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Polypectomy Techniques, Endoscopist Characteristics, and Serious Gastrointestinal Adverse Events

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Synopsis:

A use of polypectomy techniques and the odds of serious gastrointestinal adverse events vary by endoscopist specialty (i.e., primary care, surgery, and gastroenterology) and for low-, medium-, and high-volume providers. Simple cold biopsy forceps appeared to be safe for the use by all types of endoscopists. For primary and single hot biopsy forceps/ablation or snare polypectomy, high-volume endoscopists may be preferred providers; and gastroenterologists or surgeons may be best fit to provide complex polypectomy procedures.

Abstract:

Background: A use of polypectomy techniques by endoscopist specialty (primary care, surgery, and gastroenterology) and experience (volume), and associations with serious gastrointestinal adverse events, were examined.

Methods: A retrospective follow-up study with ambulatory surgery and hospital discharge datasets from Florida, 1999-2001, was used. Thirty-day hospitalizations due to colonic perforations and gastrointestinal bleeding were investigated for 323,585 patients.

Results: Primary care endoscopists and surgeons used hot biopsy forceps/ablation, while gastroenterologists provided snare polypectomy or complex colonoscopy. Low-volume endoscopists were more likely to use simpler rather than complex procedures. For hot forceps/ablation and snare polypectomy, low- and medium-volume endoscopists reported higher odds of adverse events. For complex colonoscopy, higher odds of adverse events were reported for primary care endoscopists (1.74 [95%CI, 1.18 to 2.56]) relative to gastroenterologists

Conclusions: Endoscopists regardless of specialty and experience can safely use cold biopsy forceps. For hot biopsy and snare polypectomy, low volume, but not specialty, contributed to increased odds of adverse events. For complex colonoscopy, primary care specialty, but not low volume, added to the odds of adverse events. Comparable outcomes were reported for surgeons and gastroenterologists. Cross-training and continuing medical education of primary care endoscopists in high-volume endoscopy settings are recommended for complex colonoscopy procedures.

Background (Word Count – 3,038)

Colorectal cancer (CRC) remains one of the most common cancers and causes of cancer mortality in the United States [1,2]. The expenditures for treatment of CRC were approximately $8.4 billion in 2004 [3]. CRC is preventable through removal of premalignant polyps, which makes colonic polypectomy a preferred method of CRC prevention [2]. The number of colonoscopies is approximately 14 million per year [4]. The demand for colonoscopy is expected to grow due primarily to the aging population in the U.S [4]. Advances in technology and inclusion of gastrointestinal (GI) endoscopy in training of primary care physicians and surgeons allowed generalists to provide colonoscopy procedures that used to be in the realm of gastroenterologist care [5]. A shortfall of up to 1,550 gastroenterologists is estimated by 2020 [6] and as such, the role of primary care physicians and surgeons in providing CRC prevention services including colonoscopy is likely to remain unchanged over time. In the era of health reform with its focus on improvement of quality of care, cost containment, and population health, both specialists and generalists need to demonstrate the value and quality of care [7], particularly when it is relevant to cancer prevention.

Previous research has generally favored specialists over generalists for quality of care across various conditions [8]. Research findings on the endoscopist specialty, quality of colonoscopy, and patient outcomes were mixed [7]. No difference among gastroenterologists and family physicians in the proportion of cecal intubation and polyp detection rates for colonoscopy patients was reported [7]. One study favored gastroenterology over surgical trainees for colonoscopy completion rates and adenoma detection rates [9]. The risk of post-colonoscopy CRC was higher for primary care endoscopists in comparison with surgeons and gastroenterologists suggesting that primary care endoscopists were more likely to miss or leave

residual polyps during colonoscopy [10]. Endoscopist experience that was operationalized as an annual volume of procedures may affect patient outcomes, as previous research favored high-volume over low-volume endoscopists in terms of the risks of adverse gastrointestinal (GI) events due to colonoscopy [11,12].

Screening and diagnostic colonoscopy procedures are relatively safe; however, outpatient polypectomy is associated with a nine-fold increase in risks of serious adverse events, such as colonic perforations and GI bleeding that require inpatient admission, in comparison with colonoscopy without polypectomy [13]. Prior research also discovered that as complexity of polypectomy increased, a higher risk of serious GI adverse events was reported [12]. While gastroenterologists' use of polypectomy techniques is highly variable for polyps of similar sizes [14], a preferred polypectomy technique is not yet identified [12-15]. Primary care endoscopists tend to use less complex GI procedures and select healthier patients with lower severity of illness and less comorbidities [5]. As such, the risks of serious GI adverse events due to polypectomy may depend on the endoscopist specialty and experience [9,12], a specific polypectomy technique [12], clinical factors (e.g., severity of illness, polyp size and type) [16], and patient characteristics (e.g., age, comorbidities) [17].

With a growing emphasis on quality and efficiency of colonoscopy for CRC prevention, the debate about the use of polypectomy and the value of endoscopist specialty and experience may intensify. However, a lack of data on a preferential use of specific polypectomy techniques by endoscopist specialty and experience, as well as its impact on the rates of serious GI adverse events, leaves a substantial gap in the literature. In addition, previous research on the efficiency and effectiveness of care provided by generalists versus specialists was criticized for methodological shortcomings such as failures to account for confounding factors of physician

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experience, practice settings, severity of illness and comorbidity in the patient populations [8].

We study a preferential use of polypectomy techniques by endoscopist specialty (primary care, surgery, and gastroenterology) and experience (volume), and their associations with serious gastrointestinal adverse events. This study accounts for differences in practice settings and uses a validated method of risk adjustment for both severity of illness and comorbid diagnoses. This study uses a large, encounter-level, and all payer dataset with patient and physician identifiers for all Florida ambulatory surgery centers (ASC), hospital-based outpatient departments (HOPD), and hospitals to identify hospitalizations for serious GI adverse events due to colonic perforations and GI bleeding within 30 days after colonoscopy. These data covered the entire population of Florida that was treated in the outpatient surgery setting. Another unique feature of these databases is that they included operating physicians' identification numbers and specialty codes important for construction of key endoscopist measures for the period 1999 – 2001. Even though the study uses historic data, it provides an important baseline research, as it is the first study investigating associations among the main polypectomy techniques that are currently in use and endoscopist specialty, experience, and patient outcomes. As such, the study findings are useful for future research and policy-making on polypectomy guidelines, post-graduate and continuing medical education in endoscopy, and CRC prevention.

Methods

Data Sources:

Ambulatory surgery and inpatient hospital discharge datasets were obtained from the Florida Agency for Health Care Administration for 1999 through 2001. Both datasets were at the encounter-level and included unique patient identifiers, primary and secondary diagnoses as classified by the International Classification of Diseases, Ninth Revision, Clinical Modification

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(ICD-9-CM), primary and secondary procedure codes based on Current Procedural Terminology (CPT), payer types, facility types, dates of outpatient procedures and hospitalizations, and patient demographic characteristics. Polypectomy procedures were linked to subsequent hospitalizations to identify all hospital admissions for serious GI adverse events within 30 days. Figure 1 describes how the analytical sample of 323,585 polypectomy procedures provided by 860 endoscopists was derived for 1999-2001 as the unique (and consistent over time) physician identification numbers (UPIN) and the CMS physician specialty codes were available only for this period.
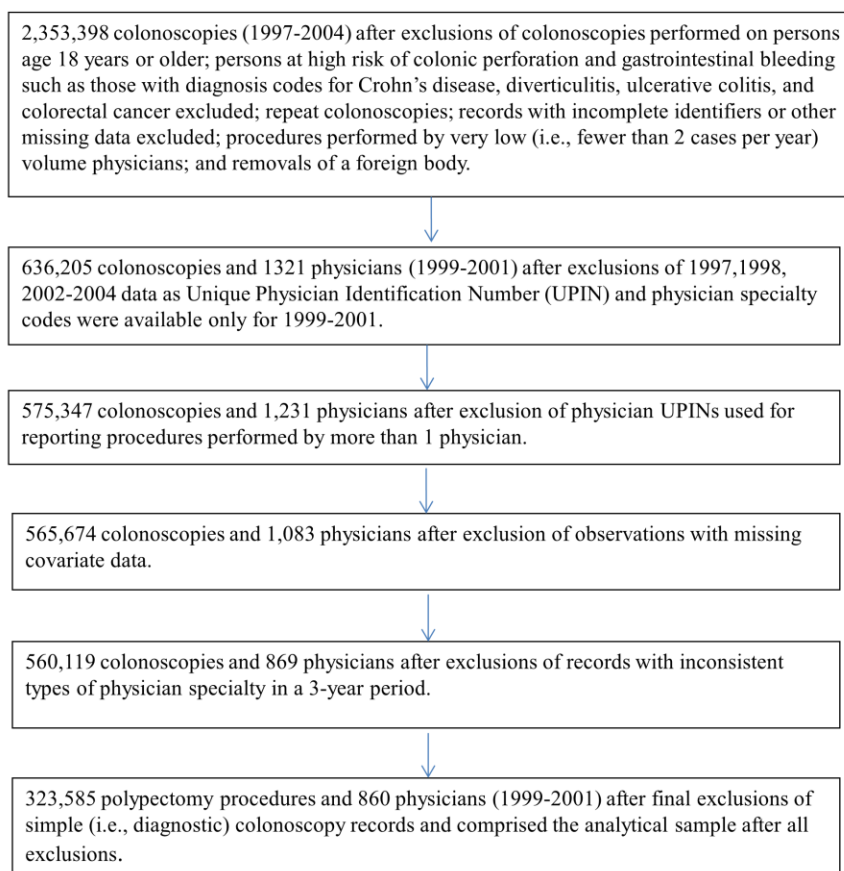

Figure 1. Description of Analytical Sample

Dependent Variables

Polypectomy Procedures:

Four polypectomy categories were constructed using the CPT codes [18]. Cold biopsy forceps were identified via primary CPT 45380 code for single or multiple biopsies and defined as the simple polypectomy [18]. Two categories of polypectomy techniques were constructed using primary CPT codes and identified as single polypectomy types: (1) hot biopsy forceps or bipolar cautery (CPT 45384) and ablation of lesion(s) not amendable to removal by hot biopsy forceps, bipolar cautery, or snare techniques (CPT 45383), combined into one category; and (2) snare polypectomy (CPT 45385) [18]. The complex colonoscopy was where multiple colonoscopy procedures were performed, and primary and secondary CPT codes with any combination of procedures with cautery, control of bleeding, injections, and/or tattooing (CPT 45380, 45381, 45382, 45383, 45384, and/or 45385) were billed during the same session [18]. A use of these techniques was highly variable for removing polyps of similar sizes [14]. Endoscopists currently use these main polypectomy techniques [14] that are also identifiable in administrative databases [18].

Serious Adverse Events:

The primary patient outcome was a cumulative measure of hospitalizations due to colonic perforation and/or GI bleeding within 30 days of a polypectomy that is procedure specific [16] and potentially reflective of endoscopist skills [11-12]. Primary diagnosis codes in the inpatient hospital discharge dataset were used to identify colonic perforations [ICD-9-CM: 569.83, 998.2], GI bleeding [ICD-9-CM: 578.1, 578.9, 998.1], acute postheomorrhagic anemia [ICD-9-CM: 285.1], and blood transfusion [ICD-9-CM: 280-284.9, 285.2-285.9, 99.03, 99.04].

Key Explanatory Variables

Endoscopist Specialty:

Endoscopist specialty categories were defined via the CMS specialty codes as: (1) primary care (i.e., family practice, geriatric medicine, internal medicine, general practice, obstetrics/gynecology, or preventive medicine), (2) surgery (i.e., thoracic surgery; surgical oncology, vascular surgery, general surgery, or colorectal surgery), and (3) gastroenterology.

Endoscopist Polypectomy Volume:

The annual polypectomy volume for each endoscopist was calculated as the total number of primary polypectomy procedures in each year of the study. Physicians were assigned to low (less than 150 cases per year), medium (150-299 cases per year), or high (more than or equal to 300 cases per year) volume categories based on annual volume of all polypectomy procedures. Providers' volume was allowed to vary from year to year. The annual volume is often use as a measure of provider experience [19].

Endoscopist Polypectomy Rate and Repeat Endoscopy:

A polypectomy rate (PR) for each endoscopist was calculated as a proportion of snare polypectomy, hot biopsy, and cold biopsy procedures that had the ICD-9 code of 211.3 for polyp detection to all diagnostic and polypectomy colonoscopies for the study period (1999-2001) [20]. We calculated the PR separately for each physician identifier and calendar year on a sample (n=560,119) before exclusion of simple (i.e., diagnostic) procedures (Figure 1). The PR calculated form administrative claims data are validated against adenoma detection rates (ADR)

derived from endoscopy reports [20]. The PR is an accurate surrogate for the ADR [20]. A PR of 35% is needed to achieve a recommended ADR benchmark of 20% [20]. We included the PR as a covariate reflecting experience of endoscopists in detecting adenomas.

Following the surveillance guidelines [21], a measure of repeat endoscopy was constructed as an indicator variable when any type of colonoscopy procedures was provided to the same patient within 12 months of an initial polypectomy. The measure of repeat endoscopy was used as a covariate in multivariate logistic regression models to account for removal of large sessile adenomas (that were likely removed piecemeal) at a shorter interval and required individualized surveillance of patients by experienced endoscopists [21].

Control Variables:

A dichotomous variable representing facility type was included to identify facility types as ASC or HOPD, where the majority of polypectomy procedures usually take place. Patient age was categorized as: $19 - 49$, $50 - 64$, $65 - 74$, $75 - 84$, and ≥ 85 years old. Race/ethnicity was specified as: white, Hispanic, black or African American, or other (including unknowns). Gender was included as a binary variable. Health insurance types were categorized as Medicare, Medicare HMO, Medicaid, Medicaid HMO, commercial Indemnity, commercial Health Maintenance Organizations (HMO), commercial Preferred Provider Organizations (PPO), self-pay or charity, and other. Diagnostic cost groups/hierarchical condition categories (DCG/HCC), which used all available ICD-9-CM diagnostic codes to categorize patients, were used to incorporate all comorbid conditions and indicate a greater severity of illness among patients with higher risk scores [22-24]. Finally, unobserved changes over time common for both ASCs and HOPDs (e.g., changes in practice guidelines, new policy recommendations) were controlled by

including a set of dummy variables for each year between 1999 and 2001.

Statistical analysis:

Polypectomy procedures, provider, and patient characteristics were examined by endoscopist specialty using univariate tests. Unadjusted rates for serious GI adverse events were calculated by dividing the total numbers of adverse events by the total number of procedures for specific polypectomy types by endoscopist specialty. Wald tests of linear restrictions were used for descriptive analyses.

Multivariate logistic regression models were used to predict the preferential use of polypectomy procedures (with each polypectomy category as a dependent variable) for endoscopists specialized in primary care, surgery, or gastroenterology (referent) and those in low-, medium-, and high-volume (referent) categories. In a separate set of multivariate analyses with serious GI adverse events as the dependent variable, polypectomy categories were used for stratification, to predict the adjusted odds of adverse events for each endoscopist specialty and volume categories as described above.

Odds ratios were estimated to evaluate the magnitude and direction of the effect for the key parameters of interest, after adjusting for the contributions of other covariates: 2 facility types with HOPD as the reference; 5 patient age categories with 19 – 49 as the reference; 4 race/ethnicity categories with white as the reference; gender with male as the reference; 4 health insurance types with Medicare as the reference; patient severity of illness measured as continuous risk scores; and variables for each year with 1999 as the reference.

As the univariate tests were exploratory and meant to highlight differences, their significant results were not subjected to any corrections for multiple testing. The results from the multivariate analyses are most definitive. There are no corrections for multiple testing to their

results, as these findings are to be taken as suggestive only due to the source and nature of the data, with their inherent limitations. We tested for multicollinearity, correlations, and interactions between covariates. Statistical significance was determined at $p < 0.05$. The university institutional review board approved the study.

All data were collected in 2006, and the current analysis was conducted in 2013. There is a time lag of several years for organizing claims data into analytical files and making them available to researchers. We obtained these data from the Florida Agency for Health Care Administration to study comparative effectiveness of ASCs and HOPDs. Once that analysis was complete, the research team turned to other topics of interest including the one presented in this paper. When using claims data, a lag of several years is not unusual.

Results

Descriptive analyses:

Gastroenterologists represented the majority of endoscopists (n=528, 61.4%) (Table 1). There were 153 (17.8%) primary care providers of polypectomies, specializing in internal medicine (n=107, 69.9%), family medicine (n=33, 21.6%), general practice (n=8, 5.2%) and obstetrics/gynecology (n=5, 3.3%). Surgeons (n=179, 20.8%) specializing in general surgery (n=137, 76.5%), colon/rectal surgery (n=37, 20.7%), and other types of surgery (n=5. 2.8%). Less than 1% of polypectomy procedures resulted in serious GI adverse events. Adverse events by specialty categories were not statistically different for primary care (0.43%), surgery (0.39%), and gastroenterology (0.35%). Primary care endoscopists provided higher proportions of cold biopsy procedures than surgeons and gastroenterologists. Surgeons used more of hot biopsy/ablation procedures in comparison with primary care physicians and gastroenterologists.

Gastroenterologists primarily performed snare polypectomy and complex colonoscopy procedures. Surgeons performed more polypectomy procedures in a hospital-based setting rather than in ASCs. Gastroenterologists performed a higher mean volume of polypectomy procedures (n=321) in comparison with primary care endoscopists (n=200) and surgeons (n=180). A polypectomy rate was lower for surgeons (0.33) than for primary care endoscopists (0.39) and gastroenterologists (0.38). Table 1 also reports patient characteristics by endoscopist specialties that were primarily similar across endoscopist specialties. Primary care endoscopists treated higher proportions of minorities and patients covered by Medicare HMO, Medicaid, self-pay/charity, and other payers. Different types of endoscopists provided polypectomies to patients with comparable severity of illness (Table 1).

Table 1. Serious GI Adverse Events, Procedure, Provider, and Patient Characteristics by Endoscopist Specialty

	Primary Care	Surgery	Gastroenterology	Total	P-value
Number of endoscopists (%)	153 (17.79)	179 (20.81)	528 (61.4)	860 (100)	***
Serious GI adverse events, n (%)	99 (8.43)	90 (7.67)	985 (83.90)	1,174 (100)	***
Unadjusted rate of AE (%)	0.43	0.39	0.35	0.36	
Polypectomy procedures (%)	22,797 (7.05)	23,019 (7.11)	277,769 (85.84)	323,585 (100)	***
Total number of procedures	39,165 (6.70)	45,518 (8.13)	475,422 (84.88)	560,105 (100)	***
Repeat endoscopy (%)	415 (1.82)	588 (2.55)	5,566 (2.00)	6,569 (2.03)	***
Polypectomy Procedures:					
Cold biopsy forceps	5,728 (25.13)	3,723 (16.17)	63,700 (22.93)	73,151 (22.61)	***
Hot biopsy forceps/Ablation	7,728 (33.90)	9950 (43.23)	80,808 (29.09)	98,486 (30.44)	***
Snare polypectomy	6,252 (27.42)	5886 (25.57)	87,638 (31.55)	99,776 (30.83)	***
Complex Colonoscopy	3,089 (13.55)	3,460 (15.03)	45,623 (16.42)	52,172 (16.12)	***
Provider Characteristics:					
Endoscopist Volume, mean (SD)	200 (154)	180 (163)	321 (238)	302 (233)	***
Volume Category, mean (SD)					***
< 150	78 (44)	67 (40)	99 (37)	91 (41)	
150 - 299	208 (40)	231 (42)	224 (42)	223 (42)	
≥ 300	454 (104)	506 (114)	514 (256)	511 (249)	
Polypectomy rate, mean (SD)	0.392 (0.23)	0.326 (0.21)	0.381 (0.16)	0.372 (0.19)	***
ASCs, n (%)	11,185 (49.06)	9,827 (42.69)	139,003 (50.04)	160,015 (49.45)	***
HOPDs, n (%)	11,612 (50.94)	13,192 (57.31)	138,766 (49.96)	163,570 (50.55)	
Patient Characteristics:					
Age categories, years, n (%):					
19 – 49	3,295 (14.45)	3,087 (13.41)	40,851 (14.71)	47,233 (14.60)	***
50 – 64	7,182 (31.50)	6,599 (28.67)	87,448 (31.48)	101,229 (31.28)	***
65 – 74	6,913 (30.32)	7,354 (31.95)	84,536 (30.43)	98,803 (30.53)	***
75 – 84	4,691 (20.58)	5,178 (22.49)	56,342 (20.28)	66,211 (20.46)	***
> 85	716 (3.14)	801 (3.48)	8,592 (3.09)	10,109 (3.12)	***
Gender, n (%):					
Male	11,278 (49.47)	12,793 (55.58)	138,363 (49.81)	162,434 (50.2)	***
Female	11,519 (50.53)	10,226 (44.42)	139,406 (50.19)	161,151 (49.8)	
Race, n (%):					
White	17,593 (77.17)	19,035 (82.69)	233,523 (84.07)	270,151 (83.49)	***
Hispanic	2,637 (11.57)	1,658 (7.20)	14,411 (5.19)	18,706 (5.78)	***
Black/African American	1,244 (5.46)	764 (3.32)	10,962 (3.95)	12,970 (4.01)	***
Other/unknown	1,323 (5.80)	1,562 (6.79)	18,873 (6.79)	21,758 (6.72)	***
Severity of Illness:					
Risk Score, mean (SD)	1.45 (0.7)	1.44 (0.67)	1.44 (0.69)	1.44 (0.69)	
Insurance Types, n (%):					
Medicare/ Medicare HMO	11,380 (49.92)	10,993 (47.76)	135,021 (48.61)	157,394 (48.64)	***
Medicaid/ Medicaid HMO	466 (2.04)	307 (1.33)	3,091 (1.11)	3,864 (1.19)	***
Indemnity/ Commercial	10,180 (44.65)	11,226 (48.77)	132,672 (47.76)	154,078 (47.62)	***
Self pay/Charity/Other	771 (3.38)	493 (2.14)	6,985 (2.51)	8,249 (2.55)	***

***: p<0.01

Unadjusted rates of serious GI adverse events for all and specific polypectomy

procedures were calculated and increased with the rise in complexity of polypectomy procedures

for each endoscopist specialty (Table 2). The rate of increase in adverse events was the lowest

for gastroenterologists in comparison with both primary care providers and surgeons. Unadjusted

rates of serious adverse events were the highest for primary care endoscopists providing complex

colonoscopy.

Table 2. Unadjusted Rates of Serious GI Adverse Events per 1,000 Polypectomies by Procedure Type and Endoscopist Specialty

	Primary Care	Surgery	Gastroenterology
All procedures	4.343 (3.531 - 5.285)	3.910 (3.145 - 4.804)	3.546 (3.328 - 3.774)
Cold biopsy forceps	1.397 (0.603 - 2.750)	2.417 (1.106 - 4.584)	1.319 (1.052 - 1.632)
Hot biopsy forceps/Ablation	3.106 (1.991 - 4.617)	3.216 (2.201 - 4.537)	3.341 (2.955 - 3.764)
Snare polypectomy	5.758 (4.036 - 7.963)	4.927 (3.302 - 7.068)	4.507 (4.075 - 4.973)
Complex Colonoscopy	10.036 (6.829 - 14.215)	5.780 (3.534 - 8.913)	5.173 (4.535 - 5.875)

Multivariate Analyses:

Table 3 reports the likelihood of receiving each type of polypectomy by endoscopist

specialty and endoscopist polypectomy volume, controlling for other covariates. Compared to

gastroenterologists, the odds ratios for using cold biopsy forceps were significantly greater for

primary care endoscopists (1.12 [95%CI, 1.09 to 1.16]) and lower for surgeons (0.61 [95%CI,

0.59 to 0.63]). The odds ratios for using hot biopsy forceps/ablation were greater for primary

care providers (1.20 [95%CI, 1.17 to 1.24]) and surgeons (1.84 [95%CI, 1.79 to 1.90]) relative to

gastroenterologists. The odds for using snare polypectomy and complex colonoscopy procedures

were lower for non-gastroenterologists than for gastroenterologists (Table 3). Low-volume

endoscopists were more likely to use cold biopsy forceps, and hot biopsy forceps/ablation - and

were less likely to use snare polypectomy and complex colonoscopy procedures than high-

volume providers (Table 3). Polypectomy rates increased for endoscopists who used hot biopsy

forceps/ablation and complex colonoscopy procedures; however, the use of cold biopsy and

snare polypectomy was associated with decreased polypectomy rates (Table 3). Cold biopsy

forceps and complex colonoscopy were procedures of choice for repeat endoscopy. Hot biopsy

forceps/ablation polypectomy was less likely used for repeat endoscopy (Table 3).

Table 3. Odds Ratios (95% Confidence Intervals) from Multivariate Logistic Regression
Analyses of Use of Polypectomy Procedures for Endoscopist Specialty and Volume Categories.†

	Cold biopsy forceps (n=73,151)	Hot biopsy forceps/Ablation (n=98,486)	Snare polypectomy (n=99,776)	Complex Colonoscopy (n=52,172)
Primary care	1.123 (1.086 - 1.161) ***	1.201 (1.166 - 1.237) ***	0.844 (0.818 - 0.870)***	0.827 (0.795 - 0.862)***
Surgery	0.608 (0.585 - 0.632)***	1.842 (1.791 - 1.896)***	0.690 (0.668 - 0.712)***	1.023 (0.983 - 1.065)
Gastroenterology	1	1	1	1
Volume < 150	1.100 (1.072 - 1.128)***	1.158 (1.132 - 1.185)***	0.868 (0.848 - 0.888)***	0.836 (0.812 - 0.861)***
Volume 150 - 299	0.990 (0.970 - 1.011)	1.088 (1.068 -1.109)***	0.972 (0.954 - 0.99)***	0.898 (0.877 - 0.919)***
Volume > 300	1	1	1	1
Polypectomy rate	0.286 (0.269 - 0.305)***	1.823 (1.729 - 1.922)***	0.257 (0.244 - 0.272)***	12.975 (12.145 - 13.862)***
Repeat endoscopy	1.175 (1.106 - 1.248)***	0.761 (0.720 - 0.806)***	0.991 (0.940 - 1.046)	1.235 (1.160 - 1.314)***

†All models statistically controlled for differences in facility type, patient demographic characteristics,
severity of illness, comorbidities, health insurance types, and the year of a procedure.

***: $p<0.01$

In a stratified multivariate analysis of cold biopsy forceps (Table 4), neither endoscopist

specialty types nor volume categories were statistically different from referent groups in terms of

the odds of adverse events. For hot forceps biopsy/ablation, the odds ratios of serious adverse

events were not statistically significantly different for endoscopist specialties; however, low-

(1.61 [95%CI, 1.16 to 2.24]) and medium-volume (1.43 [95%CI, 1.07 to 1.90]) endoscopists

reported higher odds of adverse events relative to high-volume providers. Similarly for snare

polypectomy, the endoscopist specialty did not contribute to increased odds of adverse events,

but high-volume providers had lower odds of adverse events. For complex colonoscopy, low-

volume providers (1.45 [95% CI, 1.05 to 2.01]) reported higher odds of adverse events relative to

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high-volume endoscopists Finally, higher odds of adverse events were reported for primary care

endoscopists (1.74 [95%CI, 1.18 to 2.56]) relative to gastroenterologists for complex

colonoscopy. There were no differences in odd ratios reported for surgeons in comparison with

gastroenterologists after complex colonoscopy. Neither polypectomy rate nor repeat endoscopy

was associated with increased odds of serious adverse events.

Table 4. Odds Ratios (95% Confidence Intervals) from Multivariate Logistic Regression Analyses of Serious GI Adverse Events for Endoscopist Specialty and Volume Categories, Stratified by Polypectomy Procedure.†

Characteristics	Cold biopsy forceps (n=73,151)	Hot biopsy forceps/Ablation (n=98,486)	Snare polypectomy (n=99,776)	Complex Colonoscopy (n=52,172)
Primary care	0.965 (0.457, 2.036)	0.847 (0.552, 1.299)	1.174 (0.829, 1.661)	1.740 (1.183, 2.559) ***
Surgeon	1.526 (0.740, 3.146)	0.884 (0.605, 1.292)	1.041 (0.704, 1.540)	0.970 (0.607, 1.551)
Gastroenterology	1	1	1	1
Volume < 150	1.363 (0.774, 2.398)	1.607 (1.155, 2.237)***	1.366 (1.025, 1.821)**	1.450 (1.046, 2.009)**
Volume 150 - 299	1.143 (0.699, 1.870)	1.429 (1.073, 1.903)**	1.397 (1.112, 1.756)***	0.852 (0.633, 1.146)
Volume > 300	1	1	1	1
Polypectomy rate	0.480 (0.111 - 2.087)	1.512 (0.728 - 3.139)	1.442 (0.707 - 2.942)	1.200 (0.564 - 2.556)
Repeat Endoscopy	0.507 (0.070 - 3.651)	0.494 (0.158 - 1.544)	0.463 (0.192 - 1.121)	0.250 (0.062 - 1.006)

†All models statistically controlled for differences in facility type, patient demographic characteristics, severity of illness, comorbidities, health insurance types, and the year of a procedure.

***: $p<0.01$,**: $p<0.05$

Discussion

About half of all colonoscopy procedures are polypectomies [15]. Polypectomy is

important for CRC prevention, but is associated with adverse events. While adverse events after

polypectomy are rare, they are serious and life threatening [16]. The colonic perforation is the

most serious adverse event with reported rates of 0.1% - 0.3% and a fatality rate of 5% [16].

Gastrointestinal (GI) bleeding is the most common serious adverse event with reported risks of

0.1% - 0.6% [16]. Polypectomy was associated with up to a nine-fold increase[12-14] in risks of

serious adverse events when compared to a relatively safe diagnostic colonoscopy [16-17].

Reported risks of adverse events increased, as the complexity of polypectomy procedures has heightened [12]. Similarly to previous findings, this study's reported rate of the colonic perforations and GI bleeding is 0.4%. The current study also suggests that the complexity of polypectomy procedures may contribute to increased risks of adverse events for endoscopists in different specialty groups.

The current study is the first to investigate the use of specific polypectomy techniques for primary care, surgery, and gastroenterology endoscopists, endoscopist volume categories, and to identify associated odds ratios for serious GI adverse events. We also observed important trends in the use of polypectomy techniques by endoscopist specialty and experience. Primary care endoscopists and surgeons were more likely to use hot biopsy forceps/ablation for polyp or lesion removal in comparison with gastroenterologists. In addition, gastroenterologists provided more snare polypectomy and complex colonoscopy procedures than non-gastroenterologists. The high-volume endoscopists were more likely to provide complex colonoscopies. Polypectomy rates were higher for endoscopists who used hot biopsy forceps/ablation and complex colonoscopy procedures. Cold biopsy forceps and complex colonoscopy were procedures of choice for repeat endoscopy. It is expected that complex colonoscopy is used for detection and removal of adenomas that vary in location, types, multiplicity, and size during the initial and repeat endoscopy. Cold biopsy forceps are likely to be used in repeat endoscopy to assure a complete adenoma removal. However, a use of hot biopsy forceps for initial endoscopy require additional research as the experts recommended cold snare polypectomy instead of hot biopsy forceps.

Our study found that endoscopists in all specialty and volume categories could safely use cold biopsy forceps. These findings corroborate the literature suggesting that cold polypectomy

techniques are the safest in terms of risks of serious GI adverse events [12,24]. More research is

warranted on cold polypectomy techniques and post-colonoscopy CRC, as some studies reported

that residual polyp tissues were discovered after cold forceps [25-26]. Our study also identified

that endoscopist volume, but not specialty, may be associated with reduced risks of serious GI

adverse events after hot biopsy forceps/ablation and snare polypectomy. On the other hand,

endoscopist specialty, but not volume, may contribute to reduction of the risks of serious adverse

events after complex colonoscopy, as higher odds of adverse events were reported for primary

care providers relative to the odds of adverse events reported for gastroenterologists and

surgeons. Patient outcomes were comparable for surgeons and gastroenterologists.

For primary and single procedures requiring either polypectomy via hot biopsy

forceps/ablation or snare polypectomy, an annual volume of 300 or more polypectomies was

important for reduction of serious adverse events. The European guidelines on colonoscopy

volume recommend a 300-volume threshold [27]. Our findings suggest that hot biopsy/ablation

or snare polypectomy techniques may be improved as endoscopists provide higher volumes of

these types of procedures. In terms of snare polypectomy, these findings may correspond well

with recommended by the American College of Gastroenterology practices of cold snare

techniques over electrocautery polypectomy [28]. However, additional research on the value of

polypectomy via hot biopsy forceps/ablation is needed specifically for non-gastroenterologists

who tend to use more of this type of polypectomy in comparison with gastroenterologists.

An endoscopist specialization in gastroenterology or surgery and annual polypectomy

volume greater than 150 procedures are important for reducing the rates of serious GI adverse

events after complex colonoscopy. Complex colonoscopy is effective for detecting polyps and is

often used for repeat endoscopy. Complex colonoscopy may involve a combination of several

polypectomy techniques performed during the same session when multiple polyps or lesions of various sizes and types are likely to be removed. Previous research suggested that primary care physicians were less likely to use complex gastrointestinal procedures [5], and confirmed by our findings. Differences in duration and intensity of training in endoscopy for primary care endoscopists may explain this finding. As such, primary care endoscopists may require cross-training and/or continuing medical education in complex colonoscopy techniques to prepare for the growing demand of polypectomy due to the aging population in the U.S.

The study has limitations. We used historic data for the period 1999-2001. However, the studied polypectomy techniques are still widely used by endoscopists, and a slow adoption of new techniques, e.g. micro-clips, has been reported [14]. As such, our findings provide relevant baseline data for the future research on the impact of endoscopist specialty and polypectomy techniques on various patient outcomes. Although the study is population-based, it is restricted to a single state. New research utilizing newer datasets from additional states is warranted. A lack of access to patients' medical records to fully adjust for the quality of bowel preparation or prior use of medications (e.g., anticoagulants or antibiotics), especially by elderly patients, was a limitation. In addition, data were not available to include adverse events associated with 30-day ER visits and colonoscopies provided in physician offices. The study's data did not distinguish between GI bleeding potentially unrelated to polypectomy (e.g., bleeding from hemorrhoids, diverticula, or due to radiation proctitis, or other entities. However, the serious GI adverse events requiring inpatient admission were procedure specific and may have occurred due to medical errors. The data did not capture the few patients with colonoscopy-related adverse events who were hospitalized outside the state of Florida and those who were treated in physician offices. It is unlikely that many polypectomy procedures would be carried out in

physician offices. The data did not include information on endoscopists' age, years of practice, affiliation with academic centers, and other experiences that may potentially affect the rate of adverse events. There was also no information on lesion type, polyp size and multiplicity in the dataset. As such, there may be potential confounding between polyp or lesion type/size, multiple polyps, and choice of polyp removal technique. However, we used a validated risk adjustment approach that accounted for both severity of current illness (e.g., a polyposis) and comorbidities. More research utilizing newer datasets from additional states and clinical information is needed to better understand which type of polypectomy, endoscopist specialty and experience, are preferred for increasing adenoma detection rates, and reducing rates of adverse events and post-colonoscopy CRC. In addition, because change in endoscopy practices might require a considerable amount of time, additional research on barriers for adoption of new practices, such as awareness of and compliance with the colonoscopy guidelines across endoscopist specialties, is important to consider.

Nevertheless, this research has several implications for clinical practice and policy. We analyze all-encounter, all payer data covering the entire population of Florida for a three-year period. This provides an important advancement over previous studies that examined a limited number of facilities or health systems, used restricted datasets such as Medicare or Medicaid-only data, or were non-US-based. Our database is unique as it reports UPINs for each endoscopists allowing us to construct a measure of endoscopist specialty, and to report a use of polypectomy procedures and rates of adverse events by endoscopist characteristics.

We believe our study is the first to report important variations in the use of polypectomy techniques. We found that non-gastroenterologists and low-volume endoscopists tend to perform simpler procedures than gastroenterologists. The risk of serious adverse events is small

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for cold biopsy forceps procedures and independent of endoscopist specialty and experience. Thus, cold biopsy forceps is a safe procedure that may be widely used in clinical practice of primary care endoscopists, surgeons, and gastroenterologists. A technical proficiency in hot biopsy/ablation and snare polypectomy is achievable with experience (i.e., increased volume) for endoscopist in all specialty categories. Providing more than 300 polypectomy procedures annually may be an important benchmark for improving endoscopists experience and achieving proficiency in polypectomy. Surgeons, gastroenterologists, and higher-volume providers had lower rates of adverse events than primary care and low-volume endoscopists (i.e., providing less than 150 procedures annually) for complex colonoscopy. As such, some cross-training and continuing medical education in complex polypectomy techniques for primary care endoscopists in high-volume settings may be considered.

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