiences (e.g., consumers, purchasers, providers, policymakers) are using or could use performance results for both accountability and performance improvement to achieve the goal of high quality, efficient healthcare for individuals or populations. | A credible rationale describes how the performance results could be used to further the goal of high quality, efficient healthcare for individuals or populations. |
| **Comparison to related or competing measures** | If a measure meets the above criteria and there are endorsed or new related measures (either the same measure focus or the same target population) or competing measures (both the same measure focus and the same target population), the measures are com- pared to address harmonization and/or selection of the best measure. | Consider multiple measures in a domain if:<br>• The measure is harmonized with related measures or multiple measures are justified.<br>Consider replacing existing measure if:<br>• The measure is superior to existing measures |

## Appendix 8: Guideline Document History

| GUIDELINE VERSION | SYSTEMATIC REVIEW | | PUBLICATIONS | NOTES and KEY CHANGES |
|---|---|---|---|---|
| | Search Dates | Data | | |
| Original 2005 | 1966-July 2006 | Full Report | Rabeneck L, Rumble RB, Axler J, Smith A, Armstrong D, Vinden C, et al; Cancer Care Ontario's Colonoscopy Standards Expert Panel. Cancer Care Ontario colonoscopy standards: standards and evidentiary base. Can J Gastroenterol. 2007;21(Suppl D):5D-24D. | N.A. |
| Version 2 2013 | 2006-2012 | New data added to original Full Report | Tinmouth J, Kennedy EB, Baron D, Burke M, Feinberg S, Gould M, et al. Colonoscopy quality assurance in Ontario: systematic review and clinical practice guideline. Can J Gastroenterol Hepatol. 2014 May;28(5):251-74. | New indicators and targets. |
| Version 3 2023 | 2015-2023 | New data -original evidence summary | | New indicators and targets. |