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The quality of screening colonoscopy in rural and underserved areas

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Abstract

Background Screening colonoscopy effectiveness depends on procedure quality; however, knowledge about colonoscopy quality in rural and underserved areas is limited. This study aimed to describe the characteristics and quality of colonoscopy and to examine predictors of colonoscopy quality at rural and underserved hospitals.

Methods Adults undergoing colonoscopy from April 2017 to March 2019 at rural or underserved hospitals across the Illinois Surgical Quality Improvement Collaborative were prospectively identified. The primary outcome was colorectal adenoma detection, and secondary outcomes included bowel preparation adequacy, cecum photodocumentation, and withdrawal time. Performance was benchmarked against multisociety guidelines, and multivariable logistic regression was used to examine patient, physician, and procedure characteristics associated with adenoma detection.

Results In total, 4217 colonoscopy procedures were performed at 8 hospitals, including 1865 screening examinations performed by 19 surgeons, 9 gastroenterologists, and 2 family practitioners. Physician screening volume ranged from 2 to 218 procedures (median 50; IQR 23–74). Adenoma detection occurred in 26.6% of screening procedures (target: ≥ 25%), 90.7% had adequate bowel preparation (target: ≥ 85%), 93.1% had cecum photodocumentation (target: ≥ 95%), and mean withdrawal time was 8.1 min (target: ≥ 6). Physician specialty was associated with adenoma detection (gastroenterologists: 36.9% vs. surgeons: 22.5%; OR 2.30, 95% CI 1.40–3.77), but adequate bowel preparation (OR 1.15, 95% CI 0.76–1.73) and cecum photodocumentation (OR 1.56, 95% CI 0.91–2.69) were not.

Conclusion Colonoscopies performed at rural and underserved hospitals meet many quality metrics; however, quality varied widely. As physicians are scarce in rural and underserved areas, individualized interventions to improve colonoscopy quality are needed.

Keywords Endoscopy · Colorectal cancer · Screening

Colonoscopy is a potentially life-saving screening procedure for colorectal malignancy which allows for detection and removal of premalignant lesions before they progress to cancer [1, 2]. Additionally, screening colonoscopy can detect colorectal cancer before symptom onset, permitting intervention at an earlier disease stage. The American College of Gastroenterology (ACG) and the American Society for Gastrointestinal Endoscopy (ASGE) have published joint guidelines outlining quality metrics for physicians performing screening colonoscopy [3]. These guidelines set performance targets of ≥ 85% for adequate bowel preparation, ≥ 95% for photodocumentation of cecal intubation, documentation of withdrawal time (time spent inspecting the colon for polyps) in ≥ 98% of procedures, and a mean withdrawal time of least 6 min for procedures in which no intervention is performed. Additionally, these guidelines

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recommend a threshold for adenoma detection rate (ADR, the percentage of a physician's screening colonoscopies in which at least one pathologically confirmed adenoma is detected) of ≥ 25%.

The importance of colonoscopy quality measures is well described in the literature. Prior studies have shown a strong association of higher bowel preparation quality [4, 5], higher rates of cecal intubation [6], and longer withdrawal time with increased ADR [7, 8]. Additionally, higher ADR is associated with reduced development of interval colorectal cancer between screening colonoscopies and reduced cancer-related mortality [9, 10]. For this reason, ADR is generally considered the "gold standard" quality metric for screening colonoscopy. Although current guidelines recommend that a physician's ADR should be at least 25%, more recent studies have shown benefits as ADR increases up to 35% [9, 11].

While extensive literature exists regarding colonoscopy quality, these studies primarily come from academic medical centers in urban or suburban environments. Comparatively, little work has assessed the quality of colonoscopy in rural or underserved areas, with most evidence drawn from single-physician case series and studies that lack pathology-based outcomes such as ADR [12–14]. Among rural populations, rates of screening for colorectal malignancy are lower than in urban areas, and the provision of colonoscopy in rural areas is known to differ substantially from urban centers [15, 16]. For example, physicians who perform colonoscopy in rural and underserved areas are less likely to have specialized training in gastroenterology or colorectal surgery and may perform colonoscopy at lower volumes than endoscopists in urban centers. Many procedures in rural areas are performed by general surgeons or family practitioners, who are often the sole provider of colonoscopy in their geographical region [12, 14, 17]. Thus, the knowledge gap concerning the quality of colonoscopy in rural areas is particularly important.

This study aimed to expand the understanding of screening colonoscopy quality in rural and underserved areas using unique, prospectively collected statewide quality data. Our primary objective was to evaluate screening colonoscopy quality in rural and underserved hospitals by comparing adherence with existing quality measures to thresholds published in national guidelines. Our secondary objectives were to evaluate the characteristics of physicians who performed screening colonoscopy in rural and underserved areas, whether these characteristics were associated with adherence to process measures and adenoma detection rates.

Materials and methods

Study population

The Illinois Surgical Quality Improvement Collaborative (ISQIC) is a partnership of 56 hospitals across the state of Illinois which was founded in 2014 as a vehicle for promoting quality improvement (QI) in surgical care. ISQIC consists of a diverse collection of hospitals including large, urban academic medical centers, suburban community hospitals, and rural hospitals and also includes a special program consisting of 10 small, rural hospitals. The model used for QI in ISQIC includes shared data collection and 20 other components, including collaborative-wide QI projects [18]. This study was part of one such statewide QI project targeting colonoscopy quality in rural and underserved areas.

The study population consisted of all patients 18 years or older who underwent colonoscopy at 8 rural or underserved ISQIC hospitals between April 2017 and March 2019. Hospitals were considered rural or underserved if they were not located in an Urbanized Area as defined by the US Census Bureau or were located in a Health Professional Shortage Area as defined by the Health Resources and Services Administration [19, 20]. Cases with missing or incorrectly entered surgeon identifiers and missing procedural characteristics were excluded. This study was exempt from IRB review after institutional IRB review (STU00093015).

Data collection

A colonoscopy was considered to be a "screening colonoscopy" if the patient had no recorded gastrointestinal symptoms and if colonoscopy was not performed for surveillance due to a personal history of underlying disease or findings on previous colonoscopy (e.g., prior adenoma) [9]. Procedures performed on patients noted by physicians to be at high risk of colorectal cancer based on family history were included among screening procedures if they met all other criteria for a screening examination. Other variables collected included patient characteristics, process measures (quality of bowel preparation, documentation of withdrawal time, length of withdrawal time, photographic documentation of cecum intubation), type of intervention performed, pathology results, and adverse events. Patient and procedure data were abstracted by trained Surgical Clinical Reviewers [21].

Data were supplemented using the 2018 American Medical Association (AMA) Physician Masterfile dataset [22] and manual review of hospital websites to incorporate

characteristics of physicians who performed colonoscopies. Physician characteristics obtained from the AMA Physician Masterfile included gender and board certification (gastroenterology, general surgery with or without colorectal board certification, family practice). For surgeons, the year of residency completion was also obtained, as formalized endoscopy training requirements were introduced in 2009.

Outcomes

The primary measure of colonoscopy quality was the detection of ≥ 1 adenoma, as determined by pathologic analysis of tissue samples obtained during each procedure. Additional process measures included quality of bowel preparation, documentation of withdrawal time, length of withdrawal time, and photographic documentation of cecal intubation. Quality of bowel preparation was abstracted from procedure notes and was categorized as adequate or inadequate based on the physician's description. Cases in which bowel preparation was not recorded were considered inadequate. Length of withdrawal time was defined as the number of minutes from cecum intubation until the colonoscope was removed, and documentation of withdrawal time was defined based on whether the length of withdrawal time was documented. Withdrawal time variables were only reported for procedures in which no intervention was performed [8]. Photodocumentation of cecal intubation was defined based on the presence in the medical record of photographic evidence showing the colonoscope had reached the cecum. Other abstracted variables evaluated as exploratory outcomes included pathology results (rates of adenocarcinoma, serrated polyp, and hyperplastic polyp detection) and adverse events (viscus perforation, bleeding, sedation-related complications, and other). Physician-level ADR was calculated as the percentage of screening colonoscopy procedures in which ≥ 1 adenoma was detected.

Statistical analysis

Descriptive analysis of physician and procedural characteristics, process measures, and adenoma detection was performed for all screening colonoscopies, and confidence intervals were calculated using the Clopper–Pearson exact binomial method. Process measures and outcomes were compared with ACG/ASGE quality metrics where applicable [3]. Patient factors, process measure adherence, and outcomes were compared among the different provider specialties using χ^2 tests for categorical variables and one-way analysis of variance for continuous variables. The relationship of patient and physician characteristics and process measures with adenoma detection was performed using Student's t-tests for continuous variables, and Fisher's exact or χ^2 tests for categorical variables. A hierarchical logistic regression model was constructed incorporating physicians as random intercepts to analyze association of patient factors, physician factors, and process measures with adenoma detection. Patient age, patient sex, presence of high-risk family history, adequate bowel preparation, cecal photodocumentation, and physician specialty were included as covariates in the model. Process measures related to withdrawal time were omitted in the model as they were, by definition, not available for procedures where an adenoma was detected. To evaluate a possible relationship between physician procedure volume and ADR, a Spearman correlation test was performed. All significance tests were two-sided with a threshold of $p < 0.05$. Statistical analyses were performed using SAS version 9.4 (SAS Institute, Cary, NC).

Results

A total of 4217 patients underwent colonoscopy during the study period, and 1865 screening procedures were identified for analysis after excluding patients with missing physician identifiers ($n = 21$) or procedure characteristics ($n = 2$). These procedures were performed at 8 hospitals by 30 physicians, including 19 surgeons, 9 gastroenterologists, and 2 family practitioners (Table 1). Physicians were predominantly male (28 of 30, 93.3%), only 1 surgeon had completed colorectal surgery fellowship training, and 2 graduated from residency in 2009 or later (Table 2). The number of colonoscopies performed by each physician during the study period ranged from 15 to 540, (median 97.5, IQR 56–168), with rates of screening procedures ranging from 2 to 218 (median 50, IQR 23–74). After accounting for differences in data collection duration, the estimated annual total colonoscopy volume for each physician ranged from 9 to 673 (median 106, IQR 57–155), and estimated annual screening colonoscopy volume ranged from 1 to 183 (median 46.5, IQR 31–81; Fig. 1). The median estimated annual number of screening colonoscopies performed by surgeons was 43 (IQR: 31–59, range 5–143), by gastroenterologists was 66 (IQR: 26–81, range 1–183), and by family practitioners was 65.5 (range 50–81).

No intervention was performed in 1008 screening colonoscopies (54.1%), polypectomy was performed in 771 procedures (41.3%), and other types of biopsy were performed in 86 procedures (4.6%; Table 1). At least 1 adenoma was detected in 496 screening colonoscopies, resulting in an ADR of 26.6% (target ≥ 25%) for the entire cohort. Adequate bowel preparation was achieved in 1691 procedures (90.7%; target ≥ 85%), photodocumentation of cecal intubation occurred for 1737 procedures (93.1%; target ≥ 95%), withdrawal time was documented for 914 of 1008 procedures without intervention (90.7%; target ≥ 98%), and mean withdrawal time was 8.1 min (SD 2.6; target ≥ 6 min). At

Table 1 Characteristics of patients undergoing screening colonoscopy

Characteristic	Physician specialty				p value[a]	ACG/ASGE quality target
	All specialties ($n=1865$)	Surgeon ($n=1225$)	Gastroenterologist ($n=577$)	Family practitioner ($n=63$)		
Mean patient age, years (SD)	62.2 (8.7)	62.4 (8.9)	61.6 (8.2)	62.4 (10.2)	0.16	
Female, No. (%)	883 (47.4)	550 (44.9)	302 (52.3)	31 (49.2)	0.01	
High-risk family history, No. (%)	91 (4.9)	55 (4.5)	34 (5.9)	2 (3.2)	0.36	
Rates of intervention, No. (%)						
None	1008 (54.1)	763 (62.3)	203 (35.2)	42 (66.7)	< 0.001	
Biopsy, other than polypectomy	86 (4.6)	61 (5.0)	21 (3.6)	4 (6.4)		
Polypectomy	771 (41.3)	401 (32.7)	353 (61.2)	17 (27.0)		
Process measures						
Adequate bowel preparation, No. (%)	1691 (90.7)	1126 (91.9)	504 (87.4)	61 (96.8)	0.002	≥ 85%
Cecum photodocumentation, No. (%)	1737 (93.1)	1160 (94.7)	544 (94.3)	33 (52.4)	< 0.001	≥ 95%
Withdrawal time documentation, No. (%)[b]	914 (90.7)	701 (91.9)	180 (88.7)	33 (78.6)	0.009	≥ 98%
Mean withdrawal time, minutes (SD)[b]	8.1 (2.6)	8.5 (2.7)	7.0 (2.2)	6.1 (1.0)	< 0.001	≥ 6 min
Pathology results, No. (%)						
Adenoma	496 (26.6)	276 (22.5)	213 (36.9)	7 (11.1)	< 0.001	≥ 25%
Adenocarcinoma	10 (0.5)	5 (0.4)	4 (0.7)	1 (1.6)	0.38	
Serrated polyp	61 (3.3)	22 (1.8)	39 (6.8)	0	< 0.001	
Hyperplastic polyp	315 (16.9)	150 (12.2)	160 (27.7)	5 (7.9)	< 0.001	
Any adverse event, No. (%)	3 (0.2)	2 (0.2)	1 (0.2)	0	0.95	

ACG American College of Gastroenterology, *ASGE* American Society for Gastrointestinal Endoscopy, *SD* standard deviation

[a]Calculated from comparison among physician specialties using χ^2 or one-way analysis of variance tests

[b]Among procedures during which no intervention was performed

Table 2 Characteristics of physicians by specialty

Characteristic	Surgeon ($n=19$)	Gastroenterologist ($n=9$)	Family practitioner ($n=2$)
Female, No. (%)	1 (5)	1 (11)	0
Completed residency 2009 or later, No. (%)	2 (11)	NA	NA
Colorectal board certified, No. (%)	1 (5)	NA	NA
ADR ≥ 25%, No. (%)	10 (53)	9 (100)	0

SD standard deviation, *ADR* adenoma detection rate, *NA* not applicable

least one serrated polyp was detected in 61 (3.3%) of examinations. Adverse events occurred in 3 procedures (0.2%) and included 1 patient who experienced post-procedural bleeding, 1 patient who experienced a sedation-related event, and 1 patient who was admitted due to post-procedural fever.

Differences were observed across physician specialties in patient gender distribution and in rates of intervention during screening colonoscopy (Table 1). The guideline-endorsed ADR benchmark of 25% in screening colonoscopy was met by 19 of 30 physicians in the study (mean ADR: 28.4%, range 6.7–56.5%, SD: 14.3%; Fig. 2) with 10 of 19 surgeons, 9 of 9 gastroenterologists, and 0 of 2 family practitioners meeting the threshold. The specialty-level ADR was highest among gastroenterologists at 36.9%, followed by surgeons at 22.5% and family practitioners at 11.1%. Rates of adequate bowel preparation and cecum photodocumentation differed among physician specialties, as did mean withdrawal time. When evaluating the relationship between estimated annual screening procedure volume and ADR, no association was seen (Spearman's ρ: -0.008, $p=0.97$; Fig. 3).

On adjusted analysis, patients who had an adenoma detected were older (mean age: 63.5 vs. 61.7 years, OR per year of age: 1.03, 95% CI 1.02–1.04, $p<0.001$), and males were more likely to have an adenoma detected (32.7% vs. 19.8%, OR 2.15, 95% CI 1.72–2.70, $p<0.001$, Table 3). Procedures performed by gastroenterologists were more likely to result in adenoma detection compared to surgeons (36.9% vs. 22.5%, OR 2.30, 95% CI 1.40–3.77, $p=0.001$). Adequate

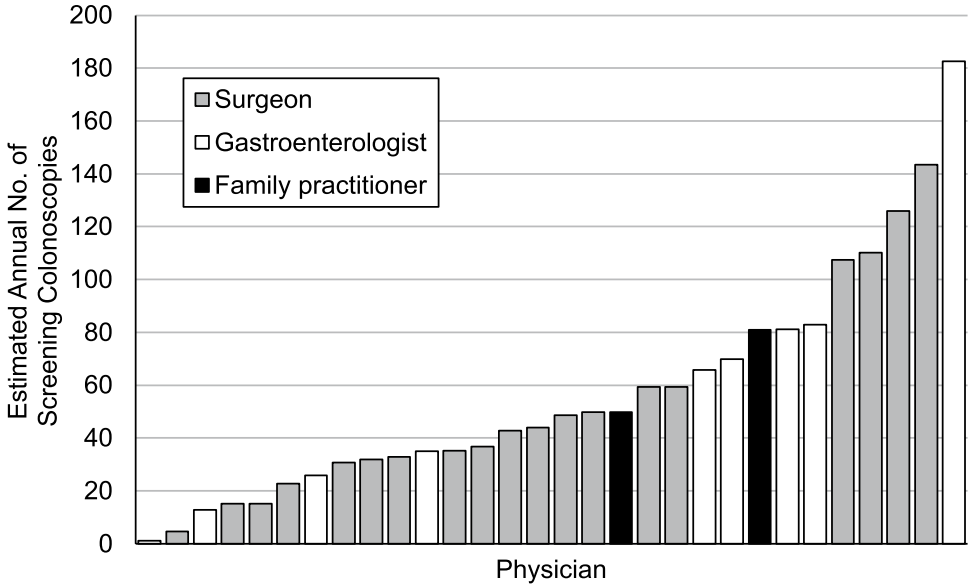

Fig. 1 Estimated annual number of screening colonoscopies performed by physician. Estimated number of screening colonoscopies performed annually by each physician during the study period

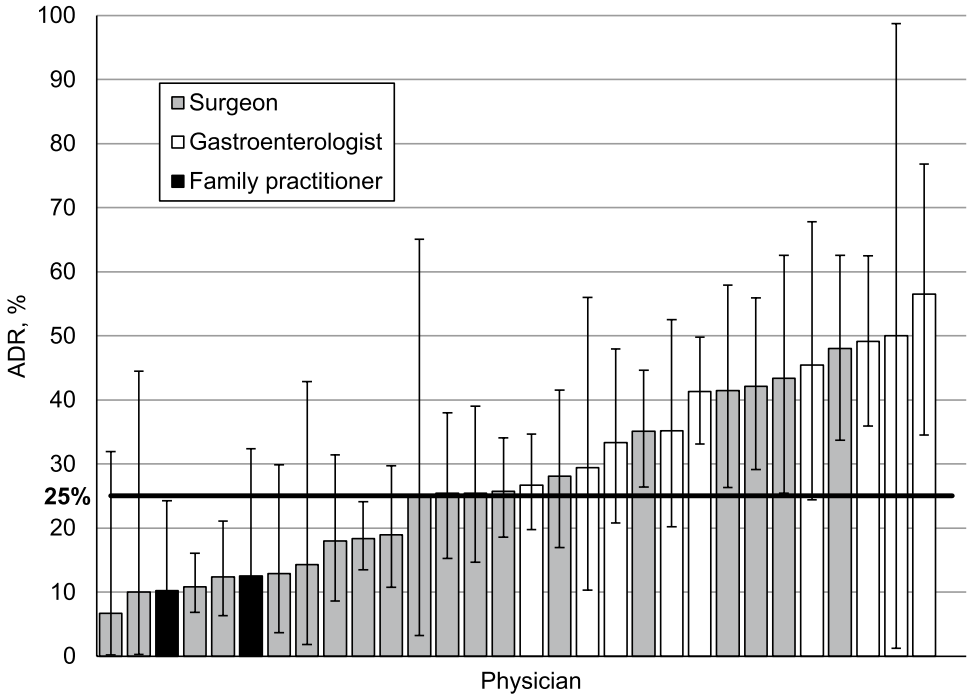

Fig. 2 Individual physician adenoma detection rates. *ADR* adenoma detection rate. Estimated individual adenoma detection rate for each physician with 95% confidence intervals. The horizontal line represents the American College of Gastroenterology/American Society for Gastrointestinal Endoscopy guideline threshold of 25% for adenoma detection rate

bowel preparation and cecum photodocumentation were not associated with adenoma detection.

Discussion

This study demonstrates that screening colonoscopies performed at 8 hospitals in rural and underserved areas meet most national quality measures. Overall rates of adenoma detection, adequate bowel preparation, and mean withdrawal time reached recommended thresholds; however, on an individual physician level, 11 of 30 physicians had an ADR below the recommended 25% threshold. Additionally, the rate of photodocumentation of cecal intubation (93.1%) was slightly below the guideline recommendation of 95% and the rate of withdrawal time documentation (90.7%) did not meet the threshold of 98%. Finally, the serrated polyp detection rate was 3%. These results suggest that screening colonoscopies performed by most physicians in rural and underserved areas are of satisfactory quality, but that room for improvement remains.

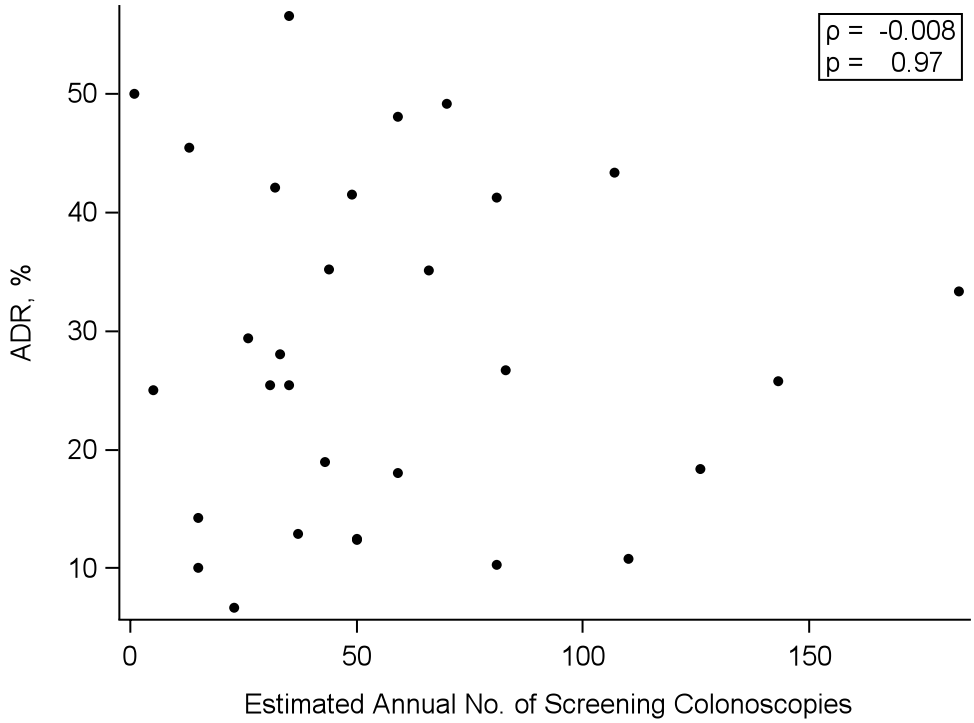

Fig. 3 Relationship between physician annual procedure volume and adenoma detection rates. *ADR* adenoma detection rate. Scatterplot of each surgeon's estimated annual screening colonoscopy volume (adjusted based on duration of data collection) and ADR. Inset panel includes Spearman's ρ and associated p-value for the correlation between ADR and screening volume

Table 3 Association of patient, procedural, and provider factors with adenoma detection

Characteristic	Adenoma detected, *n* (%)	Adjusted odds ratio (95% CI)	*p* value
Total	496 (26.6)		
Patient age in years, mean (SD)	63.5 (8.6)	1.03 (1.02–1.04)[a]	< 0.001
Patient sex			
Male	321 (32.7)	2.15 (1.72–2.70)	< 0.001
Female	175 (19.8)	1 [Reference]	NA
High risk based on family history			
Yes	27 (29.7)	1.18 (0.72–1.94)	0.50
No	469 (26.4)	1 [Reference]	NA
Adequate bowel preparation			
Yes	449 (26.6)	1.15 (0.76–1.73)	0.50
No	47 (27.0)	1 [Reference]	NA
Photodocumentation of cecum			
Yes	474 (27.3)	1.56 (0.91–2.69)	0.11
No	22 (17.2)	1 [Reference]	NA
Provider specialty			
Surgery	276 (22.5)	1 [Reference]	NA
Gastroenterology	213 (36.9)	2.30 (1.40–3.77)	0.001
Family practice	7 (11.1)	0.47 (0.15–1.42)	0.18

SD standard deviation, CI confidence interval

[a]Odds ratio for each additional year of age

Physicians who perform colonoscopies in rural and underserved areas often have different training backgrounds than those in urban academic centers and have a wider range of practice patterns. Most physicians performing screening colonoscopy in the study cohort were general surgeons, with only 1 possessing subspecialty board certification in colorectal surgery, and only 2 having graduated residency after the ACGME instituted formalized endoscopy training

requirements for surgical residents. The number of screening colonoscopies performed by each physician ranged from 2 to 218 over the study period of almost 2 years. This sizeable range may reflect differences in the practice patterns of rural physicians and/or differences in the duration of active data collection at each hospital.

Despite the findings of the overall study population, differences in quality were seen across physician specialties. Notably, while the overall ADR of the entire cohort of physicians was 26.6%, ADR ranged from 11.1% in family practitioners to 36.9% for gastroenterologists. A similar pattern was seen for serrated and hyperplastic polyp detection rates. These findings are likely attributable to improved lesion identification and removal. Previous studies have demonstrated differences in ADR between surgeons and gastroenterologists, possibly due to differences in exposure to endoscopy during training, the portion of a physician's practice that is dedicated to endoscopy, or differences in patient characteristics [6, 23–27]. It is also known that serrated polyp detection rates are more pathologist-dependent than traditional adenomas [28]. It is likely that similar mechanisms contribute in this rural and underserved patient population. Despite the differences in ADR by physician specialty, corresponding differences in process measure adherence were not observed, with surgeons having longer mean withdrawal times and higher rates of adequate bowel preparation compared to gastroenterologists. However, the association between physician specialty and ADR persisted after adjustment for process measures, suggesting that characteristics beyond adherence to known process measures likely contributed to the observed differences.

Significant variability in ADR was also seen among individual physicians, regardless of specialty. When examined at the individual physician level, ADR ranged from 6.7 to 56.5%, and 11 of 30 physicians did not met the recommended 25% threshold for ADR. Thus, there is significant room for improvement among physicians regardless of specialty, especially when considering that improved patient outcomes are seen up to an ADR of 35% [9]. Among our population, the ADR did not vary based on a physician's annual procedure volume. This agrees with previously reported studies which have shown that higher procedure volume is not associated with improved ADR [29].

There are numerous potential approaches to improve colonoscopy quality in rural and underserved areas. One possible approach would be to limit endoscopy privileges to those physicians with advanced endoscopy training or high ADR. However, this approach is likely to be counterproductive in rural and underserved areas where it would risk exacerbating an existing shortage of physicians who perform these procedures. A better strategy to improve colonoscopy quality could involve targeted education for low-performing physicians or increased exposure to colonoscopy during training for physicians planning to practice in rural or underserved areas. Additionally, colonoscopy "scorecards" could be used to report performance to individual physicians, allowing them to identify deficiencies and encouraging improvement. Such a practice has been shown to be effective among physicians at an academic medical center [30]. Finally, performance statistics could be made publicly available to permit patients to select high-performing physicians and further incentivizing self-improvement.

One approach of interest to our group uses video review of recorded colonoscopy to assess quality, identify specific areas for improvement, and provide physicians with focused educational strategies [31]. Specific feedback from video review has been demonstrated to improve colonoscopy quality [32]. Additionally, video review may be a superior method of assessing procedure quality than ADR, especially among physicians who perform relatively few procedures [31]. Because the precision of ADR is dependent on procedural volume, some have suggested that upwards of several hundred procedures are required for calculation of an acceptably precise ADR [33]. A video-based approach could therefore be an ideal strategy to assess and improve the quality of colonoscopy, not only nationally, but also as a targeted quality improvement approach to physician endoscopists in rural and underserved areas.

This study has several limitations. First, as this is an observational study, only association and not causation can be inferred from the results. Second, the duration of data collection varied by hospital and it is possible that some physicians included in this sample practiced at other sites not captured in this dataset. Therefore, the ability to draw conclusions related to a physician's procedure volume is limited. Third, the precision of ADR is dependent on physicians' procedure volume. It may therefore be limited in its ability to discriminate individual performance in this population containing multiple physicians who perform relatively few screening colonoscopy procedures annually. Finally, this study only addresses the quality of screening colonoscopy, but these results may not be applicable to procedures performed for surveillance or diagnostic indications.

Overall, colonoscopy in rural and underserved areas met, or exceeded, most national benchmarks of colonoscopy quality. However, there was substantial variability in procedure quality among physicians. As the number of physicians performing colonoscopy is limited in rural and underserved areas, alternative methods of assessing and improving colonoscopy quality, such as video review, are needed to improve quality without further restricting the already limited pool of physicians available to these vulnerable patient populations.

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Declarations

Disclosures Rajesh N. Keswani reports providing consulting services for Boston Scientific Corporation and Neptune Medical Inc. Brian C. Brajcich, Anthony D. Yang, Lindsey Kreutzer, Patrick L. Molt, Matthew B. Rossi, Karl Y. Bilimoria, and Amy L. Halverson report no conflicts of interest or financial ties to disclose.

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