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Emad Qayed Date

Association of Trainee Participation with Adenoma and Polyp Detection Rates in Screening Colonoscopy

by

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Degree to be awarded: M.P.H.
Executive MPH

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An abstract of
A Thesis submitted to the Faculty of the
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ABSTRACT

Ttile: Association of Trainee Participation with Polyp Detection Rates in Screening Colonoscopy

by
Emad Qayed, MD

Background: Colonoscopy is an important screening modality for colon cancer. It is unclear whether the participation of gastroenterology fellows in screening colonoscopy affects adenoma and polyp detection rates (ADR and PDR, respectively).

Objective: The primary aim of this study was to investigate whether the ADR and PDR in screening colonoscopies performed in the presence of fellows were different from those performed by attending physicians alone.

Methods: We performed a retrospective review of all patients who underwent a screening colonoscopy at Grady Memorial Hospital between July 1, 2009 and June 30, 2015. Patients with a history of colon polyps or cancer and those with poor colon preparation or failed cecal intubation were excluded from the analysis. Associations of fellowship training level with the ADR and PDR relative to attendings alone were assessed using uncondtional multivariable logistic regression. Models were adjusted for sex, age, race, and colon preparation quality.

Results: A total of 7,503 colonoscopies met the inclusion criteria and were included in the analysis. The mean age of the study patients was 58.2 years; 63.1% were women and 88.2% were African American. The ADR in the fellow participation group overall compared to that in the attending group was 34.5% vs. 30.7% (p=0.001), and for third year fellows it was 35.4% vs. 30.7% (adjusted odds ratio [aOR] 1.23, 95% confidence interval [CI] 1.09-1.39). For the PDR the corresponding figures were 44.5% vs. 40.1% (p=0.0003) and 45.7% vs. 40.1% (aOR 1.25, 95% CI 1.12-1.41). The ADR and PDR increased with increasing fellow training level (p for trend <0.05).

Conclusions: These results suggest that there may be a stepwise increase in ADR and PDR on screening colonoscopies across the years of gastroenterology fellow training, and that fellow participation in these colonoscopies may be associated with higher adenoma and polyp detection, especially for fellows after their first year of training. Further studies that document the exact involvement of fellows in the procedure, withdrawal time, and location of polyps would help identify factors related to higher ADR and PDR in more experienced fellows.

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1. INTRODUCTION

1.1 Colon cancer epidemiology

Colorectal cancer (CRC) is the third most common cancer and the second leading cause of cancer death in the United States. In 2016, it is estimated that 134,490 individuals will be diagnosed with CRC, and approximately 49,190 will die from this disease (26,020 males and 23,170 females) (1). This accounts for 8% of total cancer deaths. While these numbers are substantial, there has been an overall steady decline in the incidence of CRC, which represents a 40% decrease since 1975, and 45% since the peak of CRC incidence in the 1980s. More recently, between 2008 and 2012, CRC incidence decreased annually by about 3.6% in men and 3.8% in women (1). Similarly, CRC mortality has been decreasing since 1975, with the most rapid decline in the past decade of about 3% annually. Several factors have been linked to this decline in CRC incidence and mortality, including changes in diet, risk factors, medication use (aspirin, hormone-replacement therapy, and statins). However, the most likely factor behind the most recent declines in CRC is the increase in the rate of CRC screening among individuals with average or high risk for colon cancer.

1.2 Colon cancer screening

Tests for colorectal cancer screening fall into two broad categories: tests for cancer detection and tests for cancer prevention. Tests for cancer detection detect mainly cancerous lesions, rather than precancerous polyps. These include guaiac-based fecal occult blood testing, fecal immunochemical tests, and stool DNA. Tests for cancer prevention can detect both cancer and precancerous polyps. These include colonoscopy, flexible sigmoidoscopy, and CT colonography. The advantages of colonoscopy compared

to the other modalities are the ability to directly examine the colonic mucosa and remove precancerous polyps during one session. The American College of Gastroenterology recommends colonoscopy as the preferred screening modality (2). The results from several studies support that colonoscopy and polypectomy decrease mortality from colon cancer.(3-5). However, it has been consistently shown that the quality of colonoscopy varies among providers, and is dependent on several factors such as colon preparation quality, skills of the endoscopist, and length of withdrawal (examination) time. Furthermore, some studies found that colonoscopy decreases the risk of distal, but not proximal, colon cancer (6, 7). Therefore, there is intense interest in improving the quality of colonoscopy in order to achieve the intended benefit of detecting precancerous polyps and preventing cancer.

1.3 Colonoscopy quality indicators

There are several measures of the quality and effectiveness of screening colonoscopy. The most important quality metric is the adenoma detection rate (ADR). This is the percentage of screening colonoscopies in which at least one histologically proven adenoma is detected. It is calculated using the following formula.

$$ADR = \frac{\text{Number of screening colonoscopies in which at least one adenoma is detected}}{\text{Total number of screening colonoscopies}}$$

The recommended ADR for screening colonoscopies varies depending on sex, reflecting the higher prevalence of polyps in men than in women. The US Multi-Society Task Force on Colorectal Cancer recommends a target ADR of ≥25% in men and ≥15% in women. The importance of ADR derives from its correlation with interval colon

cancer, which refers to cancers diagnosed within 3-5 years following a clearing colonoscopy. Most interval cancers are related to missed lesions during a screening colonoscopy (8). The ADR was inversely associated with risk of interval colorectal cancer (9, 10), suggesting that the lower the ADR, the higher the chance is for a patient to develop colon cancer following a screening colonoscopy. Therefore, the effectiveness of screening colonoscopy is directly related to a high ADR and removal of all precancerous colonic polyps.(11) These studies strongly support the validity of the ADR as a quality measure in screening colonoscopy; therefore, it is warranted to study different factors that may affect the ADR in order to maximize the effectiveness of colonoscopy in colon cancer prevention.

Another commonly used metric is the polyp detection rate (PDR). This is the percentage of screening colonoscopies performed in which at least one polyp is detected. It is measured using the following formula.

$$PDR = \frac{\text{Number of screening colonoscopies in which at least one polyp is detected}}{\text{Total number of screening colonoscopies}}$$

The advantage of the PDR is that it can easily be calculated without the need to check histologic results. Any polyp removed (adenoma or non-adenoma) contributes to the PDR. Studies have found a strong correlation between the PDR and ADR (0.86-0.91), (12, 13). However, the PDR has several limitations. In contrast to the ADR, there are no standard targets for the PDR. In addition, some studies found the PDR to be strongly correlated with the ADR in the distal colon, but that the correlation in the proximal colon is weak (14, 15). Last, there is potential for bias in the PDR, as endoscopists may artificially inflate their PDR by removing non-significant distal colonic polyps. Therefore, the ADR remains the preferred and most validated measure of colonoscopy

quality. (11) An advanced adenoma is any adenoma that is 1 cm or larger in size, contains villous or tubulovillous histology, or contains high grade dysplasia. These polyps are considered higher risk than regular adenomas, and are more likely to progress to malignancy. Studies have found the advanced adenoma detection (AADR) rate (percentage of screening colonoscopies that contain at least one advanced adenoma) to be independent of the ADR, and recommend that it be considered as an additional measure of colonoscopy quality. (16).

An inherent drawback of the above three measures is that they do not account for the number of lesions found in the colon. For example, in any given colonoscopy, finding 1 adenoma is treated the same as finding 2 or more adenomas, as in all these cases the colonosccopy is considered to have ≥ 1 adenoma. This is similar in the PDR and the AADR. One way to account for these differences is to measure the mean number of adenomas per colon (or mean number of polyps per colon) as a method to measure lesion detection during colonoscopy.

1.4 Effect of fellow involvement on effectiveness of screening colonoscopy

Given the importance of providing a quality colonoscopy, there is great interest in studying the effects of different procedural factors on the ADR and PDR. Central to this discussion is the skill of the provider performing the colonoscopy. Colonoscopy quality differs widely among providers, and studies have reported a wide range of ADR (15-50%) among endoscopists (17, 18). There is also some evidence that colonoscopies performed by gastroenterologists are associated with higher protection against colon cancer than are those performed by other providers (5).

Fellows are gastroenterology trainees who enroll in a three-year gastroenterology fellowship. Throughout their training, gastroenterology trainees acquire several procedural and non-procedural skills. They are supervised by attending gastroenterologists during procedures. First-year fellows rapidly acquire procedural skills; however, it is unclear whether their skill level changes substantially enough within the first year of training to affect their screening colonoscopy ADR and PDR. Most fellows in their third year of training have acquired adequate endoscopic skills, and are ready for unsupervised practice. They are considered more skillful than first and second year fellows. Given that there is a known learning curve for colonoscopy, it is unclear whether the participation of fellows in screening colonoscopy affects the quality of the procedure, and whether their skill level at different stages of their training contributes to any changes in the quality of colonoscopy. There are relatively few reported studies that addressed this subject. In a small retrospective study of 309 patients, colonoscopies performed by fellows under the supervision of an attending had a higher ADR compared to those performed by attendings alone (37.2% vs. 23%, $p<0.01$) (19). Another retrospective study found that ADRs increased as fellows advanced throughout their fellowship, with third year fellows having a higher ADR than did attendings (39.5% vs 27.7%), OR = 1.7 (1.33-2.17) (20). Another study found that colonoscopies performed by fellows under the supervision of attendings were associated with a higher detection of small adenomas (<5 mm), compared to procedures performed without a fellow (25% vs 17%, $p= 0.001$) (21). There are several limitations to these studies, including the small sample sizes, the small number of procedures performed by fellows, inclusion of non-screening colonoscopies, and no stratification of fellows by year of training.

1.5 Study aims

This study provides further clarification on the effect of fellow participation at different stages of training on the quality of screening colonoscopies. The primary aim of this study is to investigate whether GI fellows at various stages of training performing screening colonoscopies have different ADR and PDR compared to attendings. This will be done by examining a large database of screening colonoscopies performed in patients aged 40 or older at a large teaching hospital.

2. METHODS

2.1 Study Design

This was a retrospective study using the endoscopic procedure database at Grady Memorial Hospital in Atlanta, GA. This database includes prospectively collected information about all endoscopic procedures performed in the Grady Memorial Hospital gastroenterology endoscopy unit, and includes procedure type, patient's medical record number, age, race, procedure indication, endoscopist, fellow participation in the procedure, and fellow training level. The study included all outpatients who were at least 40 years old who underwent a screening colonoscopy between July 1, 2009 and June 30, 2015. Excluded patients included those who underwent colonoscopy for diagnostic purposes (e.g., abdominal pain, diarrhea, bleeding), surveillance for colorectal polyps, personal history of CRC, colorectal surgery, or inflammatory bowel disease. We also excluded patients whose procedures were aborted due to complications, severe pain and discomfort, failed cecal intubation, and those with poor bowel cleansing preparation ("prep"). The study was approved by the Institutional Review Board.

2.2 Study Variables

The computerized medical record was used to confirm the age and race of the patient, endoscopic findings, prep quality, cecal intubation, and polyp size, number, location, and histology. Race was categorized as white, black, and other. Bowel prep quality was categorized as good, fair-adequate, fair-inadequate, and poor. Colonoscopies with fair-adequate prep are those in which the prep quality was judged to allow for detection of all polyps $\geq$ 5mm in size. Colonoscopies with poor prep had solid stool and

generally required a repeat procedure within 3 months. Polyps were categorized into adenomatous and non-adenomatous polyps. Adenomatous polyps were categorized into advanced and non-advanced adenomas. Advanced adenomas included polyps with size ≥ 10mm, villous or tubulovillous histology, high grade dysplasia, or adenocarcinoma. Colonoscopies were categorized according to fellow participation as follows: attending alone (procedure performed solely by attending) versus fellow present (fellow participated in any part of the procedure). Given that fellows start their fellowship training without endoscopic experience and rapidly accumulate endoscopic skills during their first year of training, fellow participation was also categorized as follows: attending alone, fellow in 1st six months of training, fellow in second six months of training, fellow in second year, and fellow in third year.

2.3 Colonoscopy information

Patients who were candidates for CRC screening were referred to the endoscopy unit from their primary care or gastroenterology clinic. Patients were given a standard 4 L of polyethylene glycol solution as a standard bowel preparation regimen. During the study period, there were 10 attendings and 34 fellows who performed the colonoscopies. In the endoscopy unit, patients are randomly assigned to endoscopy rooms during the course of the day. Endoscopy rooms are staffed by an attending, with or without a fellow. All procedures were performed under moderate sedation. In colonoscopies performed with fellows, the fellow started the procedure and attempted insertion of the colonoscope to the cecum. In general, attendings intervened when there was difficulty passing a specific part of the colon, or if there was significant patient discomfort. Once a specific area of the colon was traversed by the attending or the patient was better sedated, the scope was

usually given back to the fellow to complete the insertion to the cecum and subsequent withdrawal of the scope. However, this was left to the discretion of the attending. Second and third year fellows are usually able to complete the colonoscopy without participation of the attending. All fellows were strictly monitored by the attending physicians during insertion and withdrawal of the scope.

2.4 Statistical analysis

Descriptive statistics, including mean, standard deviation, and frequencies, were used to characterize the study population. Characteristics of patients undergoing screening colonoscopy according to whether their colonoscopy was performed by an attending physician alone or with a fellow were compared using the student t-test for continuous variables and the chi square test for categorical variables. Differences in the ADR, PDR, and advanced ADR across those for attendings alone and fellows at different points in training duration were assessed using the Mantel-Haenszel chi-square test to calculate the p for trend (non zero correlation). Associations of fellowship training level with the ADR, PDR, and AADR relative to attendings alone were assessed using unconditional multivariable logistic regression to calculate the adjusted odds ratios (ORs) and 95% confidence intervals (CIs). Models were adjusted for sex, age, race, and colon preparation quality. Statistical significance was defined as two-sided p value of $\leq 0.05\%$ or a 95% confidence interval that excluded 1.0. Analysis was performed using SAS 9.4

3. RESULTS

3.1 Patient population

Between July 1st, 2009 and July 1st, 2015, 8,175 colonoscopies were performed for the sole indication of screening for colon cancer. All procedures were performed under moderate sedation. Of these, 672 colonoscopies were excluded for the following reasons: 565 for poor colon preparation quality, 106 for failed cecal intubation, and 1 complication (laryngospasm). A total of 7,503 screening colonoscopies were included in the analysis. Figure 1 shows the study flow diagram leading to the study population. Selected characteristics of the study patients according to whether their colonoscopy was performed by an attending physician alone or with a fellow are summarized in Table 1. The mean age of the study patients was 58.2 years, and 63.1% were women, 88.2% were African American, and 88.9% had a good colon preparation quality. A total of 67.2% of colonoscopies were performed with a training fellow, and the rest were performed by an attending alone.

3.2 Adenoma, advanced adenoma, and polyp detection rates

Differences in the ADR, PDR, and advanced ADR across those for attendings alone and fellows at different points in training duration are summarized in Tables 1 and 2. The ADR in the fellow participation group (all levels of training combined) was higher than that in the attending group (34.5% vs. 30.7%, p=0.001). The increased ADR in the fellow group was mainly related to second and third year fellows, but not first year fellows. Fellows in their third year of training had a higher ADR than did attendings alone (35.4% vs. 30.7%; aOR 1.23, 95% CI 1.09-1.39). Similarly, the PDR was higher in

procedures performed with fellows compared to those performed by attendings alone (44.5% vs. 40.1%, p=0.0003). Fellows in their third year of training had a higher PDR than did attendings alone (45.7% vs. 40.1%; aOR 1.25, 95% CI 1.12-1.41). The ADR and PDR statistically significantly increased with increasing fellow training level (trend p value <0.05). Fellows also detected more adenomas and polyps than did attendings. The mean number of adenoma per colon (APC) was higher in the fellows' group than in the attendings alone group (0.68 vs. 0.61, p=0.03). Similarly, the mean number of polyps per colon (PPC) was higher in the fellows' group than in the attendings alone group (0.96 vs. 0.86, p=0.008).

There was no difference in the advanced adenoma detection rate (AADR) between the fellows group and the attending group (8.3% vs. 8.7%, p=0.49). However, fellows in their first six months of training had a lower AADR than did attendings alone (4.8% vs. 8.7%; aOR 0.52, 95% CI 0.35-0.76). We further analyzed this finding by examining the proportion of procedures that had a large adenoma (≥1 cm), villous histology, or high grade dysplasia (HGD) and/or cancer (Table 3). The lower AADR in the fellows in their first six months of training group was mainly related to a lower detection of large adenomas (3.4% vs 7.9%, p<0.0001). There were no differences in the detection of adenomas with villous histology or those with HGD and/or cancer. On average, fellows in their first six months of training detected a similar number of adenomas per colon compared to attendings (0.64 vs. 0.61, p=0.54).

4. DISCUSSION AND CONCLUSIONS

In this study, we found that the participation of fellows overall in screening colonoscopy is associated with higher adenoma and polyp detection. This increased detection is demonstrated in terms of the number of colonoscopies with at least one adenoma or polyp (ADR and PDR), and the mean number of adenomas and polyps per colon. Furthermore, our findings suggest that the fellow's level of training and experience is directly associated with polyp detection. There was a stepwise increase in adenoma and polyp detection with higher levels of fellow training. Fellows in the first year of training had similar ADR and PDR compared to attendings, while those in second and third year had higher values. These findings have clinical significance. Performance of colonoscopies by gastroenterology fellows, who have less experience than attendings, does not appear to negatively affect adenoma and polyp detection in colonoscopy, provided that they are adequately supervised, and may be associated with somewhat greater adenoma and polyp detection. The increased detection of polyps in procedures in which fellows participate could be related to the presence of an additional observer who monitors the screen with the primary endoscopist, and can lead to an increased recognition of small polyps. Previous studies found that endoscopy nurse participation leads to increased polyp detection (22, 23). In addition, participation of fellows could lead to a more focused withdrawal of the colonoscope in which the attending physician actively instructs the fellow to examine behind each colonic fold, thereby increasing the chances of detecting polyps. Our findings also suggest that detection of polyps is a learned skill that continues to improve during fellowship training, highlighting the importance of gaining adequate experience during training to maximize polyp detection.

Our study has several strengths. Unlike previous studies which included non-screening colonoscopies, we focused our analysis on outpatients presenting for the sole indication of screening for colorectal cancer. The goal of colonoscopy in patients presenting with clinical indications such as acute overt bleeding, abdominal pain or constipation is often to diagnose the etiology of symptoms and not to detect and resect polyps. Polypectomy is often deferred in these patients with acute indications until their symptoms resolve. In addition, our study included a large number of colonoscopies performed by trainees at different level of training. Finally, comparisons of colonoscopy quality between attending alone and fellows are more meaningful when the level of fellow training is considered. We categorized the level of fellow training in a way that reflects their learning curve, as fellows rapidly gain endoscopic skills in the first 6 months of training and progress to become more independent endoscopists in their second and third year. Finally, the retrospective nature of this study eliminates the possibility of the "Hawthorne effect", in which endoscopists alter their behaviour as they know that detection rates are being recorded and compared, which is more likely to occur in a prospective study design. One study found that when endoscopists know that their procedures are being recorded for review, they improve the quality of their exam (luminal distension, cleaning of the colon, and length of inspection time) resulting in an increased ADR. (24)

Our study has several limitations. It was a retrospective study and it was not possible to accurately describe the degree of fellow participation in colonoscopy. It is possible that attendings performed the withdrawal part of some procedures, and therefore we cannot directly attribute the differences in adenoma and polyp detection to the

fellow's technical skills. We did not have data on the insertion and withdrawal time of the colonoscopy. This would have provided insight about the observed increased polyp detection in second and third year fellows. Longer withdrawal times have been linked to higher adenoma etection rates in screening colonoscopy (25). It is unclear whether the higher detection rate in second and third year fellows is related to longer withdrawal times or to the technical skill of the fellow combined with the guidance and supervision from the attending, or both. Also, we did not account for several factors that affect polyp and adenoma prevalence such as family history of colon cancer and aspirin use, the data for which were unavailable. However, we accounted for several important confounders such as age, race, sex, and colonoscopy preparation quality. Given the nature of patient flow through the endoscopy unit where patients are shared between attendings, it is unlikely that there was significant difference in the proportion of patients with a family history of CRC, aspirin use, or other unmeasured confounders between the attending alone and the fellows group. Finally, our study was limited to one training program, and thus may not be generalizable to others.

The finding of a lower AADR in fellows in their first six months of training compared to attending alone was unexpected. This difference was likely primarily attributable to there having been a higher percentage of colonoscopies in which one adenoma ≥1cm was detected in procedures performed by attendings alone. It is unlikely that this is related to underestimation of polyp size by fellows in their beginning of training while they document their procedures. In general, attendings and fellows discuss findings and write down the sizes and locations of polyps during the procedure, and a final report is entered in the medical record system after the procedure is completed. In

addition, attendings sign off on the colonoscopy report and make the necessary changes as they see appropriate. It is reassuring that the ADR itself is not different between fellows in the first six month of training and attendings alone (32.4% vs. 30.7%, p=0.47). Furthermore, there was no difference in the average adenoma per colon between these two groups (0.61 vs. 0.64, p=0.54). This suggests that fellows are finding the same amount of polyps, though the size of these polyps is smaller than those found by attendings.

In summary, we found that fellow incolvement in screening colonoscopy is associated with overall higher ADR and PDR. These higher detection rates were mainly seen in procedures performed by second and third year fellows. Since the AADR was lower in procedures performed with fellows in their first six month of training, increased vigilance in these procedures and an attending joining the fellow in performing a careful withdrawal of the scope, with adequate withdrawal time and careful documentation of polyp size, are indicated. Further studies that document the exact involvement of fellows in the procedure, withdrawal time, and location of polyps would help identify factors related to higher polyp detection rates in more experienced fellows. This would ultimately allow us to optimize fellow involvement and training in screening colonoscopy, while maintaining a high quality examination.

5. APPENDIX

Figure 1: Study flow diagram.

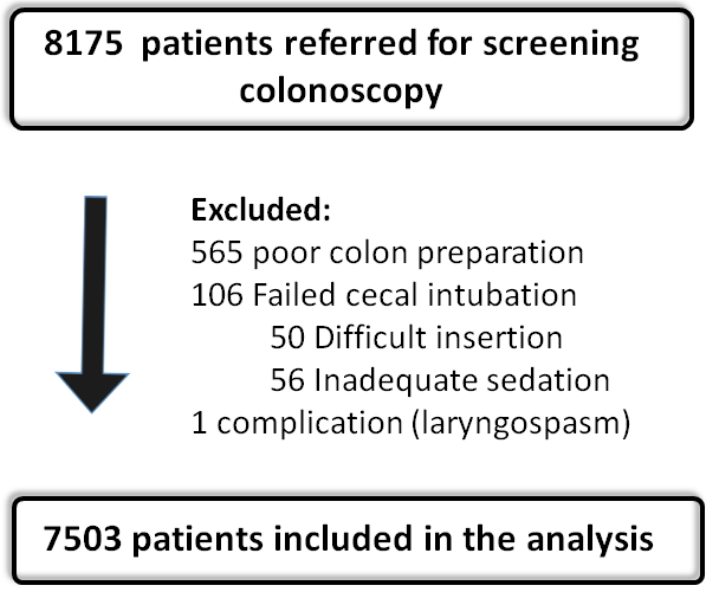

Table 1. Characteristics of patients undergoing screening colonoscopy (n = 7,503), by fellow participation

Characteristic	Attending alone (n = 2,464; 32.8%)		Attending with fellow (n = 5,039; 67.2%)		*p-value**
Age in years (mean+/-sd)	57.9 ± 7.1		58.3 ± 7.1		*0.02*
Female sex (n, %)	1,572	*63.8%*	3,161	*62.7%*	*0.37*
Race (n, %)					
White	120	*4.9%*	261	*5.2%*	*0.15*
Black	2,198	*89.2%*	4,423	*87.8%*	
Other	146	*5.9%*	355	*7.1%*	
Preparation quality (n, %)					
Good	2,199	*89.3%*	4,469	*88.7%*	*0.02*
Fair-adequate	152	*6.2%*	382	*7.6%*	
Fair-inadequate	113	*4.6%*	188	*3.7%*	
Fellow training level (n, %)					
1st 6 months	N/A		627	*12.4%*	
2nd 6 months	N/A		651	*12.9%*	
2nd year	N/A		1,413	*28.0%*	
3rd year	N/A		2,348	*46.6%*	
≥1 adenoma (ADR) (n, %)	756	*30.7%*	1,736	*34.5%*	*0.001*
≥1 advanced adenoma (AADR) (n, %)	215	*8.7%*	416	*8.3%*	*0.49*
≥1 polyp (PDR) (n, %)	988	*40.1%*	2,244	*44.5%*	*0.0003*
Mean number of adenomas per colon (APC)	0.61		0.68		*0.03*
Mean number of polyps per colon (PPC)	0.86		0.96		*0.008*

Abbreviations: ADR, adenoma detection rate; PDR, polyp detection rate; AADR; advanced adenoma detection rate
* p value from chi-square test for categorical variables, and student t test for continuous variables

Table 2. Associations of training level with ADR, PDR, and advanced ADR

Outcome	Fellowship training level	Detection rate	Trend p-value*	aOR†	95% C.I.	p-value
≥1 adenoma (ADR)	Attending alone (reference)	30.7%	*0.0003*	1	---	
	Fellow in 1st 6 months	32.4%		1.07	0.89-1.3	*0.47*
	Fellow in 2nd 6 months	33.3%		1.16	0.96-1.39	*0.13*
	Fellow in 2nd year	34.4%		1.15	1.00-1.32	*0.06*
	Fellow in 3rd year	35.4%		1.23	1.09-1.39	*0.001*
≥1 polyp (PDR)	Attending alone (reference)	40.1%	*<.0001*	1	---	
	Fellow in 1st 6 months	42.4%		1.10	0.92-1.32	*0.28*
	Fellow in 2nd 6 months	42.7%		1.14	0.96-1.36	*0.14*
	Fellow in 2nd year	44.4%		1.17	1.02-.133	*0.02*
	Fellow in 3rd year	45.7%		1.25	1.12-1.41	*0.0001*
≥1 advanced adenoma	Attending alone (reference)	8.7%	*0.70*	1	---	
(AADR)	Fellow in 1st 6 months	4.8%		0.52	0.35-0.76	*0.001*
	Fellow in 2nd 6 months	9.1%		1.06	0.78-1.44	*0.71*
	Fellow in 2nd year	9.3%		1.05	0.83-1.31	*0.70*
	Fellow in 3rd year	8.3%		0.93	0.76-1.15	*0.51*

Abbreviations: ADR, adenoma detection rate; PDR, polyp detection rate; AADR, advanced ADR; aOR, adjusted odds ratio; C.I., confidence interval

* Mantel-Haenszel chi-square (non zero correlation)

† From unconditional logistic regression model controlling for age, sex, race, and colon-cleansing preparation quality

Table 3. Advanced adenomas and total adenomas per colon in attending alone group and fellows in 1st 6 months of training

	Attending alone n=2464 n (%)	**Fellows 1st 6 months n=627 n (%)**	***p-value****
≥1 advanced adenoma (AADR)	215 (8.7%)	30 (4.8%)	*0.001*
≥1 adenoma ≥1cm	194 (7.9%)	21 (3.4%)	*<0.0001*
≥1 adenoma with villous histology	83 (3.4%)	14 (2.2%)	*0.15*
≥1 adenoma with HGD and/or cancer	26 (1.1%)	4 (0.6%)	*0.34*
Mean number of adenomas per colon (APC)	0.61	0.64	*0.54*

Abbreviations: AADR, advanced adenma detection rate; HGD, high grade dysplasia
* p value from chi-square test for categorical variables, and student t test for continuous variables

REFERENCES

1. Siegel RL, Miller KD, Jemal A. Cancer statistics, 2016. CA: A Cancer Journal for Clinicians 2016;66(1):7-30.
2. Rex DK, Johnson DA, Anderson JC, Schoenfeld PS, Burke CA, Inadomi JM. American College of Gastroenterology Guidelines for Colorectal Cancer Screening 2008. Am J Gastroenterol 2009;104(3):739-750.
3. Zauber AG, Winawer SJ, O'Brien MJ, Lansdorp-Vogelaar I, van Ballegooijen M, Hankey BF, et al. Colonoscopic Polypectomy and Long-Term Prevention of Colorectal-Cancer Deaths. New England Journal of Medicine 2012;366(8):687-696.
4. Nishihara R, Wu K, Lochhead P, Morikawa T, Liao X, Qian ZR, et al. Long-Term Colorectal-Cancer Incidence and Mortality after Lower Endoscopy. New England Journal of Medicine 2013;369(12):1095-1105.
5. Baxter NN, Warren JL, Barrett MJ, Stukel TA, Doria-Rose VP. Association Between Colonoscopy and Colorectal Cancer Mortality in a US Cohort According to Site of Cancer and Colonoscopist Specialty. Journal of Clinical Oncology 2012;30(21):2664-2669.
6. Baxter NN, Goldwasser MA, Paszat LF, Saskin R, Urbach DR, Rabeneck L. Association of Colonoscopy and Death From Colorectal Cancer. Annals of Internal Medicine 2009;150(1):1-8.
7. Singh H, Nugent Z, Demers AA, Kliewer EV, Mahmud SM, Bernstein CN. The Reduction in Colorectal Cancer Mortality After Colonoscopy Varies by Site of the Cancer. Gastroenterology 2010;139(4):1128-1137.
8. Pohl H, Robertson DJ. Colorectal Cancers Detected After Colonoscopy Frequently Result From Missed Lesions. Clinical Gastroenterology and Hepatology 2010;8(10):858-864.
9. Kaminski MF, Regula J, Kraszewska E, Polkowski M, Wojciechowska U, Didkowska J, et al. Quality Indicators for Colonoscopy and the Risk of Interval Cancer. New England Journal of Medicine 2010;362(19):1795-1803.
10. Corley DA, Jensen CD, Marks AR, Zhao WK, Lee JK, Doubeni CA, et al. Adenoma Detection Rate and Risk of Colorectal Cancer and Death. The New England journal of medicine 2014;370(14):1298-1306.
11. Fayad NF, Kahi CJ. Quality Measures for Colonoscopy: A Critical Evaluation. Clinical Gastroenterology and Hepatology 2014;12(12):1973-1980.
12. Williams JE, Holub JL, Faigel DO. Polypectomy rate is a valid quality measure for colonoscopy: results from a national endoscopy database. Gastrointestinal Endoscopy 2012;75(3):576-582.
13. Williams JE, Le TD, Faigel DO. Polypectomy rate as a quality measure for colonoscopy. Gastrointestinal Endoscopy 2011;73(3):498-506.
14. Boroff ES, Gurudu SR, Hentz JG, Leighton JA, Ramirez FC. Polyp and Adenoma Detection Rates in the Proximal and Distal Colon. Am J Gastroenterol 2013;108(6):993-999.
15. Gohel TD, Burke CA, Lankaala P, Podugu A, Kiran RP, Thota PN, et al. Polypectomy Rate: A Surrogate for Adenoma Detection Rate Varies by Colon Segment,

Gender, and Endoscopist. Clinical Gastroenterology and Hepatology 2014;12(7):1137-1142.
16. Greenspan M, Rajan KB, Baig A, Beck T, Mobarhan S, Melson J. Advanced Adenoma Detection Rate Is Independent of Nonadvanced Adenoma Detection Rate. Am J Gastroenterol 2013;108(8):1286-1292.
17. Kahi CJ, Ballard D, Shah AS, Mears R, Johnson CS. Impact of a quarterly report card on colonoscopy quality measures. Gastrointestinal Endoscopy 2013;77(6):925-931.
18. Chen SC, Rex DK. Endoscopist Can Be More Powerful than Age and Male Gender in Predicting Adenoma Detection at Colonoscopy. Am J Gastroenterol 2007;102(4):856-861.
19. Rogart JN, Siddiqui UD, Jamidar PA, Aslanian HR. Fellow Involvement May Increase Adenoma Detection Rates During Colonoscopy. Am J Gastroenterol 2008;103(11):2841-2846.
20. Peters SL, Hasan AG, Jacobson NB, Austin GL. Level of Fellowship Training Increases Adenoma Detection Rates. Clinical Gastroenterology and Hepatology 2010;8(5):439-442.
21. Buchner AM, Shahid MW, Heckman MG, Diehl NN, McNeil RB, Cleveland P, et al. Trainee participation is associated with increased small adenoma detection. Gastrointestinal Endoscopy 2011;73(6):1223-1231.
22. Dellon ES, Lippmann QK, Sandler RS, Shaheen NJ. GI endoscopy nurse experience and polyp detection during screening colonoscopy. Clinical gastroenterology and hepatology : the official clinical practice journal of the American Gastroenterological Association 2008;6(12):1342-1347.
23. Lee CK, Park DI, Lee S-H, Hwangbo Y, Eun CS, Han DS, et al. Participation by experienced endoscopy nurses increases the detection rate of colon polyps during a screening colonoscopy: a multicenter, prospective, randomized study. Gastrointestinal Endoscopy 2011;74(5):1094-1102.
24. Rex DK, Hewett DG, Raghavendra M, Chalasani N. The Impact of Videorecording on the Quality of Colonoscopy Performance: A Pilot Study. Am J Gastroenterol 2010;105(11):2312-2317.
25. Barclay RL, Vicari JJ, Doughty AS, Johanson JF, Greenlaw RL. Colonoscopic Withdrawal Times and Adenoma Detection during Screening Colonoscopy. New England Journal of Medicine 2006;355(24):2533-2541.