# A retrospective analysis of the histology of resected polyps and colonoscopy quality parameters in Belgium

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## Abstract

***Background and aims:*** **adenoma detection rate is a well known quality parameter for colonoscopy. However recently other quality parameters have emerged. We wanted to evaluate the histology of the resected polyps, different quality indicators of colonoscopy and post colonoscopy colorectal cancer (PCCRC) in Belgium and analyzed data about colonoscopies performed between 2008-2015.**

***Methods:*** **Reimbursement data on colorectal related medical procedures from the Intermutualistic Agency were linked with data on clinical and pathological staging of colorectal cancer and with histologic data of resected polyps available at the Belgian Cancer Registry over a period covering 8 years (2008-2015).**

***Results:*** **298,246 polyps were resected in 294,923 colonoscopies, of which 275,182 were adenomas (92 %) and 13,616 were SSLs (4%). There was a significant but small correlation between the different quality parameters and PCCRC. Post colonoscopy colorectal cancer rate after 3 years was 7.29 %. There were marked geographic differences in Belgium concerning adenoma detection rate, sessile adenoma detection rate and post colonoscopy colorectal cancer.**

***Conclusion:*** **Most resected polyps were adenomas, only a small percentage involved sessile serrated lesions. There was a significant correlation between adenoma detection rate and other quality parameters, and a small but significant correlation between PCCRC and the different quality parameters. The lowest post colonoscopy colorectal cancer rate was reached with an ADR of 31.4 % and a SSL-DR of 1.2 %.** (Acta gastroenterol. belg., **2023,** 86, **277-285**).

**Keywords:** adenoma detection rate, serrated polyps, colorectal cancer.

## Introduction

Colorectal cancer (CRC) is an important cause of cancer-related morbidity and mortality in the Western world and is the third most common cancer worldwide (1). It is the fourth most common cause of cancer death (2). In 2012 about 1.4 million new cases of colorectal cancer and 700,000 deaths were recorded worldwide (3). Colorectal cancer though is a preventable disease (4), and colonoscopic removal of adenomatous polyps results in reduced mortality from colorectal cancer (5). Until recently, adenomatous polyps were considered the precursor lesions of all cases of sporadic colon cancer, thought to occur via the chromosomal instability pathway, but now it is obvious that colorectal carcinogenesis can occur as well via the serrated pathway (6). Hyperplastic polyps were once regarded as harmless without malignant potential, now it is recognized that these polyps form a heterogeneous group, called serrated polyps, characterized by a saw-toothed appearance of colonic crypts. This group of serrated polyps includes hyperplastic polyps (HPs), sessile serrated lesions (SSLs) and traditional serrated adenomas (TSAs) (6).

To assess the performance of screening colonoscopy, different parameters have been described (7-9). Adenoma detection rate (ADR) was proposed as a quality indicator for colonoscopy in 2002 by the US Multi-Society Task Force on Colorectal Cancer (9). It is the most widely used quality parameter. Although recommended targets were originally based on screening studies (10), it is easier to use an overall ADR inclusive of all colonoscopy indications (11). In the latter study, ADR stratified by colonoscopy indication was highest for surveillance, then screening and then diagnostic examinations (11,12).

No histology is needed to calculate PDR or polyp detection rate. A high degree of correlation with ADR has been described between ADR and PDR (13), and individually calculated conversion rates have been proposed (14).

Sessile serrated lesion detection rate focuses on the detection of sessile serrated lesions (SSLs). They are frequently missed or incompletely resected because they are difficult to distinguish from the surrounding tissue (15).

Villous histology was previously considered as high risk but in the European guidelines for post-polypectomy colonoscopy surveillance published in 2020, patients whose polyps showed villous histology were moved into the non-surveillance group (16,17).

Minimum targets for ADR were defined as 30 % in men and 20 % in women (18), and 25 % for a male/female population (18). In Europe a minimum standard ADR of 25 % was proposed (19). Significantly higher rates of post colonoscopy colorectal cancers are found in endoscopists with low ADRs (20). In a study of Wieszczy (21) PCCRC risk was > 2-fold higher in the individuals who underwent colonoscopy by a low-performing colonoscopist.

In Belgium, no colonoscopy quality guidelines are implemented and no data about performance of colonoscopy are available. Previous studies highlighted the

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difficulties encountered when setting up a nationwide quality control programme (22). Voluntary self-registration has several disadvantages (extra workload) and is prone to serious bias (missing data). The importance of quality control in colonoscopy is reflected by the post colonoscopy colorectal cancers rate, cancers off which the majority could have been avoided.

Although physicians are reluctant toward control of quality assessment, implementation of control programmes is imperative. A colonoscopy is an expensive and invasive examination, and there is a clear need to measure and record performance.

Encountering the difficulties for the implementation of a quality control programme in Belgium , we wanted to assess retrospectively the different quality parameters as well as their relationship with post colonoscopy colorectal cancer (PCCRC) based on our 8 years database, and we also aimed to analyze the histology of resected polyps. We wanted to determine the optimal cutoff that would lead to the lowest possible risk of interval cancer.

## Methods

For this study, data from the Belgian Cancer Registry (BCR) and the Intermutualistic Agency (IMA-AIM) were used. The BCR, a national population-based cancer registry, is legally authorized to collect all data on new cancer diagnoses and on the histology of the resected polyps (starting in 2005 with codes in 2014) and cancer diagnosis. These data are provided by the oncological care programs and the laboratories for pathological anatomy. The IMA-AIM collects all reimbursement data of medical procedures, provided by the seven health insurance companies in Belgium. In Belgium, more than 99 % of people are insured thanks to compulsory health insurance. All these people are members of one of the seven health insurance organizations in Belgium and are included in the study. So more than 99 % of colonoscopies performed in Belgium are captured in the study.

### *Definitions*

Adenoma detection rate (ADR) is defined as the percentage of patients undergoing first-time colonoscopy who are 50 years or older and have 1 or more conventional adenomas detected (9). Simplified ADR is defined as an overall ADR inclusive of all colonoscopy indications (11).

PDR or polyp detection rate is defined as the number of patients with one or more polyps removed during (screening) colonoscopy in patients aged 50 years or more (13).

Sessile serrated lesion detection rate (SSL-DR) is defined as the proportion of patients where one or more sessile serrated lesions are removed during colonoscopy (15).

Advanced adenoma detection rate (AADR) is defined as the percentage of colonoscopies with at least one advanced adenomatous specimen (15).

### *Study dataset*

For the current analysis, the IMA-AIM pooled and coded reimbursement data on specific procedures (rectosigmoidoscopy, (ileo)colonoscopy, polypectomy) with histological data from resected polyps (from the cyto-histopathological register (CHP)) and data from clinical and pathological staging from colorectal cancers (from the cancer registration database). CHP and the Cancer Registration Database are part of the BCR. This dataset comprised data collected between 2008 and 2015. Histological data from the polyps were collected starting from 2008, but collection was mandatory starting in 2010. So the first 3 years may yield incomplete data. Patient data were coded and included year of birth and death if applicable, hospital and endoscopist (all coded). Location and histology of cancers and polyps were coded using the International Classification of Diseases for Oncology (ICD-0-3). Based on CRC coding, the CRC site was classified into right-sided CRC (C18.0 cecum, ileocecal valve, C18.2 ascending colon, C 19 hepatic flexure, C 18.4 transverse colon), left-sided CRC (C 18.5 splenic flexure, C 18.6 descending colon, C 18.7 sigmoid colon, C 19 rectosigmoid junction, C20 rectum) and unspecified CRC location (C 18.8 overlapping lesion in colon and C 18.9 colon, unspecified). All appendiceal, non-epithelial and neuro-endocrine and unspecified tumors were omitted.

Histology was coded using the Systematized Nomenclature of Medicine (SNOMED 3.5VF (version 2017)) classification, and was linked to the reimbursement number of the endoscopic procedure within 30 days of the procedure. Invasive tumours, very small groups with less than 15 data and polyposis coli (211 patients) were omitted.

We defined advanced adenomas in a very narrow definition as adenomatous polyps with high-grade dysplasia, since we had no information about the size of the polyp. We omitted villous histology since this does not independently confer a long-term increased risk of CRC incidence or mortality (16). Furthermore, interpretation of villous histology has a high interobserver variability among pathologists (23).

### *Statistics*

Statistical analyses performed are mainly descriptive. The final dataset comprised 2,360,599 colonoscopies (rectosigmoidoscopy, (ileo)colonoscopy, polypectomy) in 1,452,411 patients, performed between 2008-2015. Colonoscopies were performed by 1417 physicians (690 gastroenterologists, 71 gastroenterologists in training, 209 specialists in internal medicine, and 11 specialists in internal medicine in training). We did not take into account colonoscopies performed by the other 478 physicians as they accounted for only 3.1 % of all examinations. The number of colonoscopies per year by endoscopists were calculated and described. Histology of

the polyps was described and their presence compared between locations in the colon using chi-square tests.

We calculated the quality parameters (ADR, PDR, SSL-DR, NAA and AADR and R-ADR for all colonoscopies in Belgium during this period. For this calculation, only 1 polyp per colonoscopy was taken into account (if two different pathologies were present, e.g. a sessile serrated lesion and an adenoma, both pathologies were taken into account). SSL-DR was compared between different age groups, and ADR, SSL-DR and PCCRC were compared across districts using chi-squared tests and weighted Pearson correlations (using permutation to obtain p-values).

Quality parameters were estimated for all physicians having performed at least 50 full colonoscopies. We compared ADR among age groups making statistical comparisons on the basis of post-hoc pairwise comparisons. In addition, we studied the relationship between ADR and number of colonoscopies performed per year (log transformed) and compared this association between young and older physicians using an ANCOVA model. In this ANCOVA analysis, ADR was used as response variable, number of colonoscopies per year as continuous explanatory variables and age (young vs. older) as factor. The two-way interaction tests if the association is different – i.e. differences in slopes – for the two age categories. Associations between the different quality parameters among physicians were explored using weighted correlations and visualized by a heatmap.

In a final analysis we explored if a decrease in PCCRC with increasing ADR or SSADR of physicians would level of at some point. To study this, a piecewise linear regression was performed.

## Results

### *Number of colonoscopies per physician*

The endoscopists present in the dataset for more than one year performed a median number of 347 colonoscopies per year (figure 1). When the left colonoscopies without polypectomy were omitted, the median number of colonoscopies was 272 colonoscopies per year (figure 1).

### *Histology of polyps*

In total, 298,246 polyps were resected in 294,923 colonoscopies (out of a total of 1,961,674 colonoscopies, meaning that in 1,666,751 (85 %) colonoscopies no polyps were resected). In this group of polyps in total 275,182 adenomas (92 %) were detected, and 13,616 were SSLs (4.5 %) (table 1). Only few hyperplastic polyps (28 (<0.01 %)) were found. 240 polyps belonging to very small groups were not taken into account (< 0.01 %).

23,136 polyps ( 8.4 % of all adenomas) were adenomas with high-grade dysplasia. Of all SSLs 305 contained adenocarcinoma (in situ) (2.2 % of all SSLs) and were classified as high risk SSLs.

Of the SSLs with known location (7,740 out of 13,616; 57 %) 7 % (3,623 out of 50,456 (all right-sided polyps)) were located in the right-sided colon (ascending colon). Five % (671 on a total of 13,340) were located in the transverse colon and 3 % (1975 on a total of 66,685) in the left-sided colon and 3 % (1,471 out of 45,282) in the rectum. Thus, in this group of 7,740 SSL, 55 % (4294) were localized in the right hemicolon (ascending colon

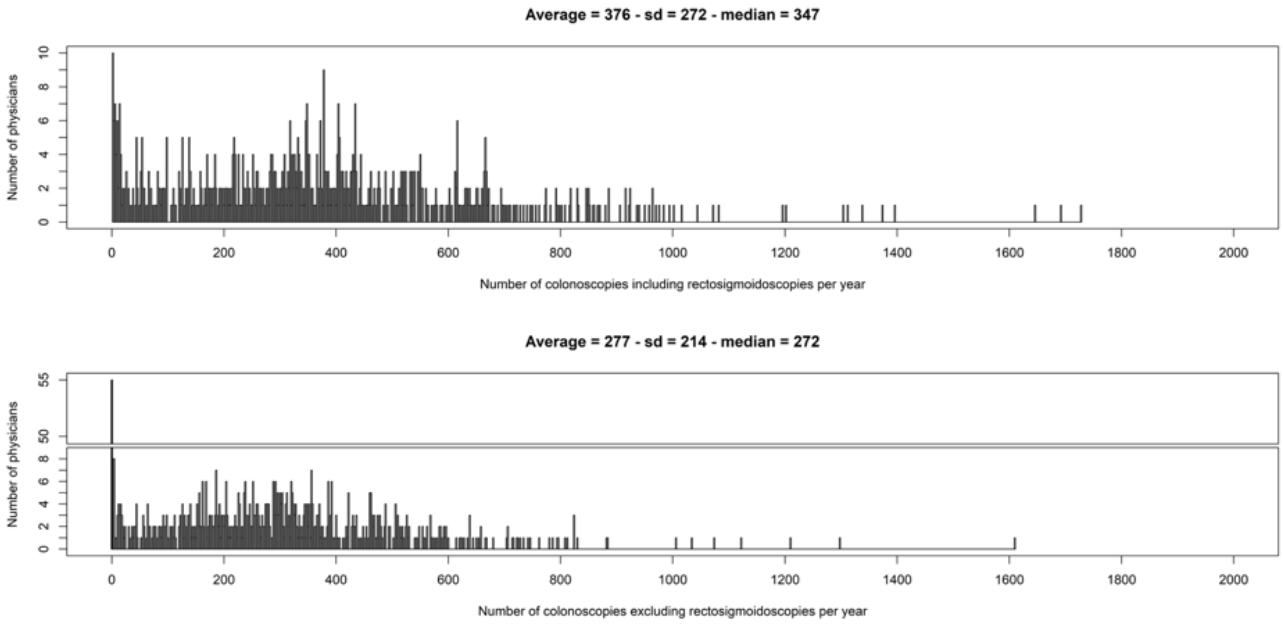


Fig. 1. — Number of colonoscopies per year, with and without rectosigmoidoscopy.

Table 1. — **Number of polyps and calculation of the different quality parameters**

| Histology code | Description | Number | Calculation PDR | Calculation ADR | Calculation SSL-DR | Calculation NAA | Calculation AADR | high risk SSL |
|---|---|---|---|---|---|---|---|---|
| M 72042 | Hyperplastic polyp | 28 | X | | | | | |
| M 81400 | adenoma NOS | 12000 | X | X | | X | | |
| M 81402 | Adenoma NOS with in situ adenoCa | 3562 | X | X | | | X | |
| M 82100 | Tubular adenoma | 194451 | X | X | | X | | |
| M 82101 | Tubular adenoma borderline | 1716 | X | X | | | X | |
| M 82102 | Tubular adenoma with in situ adenoCa | 7070 | X | X | | | X | |
| M 82120 | Flat adenoma | 35 | X | X | | | | |
| M 82130 | Serrated adenoma | 13311 | X | | X | | | |
| M 82132 | Serrated adenoma with in situ adenoCa | 305 | X | | X | | | X |
| M 82610 | Villous adenoma | 11858 | X | X | | X | | |
| M 82611 | Villous adenoma borderline | 467 | X | X | | | X | |
| M 82612 | Villous adenoma in situ adenoCa | 1652 | X | X | | | X | |
| M 82630 | Tubulovillous adenoma without HGD | 33702 | X | X | | X | | |
| M 82632 | Tubulovillous adenoma with in situ adenoCa | 8669 | X | X | | | X | |
| NSPOL | Not otherwise specified polyp | 9420 | X | | | | | |

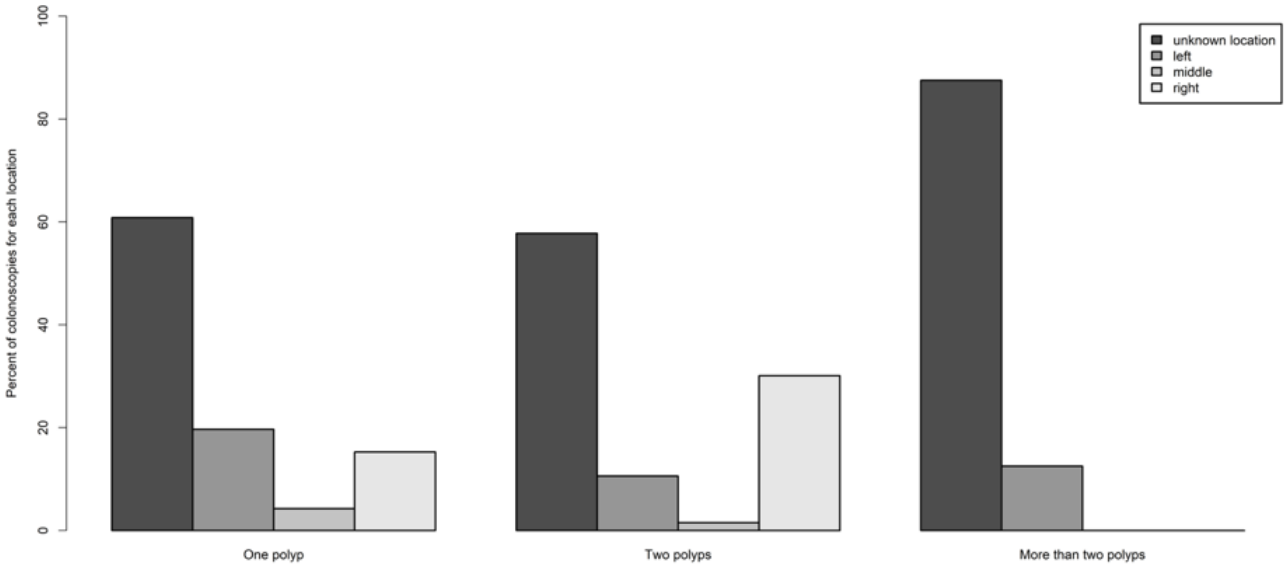


Fig. 2. — Number of polyps for each location.

and transverse colon). Of the 199 high risk SSLs with known localisation, 47% (93) were detected in the right hemicolon. Of the other adenomas with known location, only 37% occurred in the right hemicolon (63,125 on a total of 171,646). Both the SSLs ($\chi^2_1 = 1103$, $p < 0.0001$) and the high risk SSL's ($\chi^2_1 = 6.7$, $p = 0.01$) occurred significantly more frequently in the right hemicolon.

*Quality parameters and PCCRC*

In most colonoscopies only one polyp was resected. When two polyps were resected, more polyps were located in the right hemicolon. When more than two polyps were resected, fewer were of unknown location and multiple polyps appeared to be present more often in the left hemicolon (fig. 2).

Only in 52 % of all colonoscopies with a resection (436,183 resections reimbursed), histology was present in the database (227,120 polyps with histology), meaning that in 48 % of all reimbursed polypectomies no histology was received in the database. Of the 298,246 polyps taken into account no pathologic examination was reimbursed in 71,126 cases (23.8 %). The maximum number of polypectomies was 20 during one colonoscopy.

Table 2. — **PDR, ADR, SSL-DR, NAA and AADR in a Belgian database 2008-2015**

| | PDR (no histology) | PDR | ADR | SSL-DR | NAA | AADR |
|---|---|---|---|---|---|---|
| Men | 27% | 19% | 18% | 0.8% | 16% | 1.5% |
| Women | 18% | 12% | 11% | 0.6% | 9.8% | 0.9% |

PDR based on the reimbursement number was 27 % for men and 18 % for women (table 2), but based on histology in the database much lower (19 % for men, 12 % for women).

As expected – because of the low number of hyperplastic polyps – PDR based on the histology and ADR were comparable, ADR equaled 18% for men and 11% for women (table 1). SSL-DR was low (table 1). Because our database was spanning 8 years from 2008-2015, we did not have any knowledge about colonoscopies performed before 2008. To calculate polyp detection rate including only first colonoscopies we calculated polyp detection rate for the last 4 years (2012-2015) for all first colonoscopies in patients of 50 years or older that did not have another one in the first 4 years. Levels of ADR were much higher in these categories of patients (31 % for men, 20 % for women).

The highest SSL-DR was found in the age group 61-80 years (0.98 % in men, 0.81 % in women, versus 0.08 % and 0.05 % respectively in the age group 0-20 years). SSL-DR inclined from 0.31 % in 2008 to 1.13 % in 2015.

PCCRC-3yr calculated using the criteria set by the World Endoscopy Organization was 7.29 %, PCCRC-1yr was 2.13% and PCCR-5yr was 12.6 % (24).

*Geographic location*

Looking at the geographic distribution in Belgium we found significant differences between different regions in Belgium for both ADR (= 19355, $p < 0.0001$), SSADR (= 3273, $p < 0.0001$) and PCCRC (= 123, $p < 0.0001$) (figure 3). The variation between regions correlated positively between ADR and SSADR (r = 0.44, $p = 0.003$) and negatively – albeit not significantly so – with PCCRC (with ADR: r = -0.28, $p = 0.07$; with SSADR r = -0.24, $p = 0.12$).

*Physician characteristics*

Mean ADR is highest in the young physicians, and diminishes with age reaching the lowest point when physicians reach the age of 70 years (figure 3, left panel).

However, colonoscopies performed by physicians older than 70 years accounted for only 0.7 % of the total number of colonoscopies (15,000 colonoscopies). There was a significant increase in ADR with the number of performed full colonoscopies per year ($F_{1,663} = 4.85$, $p = 0.03$) and this increase was comparable between young physicians and physicians older than 60 years ($F_{1,662} = 0.01$, $p = 0.99$). As shown in the previous analysis, young physicians showed a higher ADR on average compared to physicians older than 60 years ($F_{1,663} = 43.5$, $p < 0.0001$).

We looked at the correlation between SSL-DR, ADR, NAA, AADR, total number of full colonoscopies (volume) and PCCRC per physician (figure 4).

The weighted Pearson correlation coefficients showed a moderate to strong correlation between ADR and the different other quality parameters reflecting an aspect of polyp detection, with the highest and almost perfect correlation between NAA and ADR. PCCRC-3y (calculated using the WEO criteria) (24) was weak but significantly negatively correlated with all quality parameters except AADR, and correlated best with NAA and ADR (-0.16, resp -0,15). The relationship with PCCRC and the number of performed full colonoscopies per physician was weak, yet statistically significant (0.10).

On the basis of the piecewise regression models, the lowest PCCRC was reached with an ADR of 31.4, where

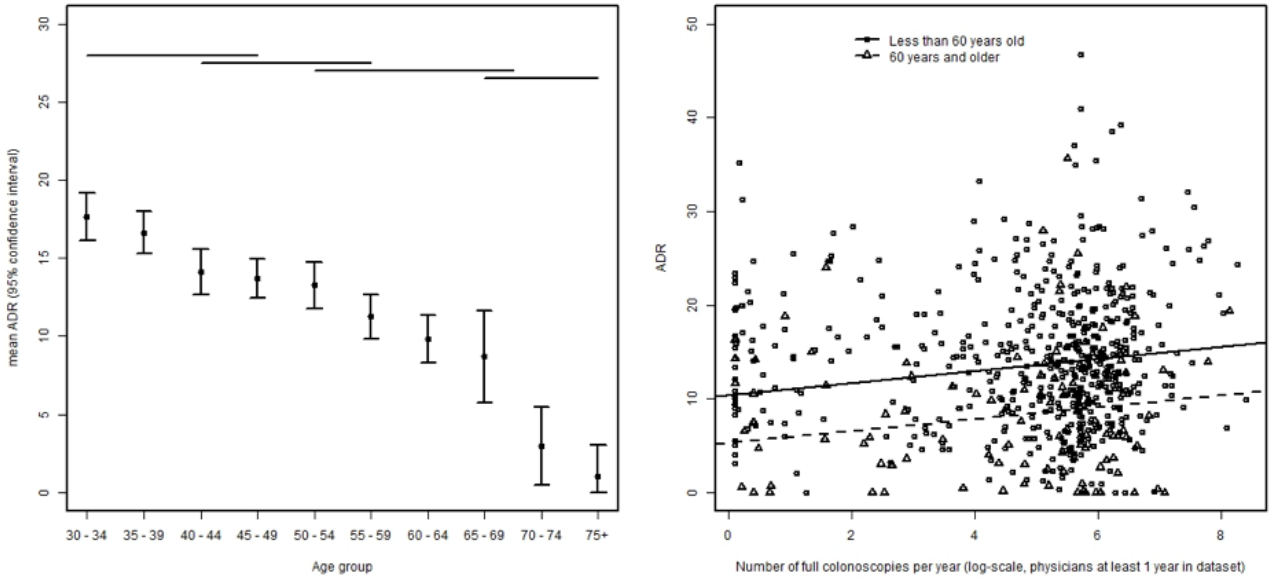


Fig. 3. — Mean ADR relative to age and case load of the physician. The horizontal lines indicate the groups that do not differ from each other, and all the groups that are not connected by a horizontal line differ from each other ($p<0.05$).

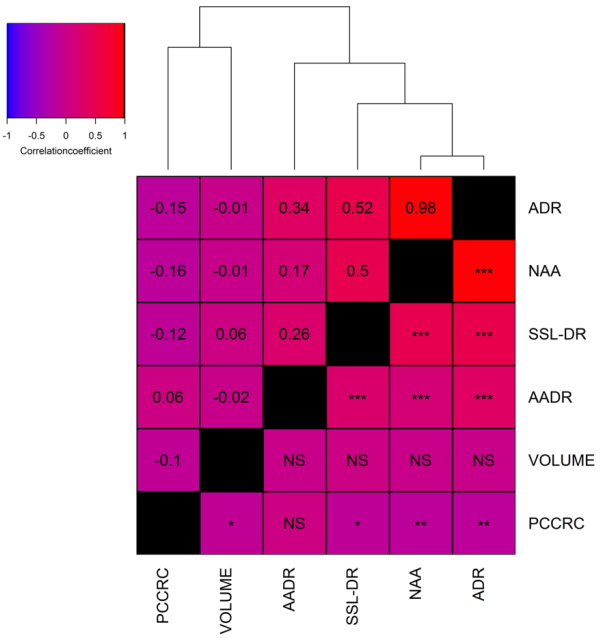


Fig. 4. — Correlation between SSL-DR, ADR, NAA, AADR, total number of full colonoscopies (volume) and PCCRC per physician (above the diagonal), and their statistical significance (below the diagonal: NS: $p > 0.05$; *: $p < 0.05$ - $p > 0.01$; **: $p < 0.01$ - $p > 0.001$; ***: $p < 0.001$).

the slope of the first regression line was significantly negative (-0.11, SE=0.04, p=0.01) and the second regression line was not significantly negative (0.17, SE = 0.14, p=0.36) (figure 5).

However, the piecewise regression did not differ significantly from the linear regression model (permutation test: p=0.18). For SSL-DR, the lowest PCCRC was reached at 1.2%, where the first slope was significantly negative (-2.58, SE=0.80, p<0.0001) while the second slope was not (0.61, SE=0.40, p=0.41). The change in slope was statistically significant (permutation test: $p = 0.002$).

## Discussion

In this study we looked at the histology of resected polyps in a Belgian database spanning 8 years and calculated PCCRC and different well-known colonoscopy quality parameters. We analyzed a very large database of 298,246 polyps that were resected in 294,923 colonoscopies (out of a total of 1,961,674 colonoscopies). Histology data were provided by the laboratories for pathological anatomy. Laboratories are obliged to share the histology of all polyps, except hyperplastic polyps. Therefore, only 28 hyperplastic polyps ended up in the database. We presume that the 48 % of polypectomies without histology were either small polyps that were discarded, or hyperplastic polyps. Normally all adenomas should have entered the database.

92 % of all resected polyps were adenomas, and 4.5 % were sessile serrated lesions. The number of SSLs is probably an underestimation, since these lesions were often missed in the past by endoscopists and pathologists. It is therefore quite possible that some SSLs were misdiagnosed as hyperplastic polyps and didn't end up in the database. Less than 10 % of all adenomas were adenomas with high-grade dysplasia, and 2.2 % of all SSLs were classified as high risk SSLs. Most SSLs were localized in the right hemicolon (ascending and transverse colon). Both SSLs and high risk SSLs occurred significantly more frequently in the right hemicolon.

The term SSL is recommended by the WHO instead of other terms, such as sessile serrated adenoma/polyp (25). SSLs differ from HPs by architectural distortion, and nowadays the presence of a single unequivocally distorted crypt is considered diagnostic for SSL (26).

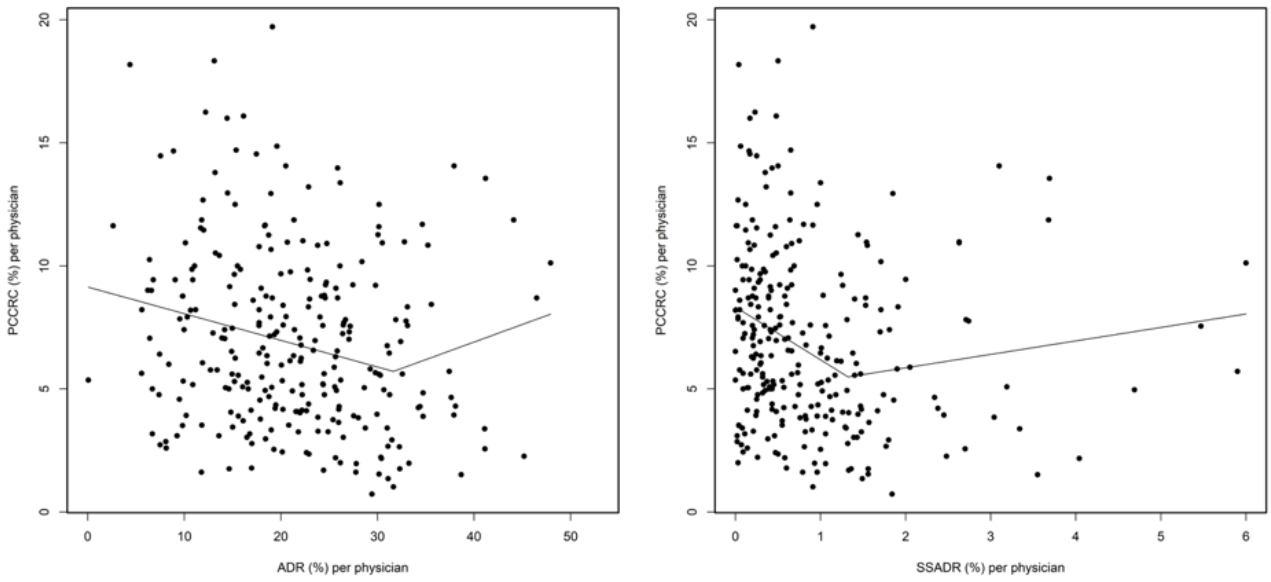


Fig. 5. — Piecewise linear regression of PCCRC in function of ADR/SSADR.

ADR is the most established quality indicator for colonoscopy, and the minimum target is 30 % in men and 20 % in women (in asymptomatic, average-risk individuals aged 50 years or more, undergoing primary screening (18) or 25 % in all settings (screening and out-patient) (19). ADR in our database was 31 % for men and 20 % for women, for all first colonoscopies in patients older than 50 years. However, it is more convenient to use an overall ADR including all ages and all colonoscopy indications. ADR independent of indication and age was considerably lower, 18 % for men and 11 % for women, well below the proposed standards. A possible explanation could be that many colonoscopies are rescheduled too soon, as we demonstrated in our earlier study (8). ADR was higher in younger physicians and physicians with a high case load, and differed considerably geographically. Previous studies gave mixed results. Mehrotra (27) reported a mean ADR of 33.2 % in a group of 201 physicians during 2 years, with a higher ADR among female physicians and more recently trained physicians. In Jover's analysis (28) however the experience of the endoscopist (expressed as age and total life-long number of colonoscopies) was associated with a better colonoscopy quality and ADR.

Although ADR is a key performance indicator in a lot of guidelines, it is not perfect and may be prone to gaming by the endoscopist, since the number of adenomas is not calculated as a quality indicator (the one and done practice). Moreover, it doesn't capture histology and completeness of polyp resection. Alternative quality indicators include AADR, NAA and SSL-DR. AADR in our study was 1.5 % for men, and 0.9 % for women (table 2). This is an underestimation as we had no information about the size of the polyp and couldn't include the polyps with a diameter of more than 10 mm. NAA was 16 % for men and 9.8 % for women (table 2).

SSL-DR could theoretically be a better quality parameter than ADR since sessile serrated lesions have the potential for rapid growth once cytologic dysplasia has developed, but prevalence of SSLs varies widely due to a high miss rate by the endoscopist and a high interobserver variability in serrated polyp classification with the risk of inaccurate histologic subclassification (29). In addition, there is a large heterogeneity between different studies (mostly about the inclusion/exclusion of small hyperplastic polyps).

The percentage of SSLs in our database was 4.5 % (13,616 on a total of 298,246 polyps) and increased with patient's age. SSL-DR was 0.8 % for men and 0.6 % for women. Hetzel (30) calculated a detection prevalence (patients with at least one polyp per 100 colonoscopies) of 11.7 for hyperplastic polyps and 0.6 for sessile serrated adenomas in 7,192 colonoscopies in average risk screening patients. In his and our study detection prevalence increased, but not to the same extent (Hetzel 4.4 in 2008, in our study SSL-DR inclined from 0.31 % in 2008 to 1.13 % in 2015). In a systematic review, published in 2020 (31) pooled sessile serrated polyp prevalence was 4.6 % and was higher when assessed through a high-performance examination. Mean clinically significant serrated polyp detection rate (including any serrated polyp, traditional serrated polyp, hyperplastic polyp > 1 cm anywhere in the colon or hyperplastic polyp > 5 mm proximal to the sigmoid colon) was 8.4 % in endoscopists with adequate ADRs of more than 25 % in 3513 screening colonoscopies (15).

There are several reasons for the low SSL-DR in our database. First of all, serrated lesions are a relatively new identity and numerous advances in the detection of sessile lesions have been made the last years. Our database however includes only data until 2015, we might expect more progress in the last 5 years that are not included in our database. We presume that a lot of serrated lesions in the first years of the database were not properly detected by the endoscopists and, if resected, were misclassified as hyperplastic polyps by the pathologist. Secondly, SSLs that have extensive cytologic dysplasia might be difficult to differentiate from conventional adenomas (32). Finally, hyperplastic polyps in our study were as mentioned not included in the pathology register. We assume that these 48 % 'missing polyps' correspond to the 28-36 % prevalence of HPs (33).

A moderately strong positive correlation between ADR and clinically significant sessile serrated polyp detection rate (any sessile serrated polyp, TSA, HP > 1 cm anywhere in the colon or HP > 5 mm in the proximal colon only) was found by Anderson in 45,996 colonoscopies by 77 endoscopists (34). Derived from ADR, his results suggested that a potential clinically significant sessile serrated polyp detection rate benchmark of 7 % could be used to assess quality. In a US multicenter cohort a significant but only moderate correlation between ADR and clinically significant sessile lesions detection rate ($r=0.67$, $p<0.01$) was found (19). In our database correlation between ADR and SSL-DR was 0.52, which is comparable knowing that we had no information to separate the clinically significant sessile serrated lesions. Klair (15) feels there is need for separate benchmarks for SSL-DR and AADR because a significant percentage of endoscopists had either a low SSL-DR or a low AADR despite an adequate ADR.

Up till now ADR remains the easiest parameter to calculate and use as a quality parameter. Reproducibility in the diagnosis of SSLs is low (29), and the size of the polyp is not always noted or tracked.

However, the most interesting outcome and robust quality indicator is PCCRC.

PCCRC-3y in our database was 7.29 %, which is comparable to other countries. In Sweden PCCRC decreased from 9.4 % in 2003 to 6.1 % in 2012 (35). In England wide variation was noted across NHS colonoscopy providers, with an overall unadjusted PCCRC-3y rate of 7.4 % (36).

PCCRC-3y was weak but significantly negatively correlated with all quality parameters except AADR (which was underestimated because we had no informa-

tion about the size of the polyp). There was also a weak but significant correlation with the number of performed full colonoscopies per physician (0.10). Differences between the different quality parameters for correlation with PCCRC were low.

The association between PDR and PCCRC was reported as well in a study of 16,610 patients. Risk of PCCRC was increased 1.8-2.0-fold if the colonoscopy was performed by a physician with a low quartile PDR (37).

On the basis of the piecewise regression models, in our database the lowest PCCRC was reached with an ADR of 31.4 and a SSL-DR of 1.2%.

In conclusion, we calculated different quality parameters in all colonoscopy indications during an 8-years period in Belgium using an automated data extraction with nationwide coverage. However, we had to use the available data based on reimbursement criteria and could only calculate a limited number of key quality measures. Another limitation is our definition of an advanced adenoma. This was defined in a very narrow way as an adenomatous polyp with high-grade dysplasia, since we had no information about the size of the polyp. The majority of advanced adenomas probably have low grade dysplasia.

In our extensive Belgian database ADR for first colonoscopies in patients older than 50 years was as expected. However, overall ADR was much below the proposed thresholds and SSL-DR was low. Nonetheless PCCRC was comparable with PCCRC in other countries, and was weak but significantly negatively correlated with all quality parameters including volume of colonoscopies, except AADR. The lowest PCCRC was reached with an ADR of 31.4 % and an SSL-DR of 1.2%.

There was a marked geographic difference in Belgium between ADR, SSADR and PCCRC. These performance chart should be used to provide performance enhancing feedback to individual endoscopists driven at a unit level and identify system wide issues preventing individual performance. Quality may not only be limited to the technical skills of the endoscopist, but also to endoscopy equipment, the endoscopist's behavior and attitude and the organisation of the endoscopy service.

To improve quality an evidence-based bundle of measures could be used in routine colonoscopy practice, including among others a minimal cecal withdrawal time of > 6 minutes, supine position for transverse colon examination and rectal retroflexion. This simple intervention changed practice and colonoscopy quality as measured by ADR, particularly in poor performers, in the United Kingdom (38). As was demonstrated in a Dutch study (39), quality registry based on automated extraction of colonoscopy data is feasible, thus avoiding the administration burden for healthcare professionals. This nationwide approach provides feedback and benchmarking to all endoscopists, allowing them to assess their performance. Managing underperformance in endoscopy was described by Rees (40). It is helpful to have a designated clinician in the unit who is responsible for quality assurance. Feedback to the endoscopist may be challenging, and efforts should be made to preserve dignity and develop a culture of support and encouragement.

Endoscopy services with high rates of PCCRC should implement formal quality monitoring of performance and act on poor performance, as is recommended by the WEO consensus statements on PCCRC (24). In a retrospective analysis of PCCRCs using the WEO system of categorization, 89 % of PCCRCs might be avoidable (4). PCCRC-3y rates could be reduced to very low levels, perhaps 1-2 %.

As patient safety is paramount a collaborative strategy should be made to identify existing problems and to ensure standards of care as high as possible.

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