The effect of train-the-colonoscopy-trainer course on colonoscopy quality indicators

Geir Hoff (professor PhD, MD) [1,2,3], Edoardo Botteri (researcher PhD, MSc) [2], Gert Huppertz-Hauss (consultant PhD, MD) [4], Jan Magnus Kvamme (Head of department, ass. professor PhD, MD)[5,6], Øyvind Holme (consultant PhD, MD) [2,7,8], Lars Aabakken (professor PhD, MD) [9], Stein Dahler (consultant MD) [10], Asle W Medhus (Head of department, PhD, MD) [11], Ingrid Blomgren (consultant, MD) [12], Per Sandvei (consultant MD) [13], Ole Darre-Næss (consultant MD) [14], Øystein Kjellevold (consultant MD) [15], Birgitte Seip (consultant PhD, MD) [2,16],

1. Dept. of Research, Telemark Hospital Skien, Skien, Norway;
2. Cancer Registry of Norway, Oslo, Norway
3. University of Oslo, Oslo, Norway
4. Dept. of Medicine, Telemark Hospital Skien , Skien, Norway
5. Institute of Clinical Medicine, University of Tromsø, Tromsø, Norway
6. Dept. of Medicine, University Hospital, North Norway, Tromsø, Tromsø, Norway
7. Institute of Health and Society, University of Oslo, Oslo, Norway
8. Dept. of Medicine, Sørlandet Hospital Kristiansand, Kristiansand, Norway
9. Dept. of Transpl. Medicine, Oslo University Hospital Rikshospitalet and Faculty of Medicine, University of Oslo, Oslo, Norway
10. Dept. of Medicine, Telemark Hospital Notodden, Notodden, Norway
11. Dept. of Gastroenterology, Oslo University Hospital, , Oslo, Norway
12. Dept.of Medicine, Helse Fonna Hospital Trust, Haugesund, Norway
13. Dept. of Gastroenterology, Østfold Hospital Trust, Kalnes, Norway
14. Dept. of Medicine, Vestre Viken Hospital Trust, Bærum, Norway
15. Dept. of Medicine, Telemark Hospital Kragerø, Kragerø, Norway
16. Dept. of Medicine, Vestfold Hospital, Tønsberg, Norway

Correspondence:

Geir Hoff

Dept. of Research, Telemark Hospital, 3710 Skien, Norway

e-mail: hofg@online.no

Phone: +47 91866762

Abstract

Background

Systematic training in colonoscopy is highly recommended. For ”training-the-colonoscopy-trainer” (TCT) courses we have limited knowledge of their effects. Using a national quality register on colonoscopy performance, we aimed at evaluating the effects of TCT participation on defined quality indicators.

Methods

Observational study comparing quality indicators (pain, cecal intubation and polyp detection) between participating and non-participating centres to a TCT course. Non-participating centres were assigned a pseudo-participating year to match their participating counterparts. Results from first year after TCT (pseudo-)participation were compared to the year before TCT. Time trends up to five years after TCT (pseudo-)participation were also compared. Generalized estimating equations models, adjusted for age, sex and bowel cleansing were used.

Results

In the analyses comparing the year before and the year after the (pseudo-)participation, 11 participating and 11 non-participating centres contributed with 18,555 and 10,730 colonoscopies, respectively. In participating centres, but not in non-participating centres, there was a significant increase in detection of polyps ≥5mm, from 26.4% to 29.2% (P=0.035), and reduction in moderate/severe pain in women only, from 38.2% to 33.6% (P=0.043). In the analyses on effects over five years, 20 participating and 18 non-participating centres contributed with 85,691 and 41,569 colonoscopies, respectively. In participating centres, polyp detection rate increased linearly (P=0.003), while pain decreased linearly in women only (P=0.004). Non-participating centres did not show any significant time trend during the study period.

Conclusions

Participation in TCT course improved polyp detection rates and reduced patient pain experience for women. These effects were maintained during a 5-year follow-up.

What this paper adds

What is already known on this subject:

- In a colonoscopy screening setting, train the colonoscopy trainer courses (TCT) may give a modest improvement in adenoma detection rates (ADR) for centres participating in TCT courses.
- Pain during colonoscopy may be a barrier against early action on bowel symptoms and attendance for colonoscopy.

What this study adds:

- Data from a national quality assurance register for all colonoscopies showed that detection of polyps 5mm or larger (PDR-5) improved in centres participating in TCT courses when compared to non-participating centres – an effect sustained during a 5-year follow-up period.
- For women, but not for men, pain experienced during colonoscopy improved in centres participating in TCT courses – an effect sustained during 5 years of follow-up when compared to centres not participating.

Background

Although upskill and professional courses in general are appreciated by participants and valued in questionnaires asking participants about their opinion, the ultimate effect on work performance and services provided by the participants may still be questioned. Participation in some courses may even stimulate elitism at the expense of teamwork [1, 2].

A major part of the practical training in colonoscopy is work-place dependent requiring time and local competence in teaching and supervision. Training the colonoscopy trainers (TCT) for this task is important, desirable and uncontroversial [3, 4]. There is, however, limited knowledge of the effect on endoscopy centres sending delegates to TCT courses - i.e. to which extent they manage to improve the quality of local colonoscopy services [5]. Within the framework of a national quality assurance (QA) register in Norway, Gastronet, the present study aimed to evaluate the local impact and measured benefit for patients after sending endoscopist representatives to participate in a "train – the-trainers" course.

Methods

Centralized TCT courses were launched in Norway late 2014 to train gastroenterologists in teaching colonoscopy. Since then, all gastrointestinal endoscopy centres in Norway have been offered to send endoscopists to a TCT course. Participation has been on a first-come, first-serve basis, and restricted to five participants per course.

The TCT course is a Norwegian adaption of the Train the trainers endoscopy course in colonoscopy [6]. The course includes upskill training in colonoscopy and pedagogic principles for supervision and feedback . The aim is both to improve own skills in colonoscopy and skills to instruct trainees. This is

a three day course held at dedicated endoscopy laboratories with patients having consented to be examined in a teaching setting.

The quality register Gastronet for colonoscopy performance started in Norway in 2003, with status as a national quality register since 2012 [7]. For the present study, Gastronet data for the 6-year period 2014-2019 were available for analyses. Variables for quality assurance in the Gastronet register include cecum intubation rate, detection of polyps ≥5mm diameter (PDR-5) and patient reported pain (no pain, slight pain, moderate pain and severe pain) – the latter dichotomized into none or slight and moderate or severe pain. These variables were selected as endpoints in the present study. We also registered bowel cleansing using Boston Bowel Preparation Scale (BBPS) scores dichotomized into a total score of ≥ 6 representing adequate cleansing and < 6 inadequate [8]. The variables were reported directly to Gastronet separately in an endoscopist and a patient report form, respectively. The patient report form which included patient reported pain, was filled in at home on the day after the examination and mailed directly to the Gastronet secretariat in a pre-paid return envelope. Two centres having reported less than 100 colonoscopies were excluded from the analyses (Suppl. fig s.1).

Centres not having participated at a TCT course were assigned a year of virtual participation ("pseudo-participation") to match the year of participating centres preferentially within the same region (same or neighboring county) (supplementary table s1). The defined end-point variables were compared between participating and non-participating centres the year before and after their year of participation and pseudoparticipation, respectively, and for the succeeding up to five years after physicians and nurses first attended a TCT course (or after pseudo-participation in the centres not participating).

The study was considered a quality assurance (QA) project and waived need for approval from the regional ethics committees of South-East Norway. Gastronet is approved by the Norwegian Data Protection Authority and the act of a patient returning the patient form is accepted as consent.

Statistical methods

We evaluated three binary outcomes, namely pain (no pain/slight pain vs. moderate/severe), cecum intubation (yes/no) and detection of polyps ≥5mm in diameter (yes/no). To take into account the fact that groups of individuals were examined in the same centres (e.g. individuals were nested within centres), we used generalized estimating equations (GEE) logit models, with centre as the clustering variable and a compound-symmetry covariance structure, to identify the independent explanatory factors.

Centres not having participated in the TCT course served as controls and were assigned a year of virtual participation (i.e. pseudo-participation) to match the year of a participating centre preferentially within the same region (same or neighboring county) (supplementary table s1). We compared *a)* the calendar year before and after the (pseudo-) participation and *b)* the succeeding up to five calendar years after the (pseudo-) participation. In *b)* the year of pseudo-participation was re-defined for four centres (supplementary table s3) to provide controls for a full 5-year period of follow-up. In *a)* we used time as a dichotomous explanatory variable (before/after), while in *b)* we used time as a continuous variable from zero (*T0*, year of (pseudo-) participation) to five years (*T5*). In both analyses, to evaluate the difference in time trends between participating and control centres, we entered an interaction term between time and participation in the GEE models. All models were adjusted for three confounders: age in years (continuous), sex and bowel cleansing (adequate, not adequate, missing). Odds ratios (OR) with 95% confidence intervals (CI) were reported.

All analyses were performed using SAS version 9.4, SAS Institute, Cary, NC. All tests were two-sided and P-values < 0.05 were considered as statistically significant.

Results

During the study period 2014-2019, 57 centres choosing to participate or not participate with endoscopist representatives at a TCT course, reported altogether 162,358 colonoscopies to Gastronet (suppl. fig s.1, suppl. table s.1).

Eleven participating centres had colonoscopies registered before and after the year of TCT participation – contributing with 18,555 colonoscopies to the “one pre- versus one post-year” analysis. Similarly, 11 matched non-participating centres contributed with 10,730 colonoscopies to this analysis.

The proportion of patients reporting moderate or severe pain the year before TCT participation and pseudo-participation (non-participation), respectively, were quite similar, both overall (30.3% and 30.8%; P=0.608) and by gender (fig 1a-c). Moderate/severe pain changed from 30.3% to 26.4% (OR 0.85; 95%CI 0.75-0.97; P=0.014; fig 1a) in participating centres, and from 30.8% to 30.9% (OR 1.03; 95%CI 0.90-1.19; P=0.665) in non-participating centres. The changes in participating centres were statistically different from the changes in non-participating centres (P for interaction = 0.046). This difference was confirmed only in women: moderate/severe pain changed from 38.2% to 33.6% (OR 0.85; 95%CI 0.73-0.99; P=0.043; fig 1c) in participating centres, and from 38.6% to 41.2% (OR 1.11; 95%CI 0.97-1.28; P=0.137) in non-participating centres (P for interaction = 0.014). In men, moderate/severe pain changed from 21.3% to 18.0% (OR 0.84; 95% CI 0.73-0.97; P=0.018; fig 1b) in participating centres, and from 21.3% to 19.1% (OR 0.91; 95% CI 0.72-1.15; P=0.402) in non-

participating centres. The changes in participating centres were not statistically different from the changes in non-participating centres (P for interaction = 0.591).

In the year before TCT (pseudo-)participation, intubation rates were higher in participating centres (95.4%) than non-participating centres (91.4%; P<0.001). Changes in intubation rates from the year before to the year after the (pseudo-)participation were not significant neither in participating nor in non-participating centres (suppl. fig s.2).

In the year before TCT (psudo-)participation, PDR-5 was higher in participating centres (26.4%) than non-participating centres (21.9%; P<0.001). PDR-5 significantly improved in participating centres, from 26.4% to 29.2% (OR 1.14; 95%CI 1.01-1.28; P=0.035), while a borderline significant opposite trend from 21.9% to 19.9% (OR 0.86; 95%CI 0.74-1.01; P=0.059) was observed in non-participating centres (suppl. fig s.3a). The changes in participating centres were statistically different from the changes in non-participating centres (P for interaction = 0.019). Similar results were observed in men and women (suppl. fig s.3b-c).

We then performed 5-year follow-up analyses (fig 2 and suppl. fig s.4-5), using the year of TCT (pseudo-)participation rather than year of pre-TCT as baseline (supplementary table s.3) and reporting the outcomes of interest for a total follow-up of five years. At baseline, participating centres reported lower pain rates, higher intubation rates and higher PDR-5 compared to non-participating centres (P<0.001 for all three outcomes; fig 5 and suppl. fig s.4-5).

A significant linear pain-reducing effect was shown for women attending TCT-participating centres (from 33.9% to 28.0%; OR for each additional year of follow-up ($OR_{1\ year}$) 0.93; 95%CI 0.89-0.98; P= 0.004; fig 2c). A non-significant improvement was also seen for women attending non-participating centres (from 38.2 to 36.1%; $OR_{1\ year}$ 0.98; 95%CI 0.95-1.02; P=0.297). The linear trend in participating centres were borderline statistically different from the trend in non-participating centres (P for interaction = 0.067). For men, both participating and non-participating centres had similar improvements in patients' pain perception (P for interaction = 0.301; fig 2b).

Participating centres showed an overall linear improvement in cecal intubation rate, from 95.6% to 97.2% ($OR_{1\ year}$ 1.17; 95%CI 1.04-1.31; P=0.007), but this was not significantly different from non-participating centres which went from 94.2% to 94.3% ($OR_{1\ year}$ 1.18; 95%CI 0.95-1.47; P=0.099; P for interaction = 0.852; suppl. fig s.4a). Similar results were found for men and women separately (suppl. fig s.4b-c).

In the follow-up analysis on PDR-5, there was an overall improvement after TCT participation (from 30.8% to 37.9%; $OR_{1\ year}$ 1.06; 95%CI 1.02-1.10; P=0.003), confirmed both for men (from 35.4% to

41.5%; $OR_{1\ year}$ 1.05; 95%CI 1.00-1.10; P=0.035) and women (from 26.6% to 34.6%; $OR_{1\ year}$ 1.08; 95%CI 1.01-1.17; P=0.036). PDR-5 for non-participating centres did not change (suppl. fig s.5b-c). The linear trend in participating centres were statistically significantly different from the trend in non-participating centres in the whole study population (P for interaction 0.041), but only borderline statistically significantly different in men and women (P for interaction = 0.055 for men and 0.057 for women, respectively).

As a sensitivity analysis, we stratified the population of the TCT-participating centres according to the median age. A significant linear pain-reducing trend was confirmed in women younger than 64 and 64 or older. An overall improvement in PDR-5 was confirmed in individuals younger than 65 and 65 or older.

Discussion

Based on analyses of more than 140,000 colonoscopies during a 5-year follow-up period, this is, to our knowledge, the largest study so far evaluating multiple effects of courses aiming to improve competence in training colonoscopists for the task of training others.

A large randomized study in Poland comparing TCT-course with passive feedback on performance in 56,517 colonoscopies from 40 centres, showed a modest increase from 18.4% to 24.1% in adenoma detection rate (ADR) after 3 years – a net improvement of 3.9% compared to the passive feedback group [5]. A meta-analysis based on 33,184 colonoscopies in 12 studies, showed an effect of feedback to endoscopists on their adenoma detection rates which increased from 30.5% to 36.0 [9], but without improvement in withdrawal time (believed to contribute to improved adenoma and polyp detection). Polyp detection also improved, but similar to our study, there was no effect on cecal intubation rate.

A Hawthorne effect may play a role particularly in studies on polyp detection, since consciousness of being observed may by itself improve performance [10]. In our study, all 22 centres providing data to the pre-/post-TCT analyses (supplementary table s2) and 39 of 40 centres counting in the follow-up analyses (supplementary table s3) were well established with continuously reporting colonoscopies to Gastronet and receiving individual endoscopist feedback before entering the study. In centres where endoscopists are used to being observed and receive regular feedback, the risk of bias due to a Hawthorne effect is reduced. In most centres, however, there is a continuous turnover where new endoscopists join in and their reporting may be more prone to a Hawthorne effect. We do not have data on endoscopist turnover in the centres studied, but a Hawthorne effect is markedly reduced

compared to 'stand-alone'/separate studies where data are not fed continuously into a quality register.

In Gastronet, detection of polyps ≥5 mm (PDR-5) has been chosen as a quality variable rather than total PDR irrespective of size (which includes polyps <5 mm and these are adenomatous in only about 20% of cases [11]), or ADR which requires a second phase of registration once a histology report is obtained. Several studies have found a good correlation between PDR and ADR [12]. PDR-5 may, however, be closer correlated to polypectomy rates, since polypectomy should always be used for this size of polyps (polyps ≥5mm), but infrequently used for minute polyps [12]. An unadjusted 2.8% improvement in PDR-5 from 24.6% to 29.2% in our study is in line with the modest improvement observed in other studies [5, 9].

Pain related to colonoscopy is a major concern. It affects the willingness to participate in screening programs [13]. If colonoscopy has a reputation of being painful, this may contribute to patients' delay and inadequate response to bowel symptoms that ought to be investigated properly. Women more than men frequently experience pain during colonoscopy. It is therefore of particular value that participation in a centralized TCT-course now seems to have an unadjusted short-term 4.6% pain-reducing effect from 38.2% to 33.6% for women and this effect may be maintained during five years of follow-up. Standard procedure in Norway is light sedation/analgesics (usually midazolam and/or fentanyl/alfentanyl) on demand and maintenance of ability to leave the premises immediately after the procedure. On average, sedation/analgesics are administered in 32% of colonoscopies reported to Gastronet [14]. With this level of consciousness, we have found it most appropriate to provide the patient with a reply form to be filled in at home on the day after colonoscopy to reduce the risk of willingness to please hospital staff/doctors. The form is sent directly to the Gastronet secretariat – not to the endoscopy centre.

The lack of effect of TCT participation on cecal intubation rate is not surprising. Baseline data were good or acceptable in both sets of analyses – even in the pre- to post-TCT comparisons where intubation rate for women (89.8%) at non-participating centres was close to the recommended minimum standard of 90% [15].

There are several limitations to this study. The main weakness is lack of randomization to intervention (TCT participation) and control group (TCT non-participants, i.e. TCT pseudo-participants) in addition to reporting bias in quality registers [16]. The strengths of the study are mainly its size and design with assignment of non-participating centres to years of pseudo-participation and using generalized estimating equations (GEE) to adjust for co-factors and interactions. Individuals admitted to a specific centre share several important factors (e.g. same

facilities, capacity, geographical area, endoscopists…), which might influence the outcomes under investigation. Therefore we used GEE models, which take into account the fact that individual patients within each centre are more related to each other (e.g. correlated) than to individuals admitted to other centres.

Self-selection to participate remains a challenge for evaluation of all non-randomized studies. Apart from similar baseline pain reporting in the two groups in the pre- to post-TCT year analysis, the other set of baseline data in our 5-year follow-up study suggest self-selection where centres already performing well tend to send representatives to TCT courses more often than centres in greater need to improve their quality. Training in gastroenterology is very decentralized in Norway. Pain scores and detection rates for PDR-5mm and cecal intubation were comparable for academic and non-academic centres (data not shown). There may be quality-independent reasons for non-participation which may drive results in either direction. Self-selection not to send endoscopists to a TCT course may for example be local dependence on 'all hands to take care of waiting lists' although quality may be good. Other centres may have managed to send an endoscopist, but capacity problems may prohibit knowledge obtained at the TCT course to be dispersed locally and an effect of TCT participation will not materialize.

Further to limitations, we do not know how colonoscopy-trainer competence at the different centres may have changed during the years of follow-up. Centres may send several of their endoscopists to these courses during the years with or without a need to substitute previous TCT-course participants who may have retired or moved to other centres. Also, we do not know if the improvement observed is a result of improved endoscopist performance, endoscopy technology, skills of endoscopy assistants or more liberal use of analgesics. In a previous report from Gastronet [14], there was, however, no association between the use of sedoanalgesics and painless colonoscopies, emphasizing the importance of training technique.

Changing local standards and culture may take more than one year and it may depend not only on local leadership to allow time for training, but also on the number of representatives at TCT courses and the number of endoscopists to be trained and supervised. Eventually, the climate for learning, the personality of TCT participants taking charge and the receptiveness of those being trained are crucial factors for success. Efforts to monitor benefits of TCT course participation is to be encouraged.

The findings suggest that the current TCT-courses in Norway have contributed to quality improvement at centres represented at the courses.

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Contributorship

GH and BS conceived the idea. GH, BS and EB drafted the manuscript. EB did the final statistical analyses. BS, GHH, JMK, ØH, LAa, SD, AWM, IB, PS, OD-N and ØK contributed with provision of data from endoscopy centres. All authors contributed to refinement of the manuscript and approval of the final version to be submitted for publication.

Competing interests

BS is head of the endoscopy school running TCT courses. The remaining authors declare that there is no conflict of interest.

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Figure text

Fig. 1a-c. Patient reported pain the year before and after TCT participation for men and women (1a), men (1b) and women (1c). Participating=Colonoscopies at centres participating in TCT courses. Not participating= Colonoscopies at centres not participating in TCT courses (pseudo-participation). Pain = Moderate or severe pain (in contrast to none or slight pain)

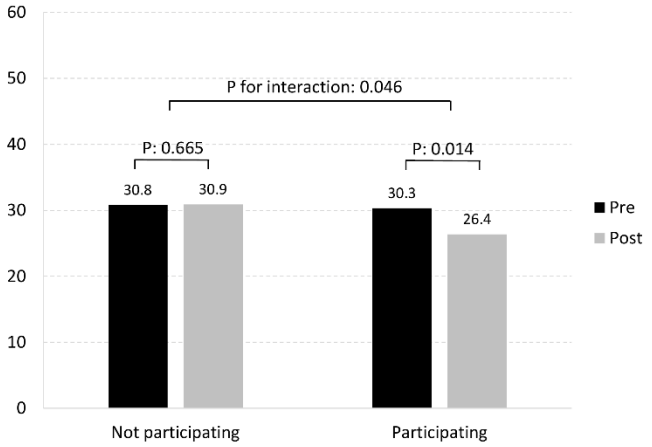
Fig. 2a-c. Pain reported during 5-year follow-up for men and women (2a), men (2b) and women (2c). 'Participating' and 'not participating' = (see explanation for fig 1a-c). Pain = Moderate or severe pain (in contrast to none or slight pain)

Literature

1. Espedal B GP, Evensen HM: The impact of global leadership development programs on social networks and knowledge sharing in multinational enterprises. Human Resources Management & Ergonomics 2012;6:45-65.
2. Campbell NC, Murray E, Darbyshire J et al: Designing and evaluating complex interventions to improve health care. Bmj 2007;334:455-459.
3. Waschke KA, Anderson J, Valori RM et al: ASGE principles of endoscopic training. Gastrointestinal endoscopy 2019;90:27-34.
4. Waschke KA, Anderson J, Macintosh D, Valori RM: Training the gastrointestinal endoscopy trainer. Best practice & research Clinical gastroenterology 2016;30:409-419.

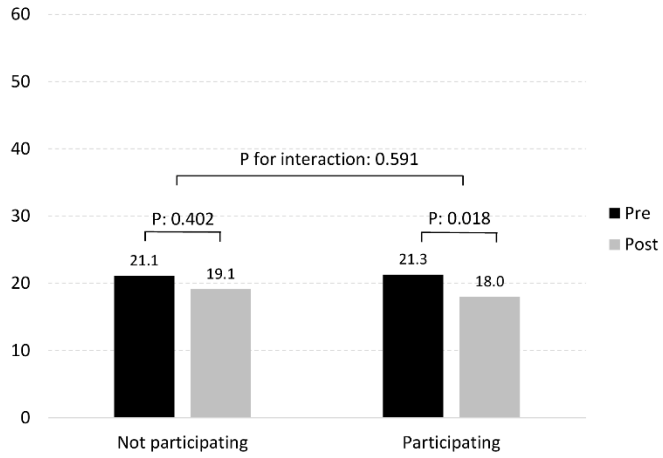
5. Kaminski MF, Anderson J, Valori R et al: Leadership training to improve adenoma detection rate in screening colonoscopy: a randomised trial. Gut 2016;65:616-624.
6. Anderson J, Valori R: Training for trainers in endoscopy (colonoscopy). In: Training in minimal access surgery. edn. Edited by Francis N, Fingerhut A, Bergamaschi R, Motson R. London: Springer; 2015.
7. Moritz V, Bretthauer M, Holme O et al: Time trends in quality indicators of colonoscopy. United European gastroenterology journal 2016;4:110-120.
8. Clark BT, Protiva P, Nagar A, et al: Quantification of Adequate Bowel Preparation for Screening or Surveillance Colonoscopy in Men. Gastroenterology 2016;150:396-405; quiz e314-395.
9. Bishay K, Causada-Calo N, Scaffidi MA et al: Associations between endoscopist feedback and improvements in colonoscopy quality indicators: a systematic review and meta-analysis. Gastrointestinal endoscopy 2020;92:1030-40.
10. Delgado-Rodriguez M, Llorca J: Bias. Journal of epidemiology and community health 2004; 58:635-641.
11. Klein JL, Okcu M, Preisegger KH, Hammer HF: Distribution, size and shape of colorectal adenomas as determined by a colonoscopist with a high lesion detection rate: Influence of age, sex and colonoscopy indication. United European gastroenterology journal 2016;4:438-448.
12. Niv Y: Polyp detection rate may predict adenoma detection rate: a meta-analysis. European journal of gastroenterology & hepatology 2018;30:247-251.
13. Kirkoen B, Berstad P, Botteri E et al: Acceptability of two colorectal cancer screening tests: pain as a key determinant in sigmoidoscopy. Endoscopy 2017;49:1075-1086.
14. Holme O, Moritz V, Bretthauer M et al: [Pain in connection with colonoscopy in Norway]. Tidsskrift for den Norske laegeforening : tidsskrift for praktisk medicin, ny raekke 2013; 133:1074-1078.
15. Kaminski MF, Thomas-Gibson S, Bugajski M et al: Performance measures for lower gastrointestinal endoscopy: a European Society of Gastrointestinal Endoscopy (ESGE) Quality Improvement Initiative. Endoscopy 2017;49:378-397.
16. Hoff G, de Lange T, Bretthauer M et al: Registration bias in a clinical quality register. Endoscopy international open 2019;7:E90-E98.

Fig 1a.



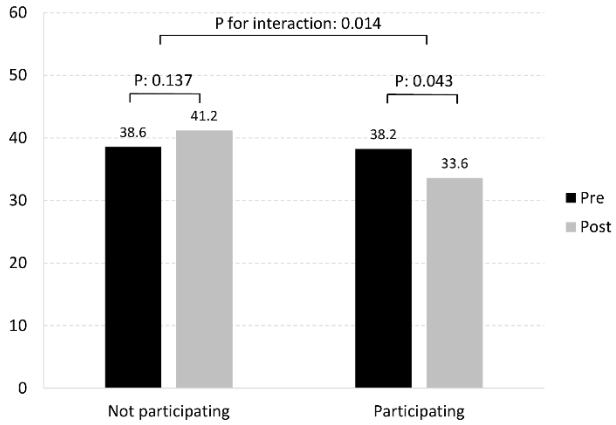
Men & women	Not participating		Participating	
	Pre	Post	Pre	Post
All	3835	3647	5390	6879
Pain	1181	1127	1633	1814
% Pain	30.8	30.9	30.3	26.4

Fig 1b.



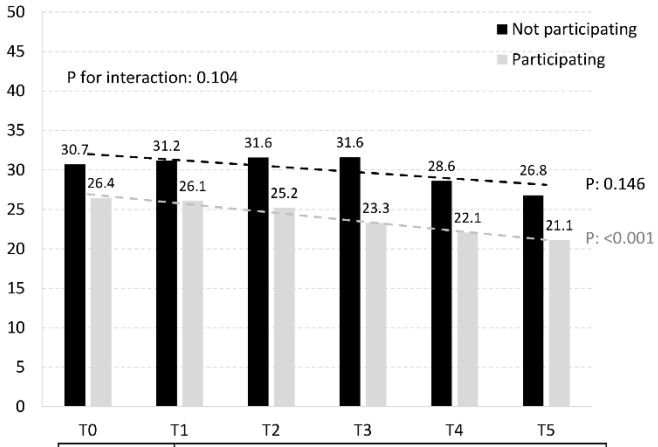
Men	Not participating		Participating	
	Pre	Post	Pre	Post
All	1706	1700	2520	3190
Pain	360	325	536	574
% Pain	21.1	19.1	21.3	18.0

Fig 1c.



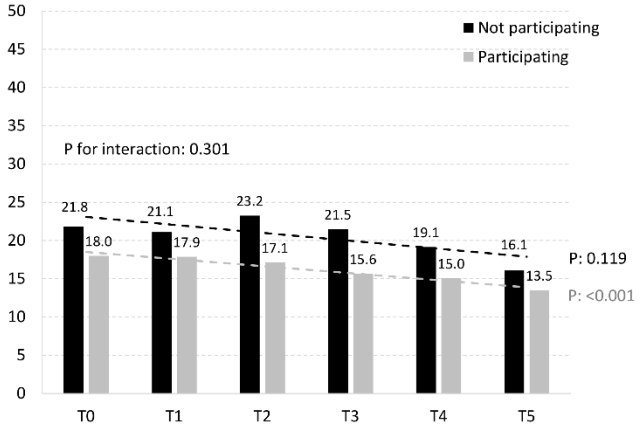
Women	Not participating		Participating	
	Pre	Post	Pre	Post
All	2129	1947	2870	3689
Pain	821	802	1097	1240
% Pain	38.6	41.2	38.2	33.6

Fig 2a.



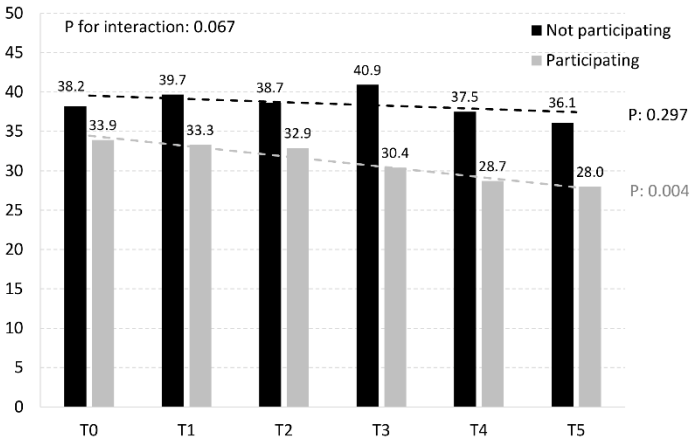
Men & women	Not participating					
	T0	T1	T2	T3	T4	T5
All	7878	8189	4554	3902	2122	2099
Pain	2418	2553	1438	1233	607	562
% Pain	30.7	31.2	31.6	31.6	28.6	26.8
	Participating					
All	12986	14334	8784	8618	6121	5847
Pain	3433	3736	2213	2005	1350	1235
% Pain	26.4	26.1	25.2	23.3	22.1	21.1

Fig 2b.



Men	Not participating					
	T0	T1	T2	T3	T4	T5
All	3613	3748	2091	1868	1029	977
Pain	789	791	486	401	197	157
% Pain	21.8	21.1	23.2	21.5	19.1	16.1
	Participating					
All	6091	6715	4278	4160	2978	2765
Pain	1095	1200	732	650	448	373
% Pain	18.0	17.9	17.1	15.6	15.0	13.5

Fig 2c.



Women	Not participating					
	T0	T1	T2	T3	T4	T5
All	4265	4441	2463	2034	1093	1122
Pain	1629	1762	952	832	410	405
% Pain	38.2	39.7	38.7	40.9	37.5	36.1
	Participating					
All	6895	7619	4506	4458	3143	3082
Pain	2338	2536	1481	1355	902	862
% Pain	33.9	33.3	32.9	30.4	28.7	28.0

Supplementary material

The effect of train-the-colonoscopy-trainer course on colonoscopy quality indicators

Hoff G et al.

Figure text

Fig. 1s Flow chart of number of endoscopy centers and volume of colonoscopies (CS) registered in Gastronet in the study period 2014-2019.

Fig. 2s a–c. Cecum intubation the year before and after TCT participation. 'Participating' and 'not participating' = (see explanation for fig 2a-c)

Fig. 3s a–c. Detection of polyp(s) ≥5 mm the year before and after TCT participation. Attending=TCT participation. 'Participating' and 'not participating' = (see explanation for fig 2a-c)

Fig. 4s a–c. Cecum intubation reported during 5-year follow-up. 'Participating' and 'not participating' = (see explanation for fig 2a-c)

Fig. 5s a–c. Detection of polyps ≥5mm reported during 5-year follow-up. 'Participating' and 'not participating' = (see explanation for fig 2a-c)

Fig. 1s Flow chart of number of endoscopy centers and volume of colonoscopies (CS) registered in Gastronet in the study period 2014-2019.

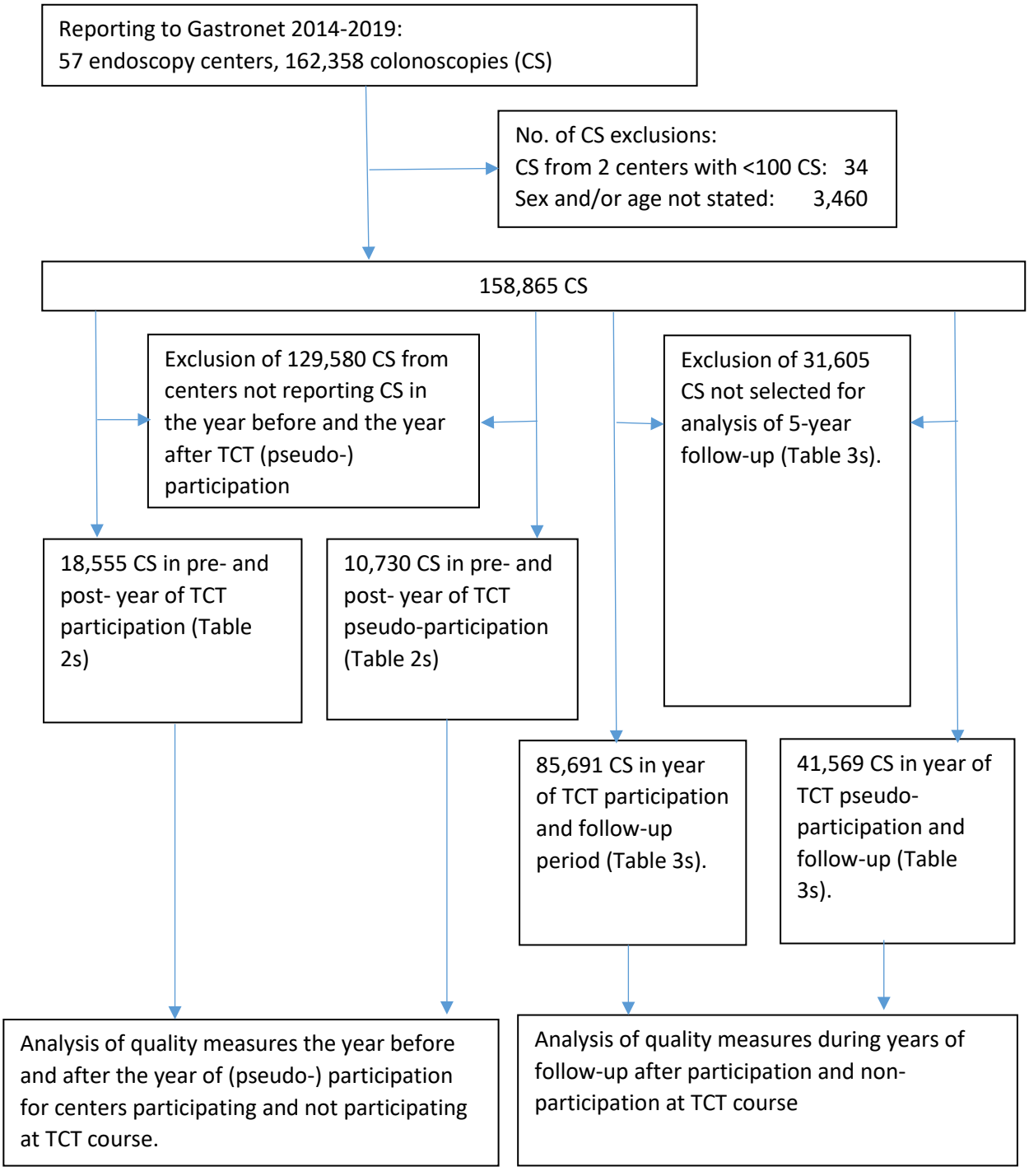
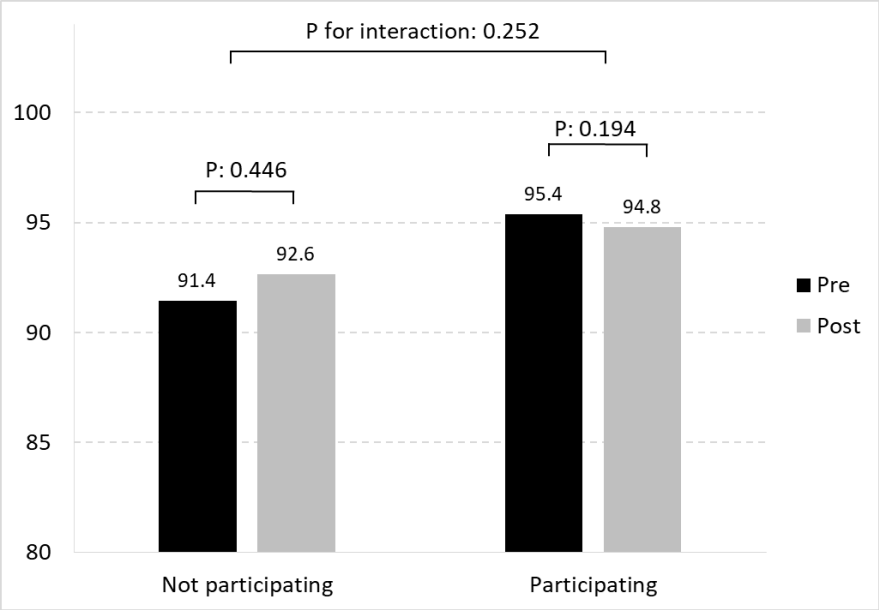
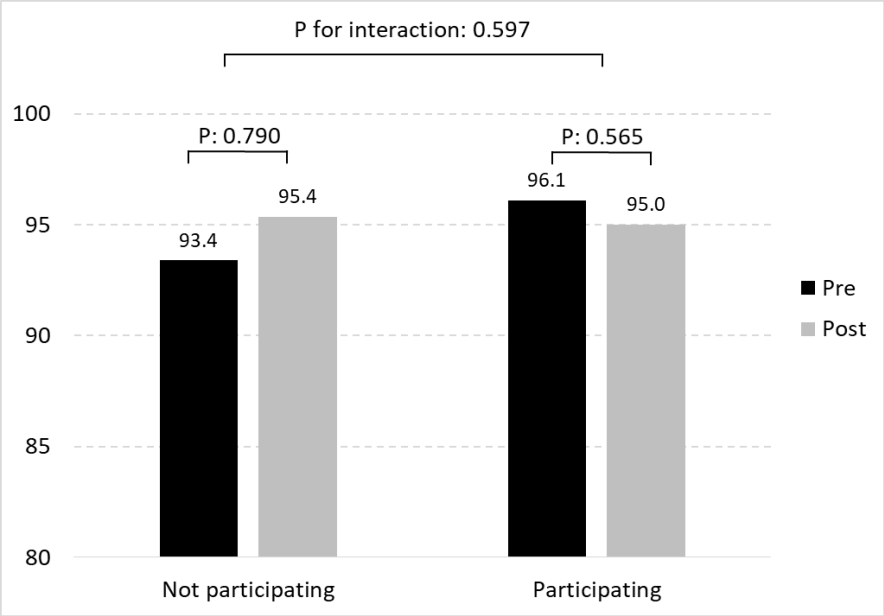


Fig. 2s a. Cecum intubation. Pre vs/ post. Men and women



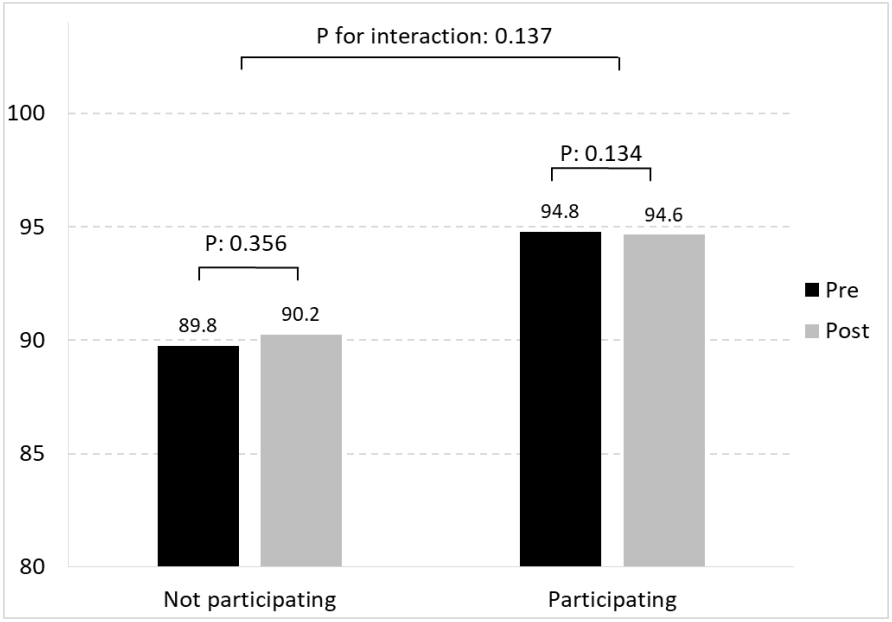
Men & women	Not participating		Participating	
	Pre	Post	Pre	Post
All	5008	4796	7505	10247
Cecum intubated	4579	4443	7159	9715
% Intubated	91.4	92.6	95.4	94.8

Fig. 2s b. Cecum intubation. Pre vs/ post. Men



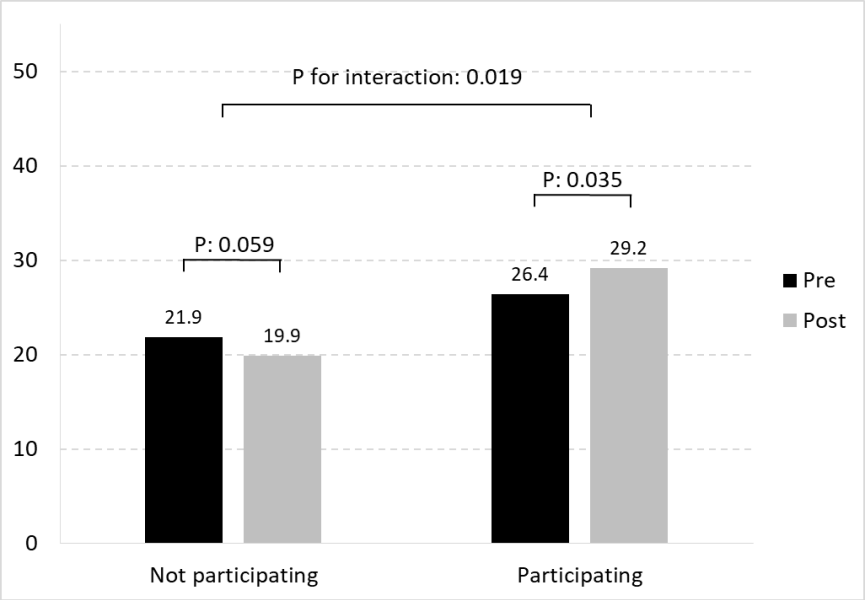
Men	Not participating		Participating	
	Pre	Post	Pre	Post
All	2314	2245	3487	4766
Cecum intubated	2161	2141	3351	4528
% Intubated	93.4	95.4	96.1	95.0

Fig. 2s c. Cecum intubation. Pre vs/ post. Women



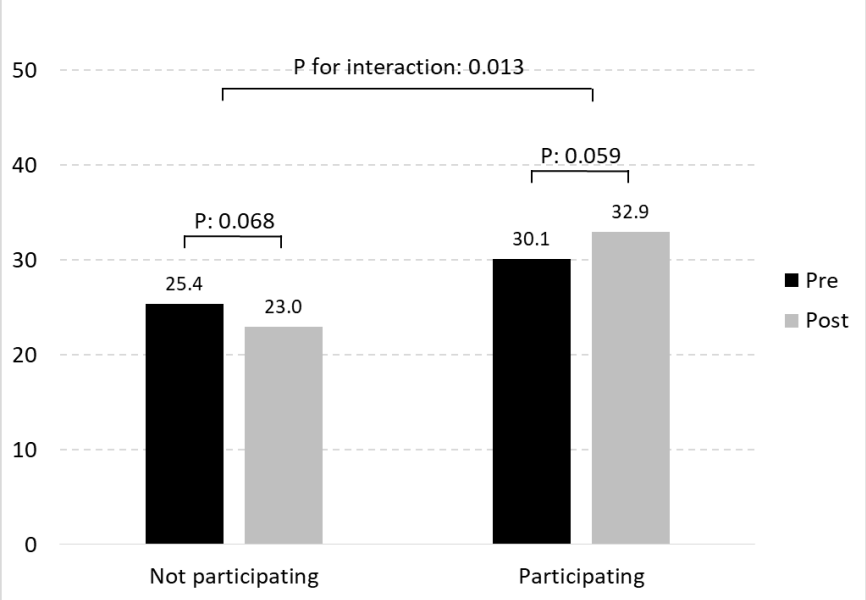
Women	Not participating		Participating	
	Pre	Post	Pre	Post
All	2694	2551	4018	5481
Cecum intubated	2418	2302	3808	5187
% Intubated	89.8	90.2	94.8	94.6

Fig. 3s a. Polyp detection. Pre vs/ post. Men and women



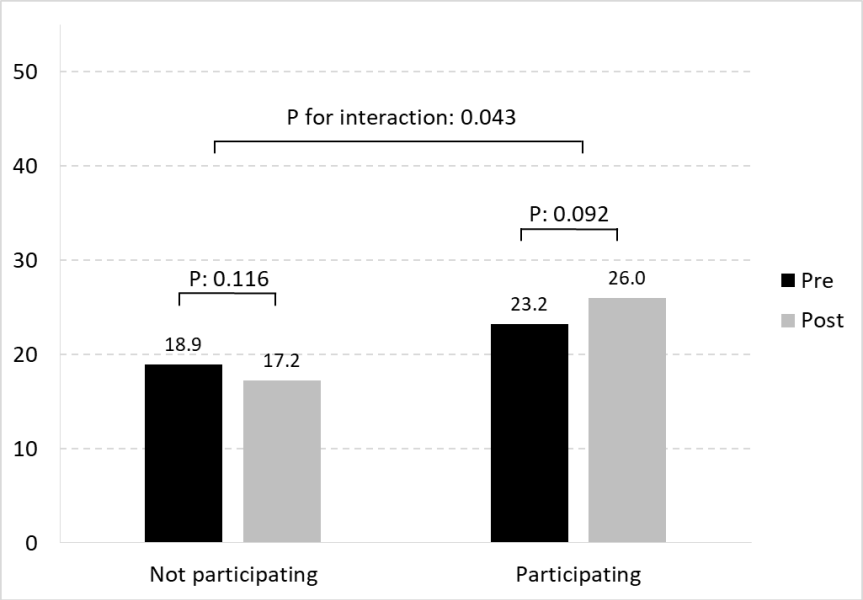
Men & women	Not participating		Participating	
	Pre	Post	Pre	Post
All	5431	5299	7867	10688
Polyp(s) ≥5mm	1189	1055	2077	3121
% with polyps ≥5mm	21.9	19.9	26.4	29.2

Fig. 3s b. Polyp detection. Pre vs/ post. Men



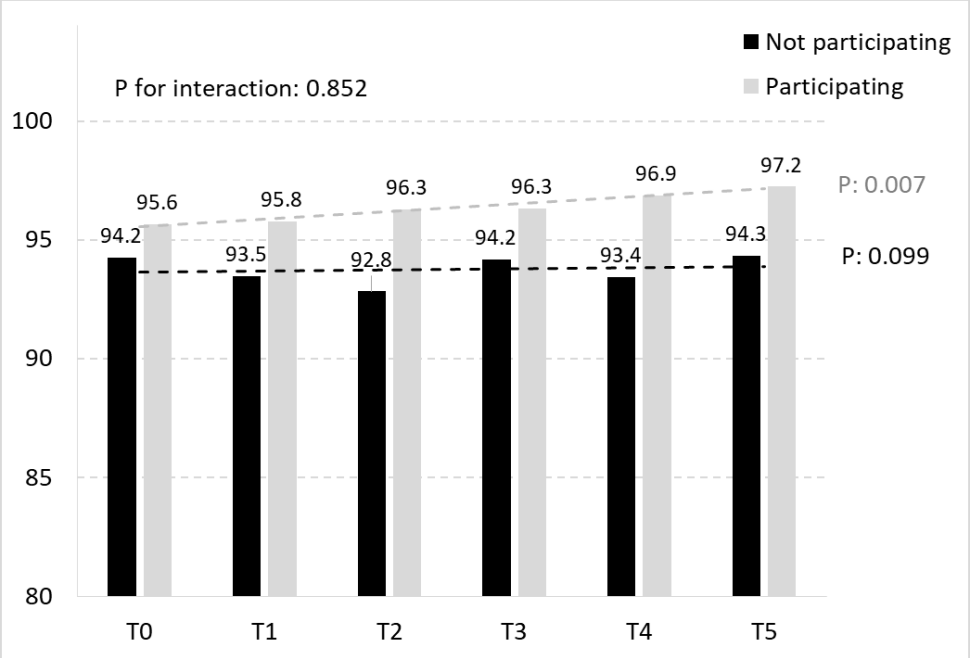
Men	Not participating		Participating	
	Pre	Post	Pre	Post
All	2516	2474	3662	4967
Polyp(s) ≥5mm	638	568	1101	1636
% with polyps ≥5mm	25.4	23.0	30.1	32.9

Fig. 3s c. Polyp detection. Pre vs/ post. Women



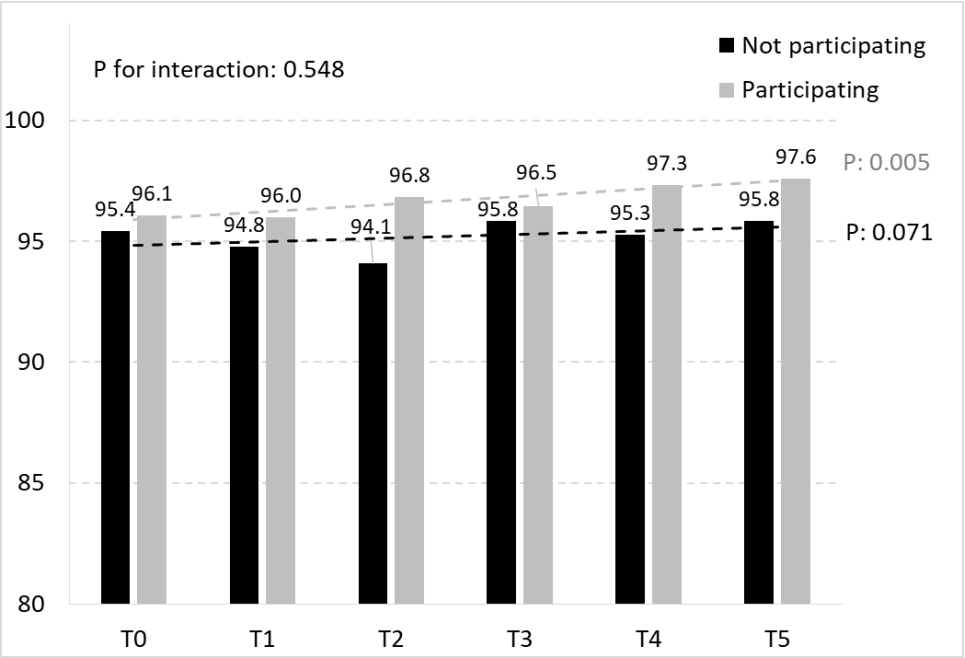
Women	Not participating		Participating	
	Pre	Post	Pre	Post
All	2915	2825	4205	5721
Polyp(s) ≥5mm	551	487	976	1485
% with polyps ≥5mm	18.9	17.2	23.2	26.0

Fig. 4s a. Cecum intubation. Follow-up. Men & women



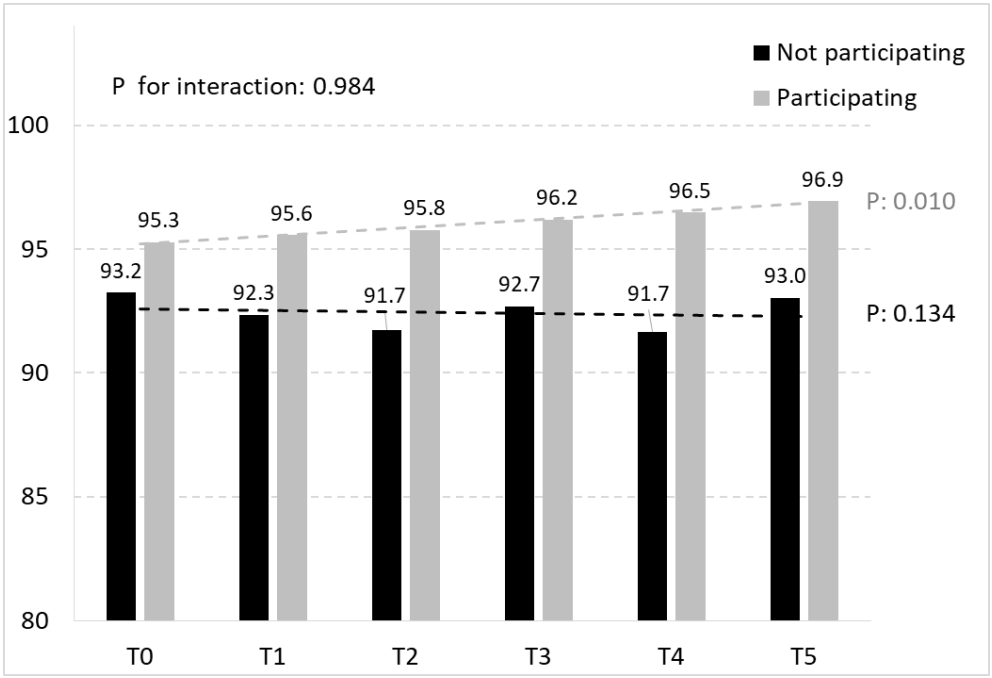
Men & women	Not participating					
	T0	T1	T2	T3	T4	T5
All	10477	11077	6086	5252	2934	3002
Cecum intubated	9874	10353	5650	4946	2741	2832
% intubated	94.2	93.5	92.8	94.2	93.4	94.3
	Participating					
All	18340	20697	12281	12450	9058	8786
Cecum intubated	17542	19818	11823	11991	8775	8543
% intubated	95.6	95.8	96.3	96.3	96.9	97.2

Fig. 4s b. Cecum intubation. Follow-up. Men



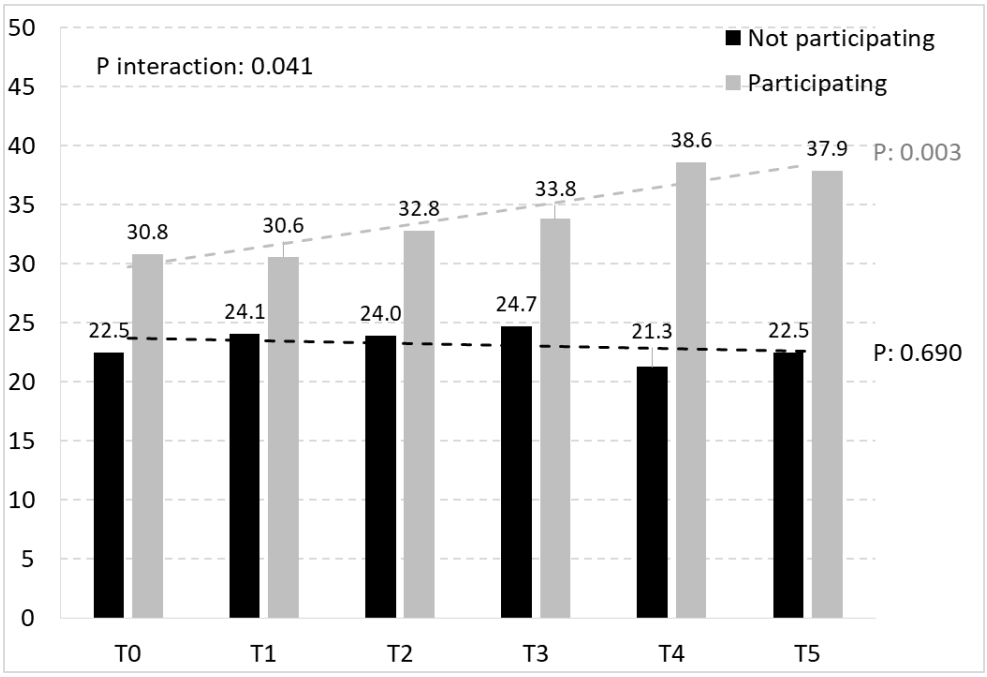
Men	Not participating					
	T0	T1	T2	T3	T4	T5
All	4834	5151	2839	2498	1436	1414
Cecum intubated	4613	4881	2671	2394	1368	1355
% intubated	95.4	94.8	94.1	95.8	95.3	95.8
	Participating					
All	8766	9749	5924	5936	4361	4176
Cecum intubated	8422	9357	5736	5726	4244	4075
% intubated	96.1	96.0	96.8	96.5	97.3	97.6

Fig. 4s c. Cecum intubation. Follow-up. Women



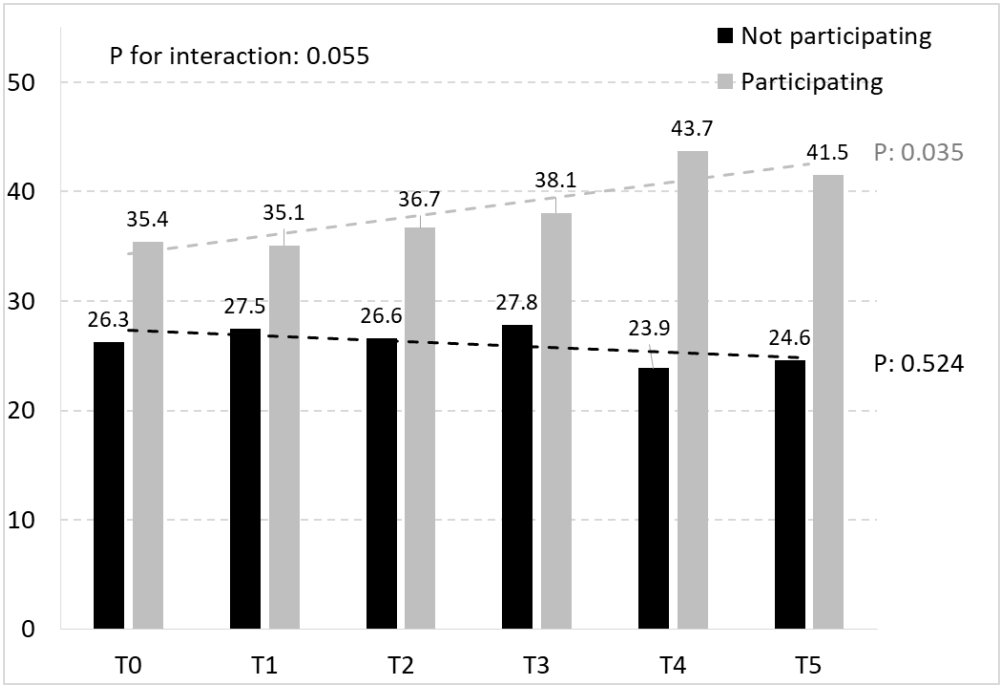
Women	Not participating					
	T0	T1	T2	T3	T4	T5
All	5643	5926	3247	2754	1498	1588
Cecum intubated	5261	5472	2979	2552	1373	1477
% intubated	93.2	92.3	91.7	92.7	91.7	93.0
	Participating					
All	9574	10948	6357	6514	4697	4610
Cecum intubated	9120	10461	6087	6265	4531	4468
% intubated	95.3	95.6	95.8	96.2	96.5	96.9

Fig. 5s a. PDR-5. Follow-up. Men & women



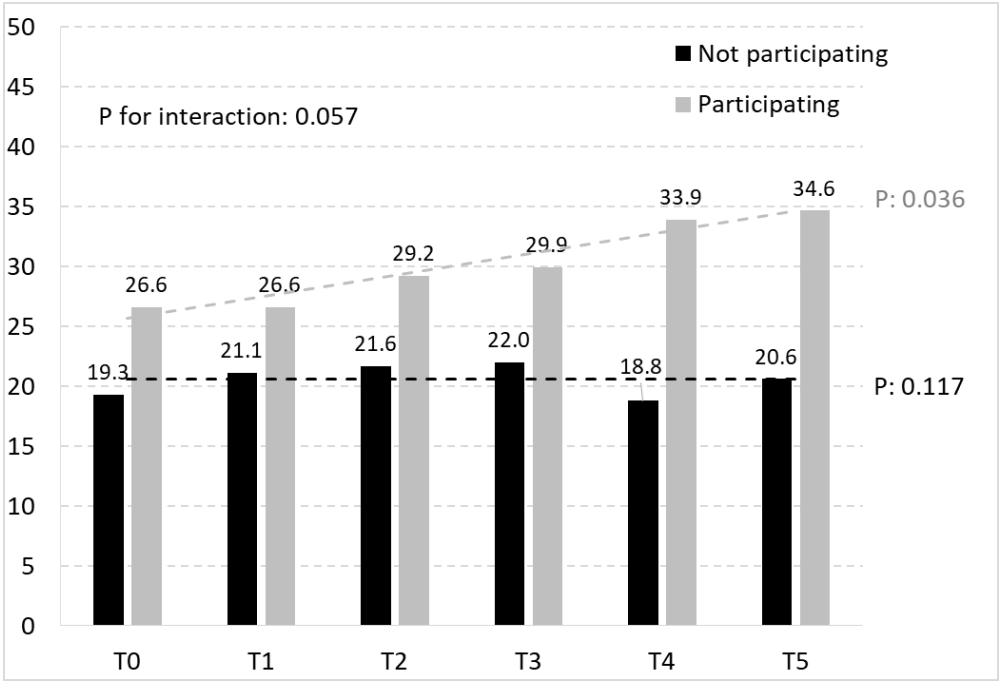
Men & women	Not participating					
	T0	T1	T2	T3	T4	T5
All	11133	11719	6478	5783	3309	3147
Polyp(s) ≥5mm	2505	2821	1552	1431	704	707
% with polyps ≥5mm	22.5	24.1	24.0	24.7	21.3	22.5
	Participating					
All	19298	21710	13043	13096	9452	9092
Polyp(s) ≥5mm	5945	6643	4279	4427	3649	3446
% with polyps ≥5mm	30.8	30.6	32.8	33.8	38.6	37.9

Fig. 5s b. PDR-5. Follow-up. Men



Men	Not participating					
	T0	T1	T2	T3	T4	T5
All	5138	5453	3032	2751	1621	1476
Polyp(s) ≥5mm	1349	1497	806	765	387	363
% with polyps ≥5mm	26.3	27.5	26.6	27.8	23.9	24.6
	Participating					
All	9217	10211	6286	6236	4534	4320
Polyp(s) ≥5mm	3266	3584	2307	2373	1982	1793
% with polyps ≥5mm	35.4	35.1	36.7	38.1	43.7	41.5

Fig. 5s c. PDR-5. Follow-up. Women



Women	Not participating					
	T0	T1	T2	T3	T4	T5
All	5995	6266	3446	3032	1688	1671
Polyp(s) ≥5mm	1156	1324	746	666	317	344
% with polyps ≥5mm	19.3	21.1	21.6	22.0	18.8	20.6
	Participating					
All	10081	11499	6757	6860	4918	4772
Polyp(s) ≥5mm	2679	3059	1972	2054	1667	1653
% with polyps ≥5mm	26.6	26.6	29.2	29.9	33.9	34.6

Table 1s Colonoscopies (CS) reported to Gastronet from endoscopy centers 2014-2019. First year with a TCT course participant is marked in red. Blue background indicates centers that have pre-and post-TCT registration of CS. Yellow indicates CS in year of virtual TCT for non-participating centers with CS registrations pre and post their year of pseudo-participation.

Hospital site/clinic	2014	2015	2016	2017	2018	2019	Total
Skien	1021	**1236**	1219	777	1547	1720	7520
Tønsberg	**1304**	1227	1297	1391	1735	2589	9543
Kristiansand	1207	1545	**1366**	1363	1569	1676	8726
Arendal	1064	1091	**1097**	1146	1042	1090	6530
Notodden	500	591	862	854	805	749	4361
Larvik	**566**	469	390	384	80	117	2006
Oslo Univ.Hospital, Gaustad	**143**	284	571	678	702	804	3182
Flekkefjord	236	215	301	327	**493**	446	2018
Fredrikstad	**1044**	1114	1845	2250	1917	2249	10419
Kongsberg	486	475	494	525	**516**	510	3006
Haukeland	0	0	0	0	**779**	804	1583
Moss	**643**	683	523	516	448	74	2887
Kragerø	1012	1222	1199	1121	1177	966	6697
Stavanger	721	1195	975	1111	**1837**	2346	8185
Hamar	0	0	**0**	106	34	499	639
Bærum	**1027**	1336	1347	1503	1349	1817	8379
Molde	855	931	1057	1051	1073	1004	5971
Volda	197	246	188	16	254	428	1329
Mo i Rana	0	0	0	0	0	482	482
*Diakonhjemmet ,Oslo	894	323	0	**194**	456	543	2410
Ålesund	0	0	213	**1137**	863	711	2924
Kristiansund	629	743	719	759	**652**	538	4040
Oslo Univ. Hospital, Ullevål	**0**	0	0	0	2258	2565	4823
Haugesund	0	0	0	**0**	219	884	1103
Haraldsplass, Bergen	0	0	0	0	0	**499**	499
NordICC Screening Kristiansand	277	0	**0**	0	0	0	277
Tromsø	0	0	698	763	**809**	1561	3831
Elverum	65	**0**	0	0	356	433	854
Screening Moss	**850**	904	890	751	688	740	4823
Screening Bærum	**671**	770	1089	712	813	702	4757
NordICC Screening Arendal	494	0	**0**	0	0	0	494
Drammen	133	189	**168**	240	449	598	1777
Harstad	564	552	690	681	664	**657**	3808
Namsos	150	128	103	0	0	0	381
DD-Clinic Sandnes	697	0	0	0	0	0	697
Aleris Private Centre	153	52	74	19	19	0	317
Stord	119	361	286	245	422	180	1613

Gjøvik	0	**13**	109	148	0	61	331
Mosjøen	0	0	443	401	332	348	1524
Lillehammer	0	0	0	0	0	**925**	925
Narvik	0	0	0	0	12	**311**	323
Ahus	0	0	**1528**	1207	860	1713	5308
Hammerfest	0	0	277	453	357	**239**	1326
Sandnessjøen	0	0	289	449	424	447	1609
Ringvoll Clinic	0	0	164	163	0	11	338
Lovisenberg	0	0	0	0	0	**190**	190
Bodø	0	0	0	0	456	913	1369
Kanalspesialistene Bergen	0	0	0	0	**3545**	4235	7780
Spesialistsenteret Karasjok	0	0	0	0	188	160	348
Voss	0	0	0	0	554	556	1110
Moelv mage og tarm	0	0	0	0	601	1054	1655
Odda	0	0	0	0	48	152	200
Førde	0	0	0	0	0	**1008**	1008
IBSEN hospital Porsgrunn	0	0	0	0	0	288	288
Ski	0	0	0	0	0	342	342
Total	17722	17895	22471	23441	33402	43934	158865

*No data in 2016. Therefore, 2015-data used to represent pre-TCT data

Table 2s Registered pre- and post-TCT colonoscopies for centers with real and allocated year of virtual (pseudo-) participation.

Hospital/ center site	TCT participation	2014	2015	2016	2017	2018	2019	Total
Skien	Yes	1021		1219				**2240**
Kristiansand	Yes		1545		1363			**2908**
Arendal	Yes		1091		1146			**2237**
Drammen	Yes		189		240			**429**
Diakonhjemmet, Oslo	Yes		323			456		**779**
Ålesund	Yes			213		863		**1076**
Flekkefjord	Yes				327		446	**773**
Kongsberg	Yes				525		510	**1035**
Stavanger	Yes				1111		2346	**3457**
Kristiansund	Yes				759		538	**1297**
Tromsø	Yes				763		1561	**2324**
Volda	No	197		188				**385**
Namsos	No	150		103				**253**
Aleris Private Centre	No	153		74				**227**
Kragerø	No		1222		1121			**2343**
Molde	No		931		1051			**1982**
Harstad	No		552		681			**1233**
Hammerfest	No			277		357		**634**
Notodden	No				854		749	**1603**
Stord	No				245		180	**425**
Mosjøen	No				401		348	**749**
Sannessjøen	No				449		447	**896**
	Participating	**1021**	**3148**	**1432**	**6234**	**1319**	**5401**	**18555**
	Not participating	**500**	**2705**	**642**	**4802**	**357**	**1724**	**10730**
	Total	**1521**	**5853**	**2074**	**11036**	**1676**	**7125**	**29285**
	Ratio	2,0	1,2	2,2	1,3	3,7	3,1	1,7

Table 3s. Selection of CS for follow-up after TCT (pseudo-)participation.

Hospital/Center site	TCT participation	2014	2015	2016	2017	2018	2019	Total
Tønsberg	Yes	1304	1227	1297	1391	1735	2589	**9543**
Larvik	Yes	566	469	390	384	80	117	**2006**
Oslo Univ. Hospital, Gaustad	Yes	143	284	571	678	702	804	**3182**
Fredrikstad	Yes	1044	1114	1845	2250	1917	2249	**10419**
Moss	Yes	643	683	523	516	448	74	**2887**
Bærum	Yes	1027	1336	1347	1503	1349	1817	**8379**
Screening Moss	Yes	850	904	890	751	688	740	**4823**
Screening Bærum	Yes	671	770	1089	712	813	702	**4757**
Skien	Yes		1236	1219	777	1547	1720	**6499**
Kristiansand	Yes			1366	1363	1569	1676	**5974**
Arendal	Yes			1097	1146	1042	1090	**4375**
Drammen	Yes			168	240	449	598	**1455**
Diakonhjemmet, Oslo	Yes				194	456	543	**1193**
Ålesund	Yes				1137	863	711	**2711**
Flekkefjord	Yes					493	446	**939**
Kongsberg	Yes					516	510	**1026**
Stavanger	Yes					1837	2346	**4183**
Kristiansund	Yes					652	538	**1190**
Tromsø	Yes					809	1561	**2370**
Kanalspesialistene Bergen	Yes					3545	4235	**7780**
Volda	No	*197	246	188	16	254	428	**1329**
Kragerø	No	*1012	*1222	1199	1121	1177	966	**6697**
Molde	No	*855	*931	1057	1051	1073	1004	**5971**
Notodden	No	*500	*591	*862	*854	805	749	**4361**
Namsos	No		128	103				**231**
Aleris private Centre	No		52	74	19	19		**164**
Harstad	No			690	681	664		**2035**
Hammerfest	No				453	357		**810**
Stord	No					422	180	**602**
Mosjøen	No					332	348	**680**
Sandnessjøen	No					424	447	**871**
Kristiansand	#No	1207	1545					**2752**
Arendal	#No	1064	1091					**2155**
Diakonhjemmet, Oslo	#No	894	323					**1217**
Drammen	#No	133	189					**322**
Flekkefjord	#No	236	215	301	327			**1079**
Kongsberg	#No	486	475	494	525			**1980**
Stavanger	#No	721	1195	975	1111			**4002**

Kristiansund	#No	629	743	719	759			**2850**
Tromsø	#No			698	763			**1461**
	Participating	**6248**	**8023**	**11802**	**13042**	**21510**	**25066**	**85691**
	Not participating	**7934**	**8946**	**7360**	**7680**	**5527**	**4122**	**41569**
	Total	**14182**	**16969**	**19162**	**20722**	**27037**	**29188**	**127260**
	Ratio	0.9	0.9	1.6	1.7	3.9	6.1	2.1

*Years preceding the assigned year of pseudo-participation used in the evaluation of changes from the pre- to the post-TCT year of pseudo-participation (Table 2s). In the follow-up analyses and for these four centers, pseudo-participation year was re-defined as the first registered for each center to facilitate a control group for the whole five-year follow-up period.

These colonoscopies constitute examinations performed at participating centers, but before the year of TCT participation