

## ORIGINAL ARTICLE

## Quality indicators for pediatric colonoscopy: results from a multicenter consortium

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**Background and Aims:** Currently, there are no quality measures specific to children undergoing GI endoscopy. We aimed to determine the baseline quality of pediatric colonoscopy by using the Pediatric Endoscopy Database System—Clinical Outcomes Research Initiative (PEDS-CORI), a central registry.

**Methods:** We conducted prospective data collection by using a standard computerized report generator and central registry (PEDS-CORI) to examine key quality indicators from 14 pediatric centers between January 2000 and December 2011. Specific quality indicators, including bowel preparation, ileal intubation rate, documentation of American Society of Anesthesiologists Physical Status Classification System (ASA) class, and procedure time, were compared during the study period.

**Results:** We analyzed 21,807 colonoscopy procedures performed in patients with a mean age of  $11.5 \pm 4.8$  years. Of the 21,807 reports received during the study period, 56% did not include bowel preparation quality, and 12.7% did not include ASA classification. When bowel preparation was reported, the quality was described as excellent, good, or fair in 90.3%. The overall ileal intubation rate was 69.4%, and 15.6% reported cecal intubation only, calculated to be 85% cecum or ileum intubation. Thus, 15% of colonoscopy procedures did not report reaching the cecum or ileum. When excluding the proportion of procedures not intended to reach the ileum (31.5%), the overall ileal intubation rate increased to 84.0%. The rate of ileum examination varied from 85% to 95%, depending on procedure indication.

**Conclusions:** Colonoscopy reports from our central registry revealed significant variations and inconsistent documentation in pediatric colonoscopy. Our study identifies areas for quality improvement and highlights the need for developing accepted quality measures specific to pediatric endoscopy. (Gastrointest Endosc 2015; ■:1-9.)

Colonoscopy is an important tool for the diagnosis and management of digestive disease in children. In adults, adenoma detection remains a primary goal, and surveillance colonoscopy is routinely recommended. Cecal intubation rate and adenoma detection rate are standard quality mea-

asures in the performance of colonoscopy in adult patients. However, routine screening for adenomas generally is not recommended for persons aged <21 years. Thus, with fewer indications for cancer screening, children usually undergo colonoscopy for diagnostic purposes related to

*Abbreviations:* ASA, American Society of Anesthesiologists Physical Status Classification System; PEDS-CORI, Pediatric Endoscopy Database System—Clinical Outcomes Research Initiative.

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specific symptoms. Lower GI bleeding, abdominal pain, and diarrhea account for the majority of indications for pediatric colonoscopy.<sup>1</sup> Therefore, the immediate goals of the procedure are to provide a correct diagnosis with minimal risk to the patient. For example, ileal intubation and examination is one of the primary objectives when pediatric colonoscopy is performed to optimize diagnostic yield. Additional long-term outcomes may include improved quality of life, reduced disease activity, and enhanced patient and/or parent satisfaction. Achieving these outcomes depends on the quality of the examination. However, there are no measures of quality specific to children undergoing GI endoscopy.

Structured, computerized endoscopic reporting systems provide an ideal tool for identifying and monitoring quality indicators.<sup>2</sup> In 1995, the Clinical Outcomes Research Initiative (CORI) developed a computerized endoscopic reporting system to study outcomes of endoscopy in the United States, and it includes a pediatric arm known as Pediatric Endoscopy Database System—Clinical Outcomes Research Initiative (PEDS-CORI). During the study period, there were 14 active PEDS-CORI sites including 104 pediatric gastroenterologists in North America.

Available evidence suggests that the quality of pediatric colonoscopy in clinical practice varies.<sup>3</sup> Although quality indicators for colonoscopy in children have not been well-studied, adequate bowel preparation and complete examination (ie, ileal intubation) are factors in achieving optimal diagnostic yield. Additionally, preprocedure risk assessment is important before any invasive procedure. Therefore, we examined candidate quality metrics including quality of bowel preparation, ileal intubation rate, and documentation of American Society of Anesthesiologists Physical Status Classification System (ASA) class over a 12-year period by using the standardized reporting system PEDS-CORI.

## METHODS

We reviewed the recommendations by the American Society for Gastrointestinal Endoscopy and the American College of Gastroenterology joint taskforce on Quality in Endoscopy in adult patients and excluded those recommendations pertaining primarily to anticoagulant use and colon neoplasia screening and/or surveillance to develop a list of candidate quality measures applicable to children<sup>4</sup> (Table 1). The candidate quality measures with a specific data location in PEDS-CORI were subsequently included in the data collection (Table 2).

### Study design

This is a registry-based prospective study that uses colonoscopy information from January 1, 2000 through December 31, 2011 in PEDS-CORI on patients aged 0 to 21 years. We queried the database to identify the specific

**TABLE 1. Candidate quality indicators for pediatric endoscopy**

Preprocedure
Indication
Risk assessment
Indication
Intraprocedure
Photographic documentation
Reversal/sedation medications
Procedure duration
Biopsy documentation
Estimated blood loss
Completeness/extent of examination
Bowel preparation quality
Cecal intubation
Ileal intubation
Postprocedure
Adverse event
Unplanned intervention

**TABLE 2. Quality indicators for pediatric colonoscopy measured in PEDS-CORI**

Indicators
Preprocedure
Indication for colonoscopy
ASA risk assessment
Field completed (yes/no)
Rates of each classification
Intraprocedure
Procedure duration
Time recorded (yes/no)
Total procedure time
Completeness/extent of examination
Cecal intubation rate
Ileal intubation rate
Bowel preparation quality
Field completed (yes/no)
Preparation quality adequate (yes/no)
Postprocedure
Unplanned event/intervention
Rate of reported occurrence

ASA, American Society of Anesthesiologists Physical Status Classification System; PEDS-CORI, Pediatric Endoscopy Database System—Clinical Outcomes Research Initiative.

candidate quality indicators (Table 1) in practices with >100 colonoscopy procedures during the study period. Bowel preparations were not uniform among all centers and were judged by the endoscopist as poor, fair, good, or excellent. Duration generally was measured as actual

endoscopy time not including time for sedation or anesthesia. For each colonoscopy included in the study, we also collected demographic characteristics (sex, age, race and/or ethnicity), indication for the colonoscopy, presence of a trainee at the procedure, and type of sedation. Unplanned interventions for adverse events included only those interventions that were reported at the time of colonoscopy. We also collected specific endoscopist characteristics (eg, sex, colonoscopy volume, year graduated from medical school) for endoscopists with at least 10 colonoscopies documented in PEDS-CORI during the study period.

All participating PEDS-CORI sites have waiver of consent approval via the institutional review board at each site. The 14 sites were as follows: Texas Children's Hospital (Houston, Texas), Children's Healthcare of Atlanta (Scottish Rite), Children's Healthcare of Atlanta (Egleston), Children's Hospital of Buffalo, Phoenix Children's Hospital (Phoenix, Arizona), Children's Hospital of The King's Daughters (Norfolk, Virginia), Maine Medical Center (Portland, Maine), Children's Hospital of Wisconsin (Milwaukee, Wisconsin), Scott & White Memorial Hospital (Temple, Texas), Children's Hospital of Columbus (Columbus, Ohio), University of Kentucky Children's Hospital (Lexington, Kentucky), Wolfson-Nemours Children's Hospital (Jacksonville, Florida), Westchester County Medical Center (Valhalla, New York), and Doernbecher Children's Hospital (Portland, Oregon).

### Statistical analysis

Descriptive statistics (percentage, mean, median) were generated for candidate quality metrics at each site and overall. Pearson chi-square tests were used to compare the distribution of categorical variables describing patient demographics and procedure details (presence of fellow, type of sedation) among procedures with and without any quality metrics reported. For each quality metric, the Pearson chi-square test was used to compare immediate adverse event rates across levels of categorical variables (eg, sex, sedation type). Analysis of variance was used to compare continuous variables of interest. For each quality indicator, a summary measure was obtained for every participating physician. The majority of summary quality measures were proportions, such as the proportion of ASA risk (Table 2) that has not been documented and the proportion of colonoscopies with inadequate bowel preparation. All analyses were performed by using SAS software version 9.4 (SAS Institute, Inc, Cary, NC).

## RESULTS

We analyzed 21,807 colonoscopy procedures performed at 14 PEDS-CORI sites during the study period. Overall, the most common indications for colonoscopy were abdominal pain symptoms (40.1%), hematochezia (32.1%),

diarrhea (27.0%), inflammatory bowel disease (21.0%), and weight loss (11.6%). Abdominal pain was the sole indication for 3013 (13.8%) colonoscopies. A total of 1790 (8.2%) colonoscopies that listed abdominal pain as the primary indication also reported secondary indications including diarrhea ( $n = 667$ , 13.9%), weight loss ( $n = 394$ , 8.2%), constipation ( $n = 270$ , 5.6%), and hematochezia ( $n = 195$ , 4.1%). The mean age for these patients was 11.5 years (standard deviation [SD] 4.8 years). Race was described as white non-Hispanic in 76.8%, black non-Hispanic in 11.1%, Hispanic in 8.7%, and Asian/Pacific Islander non-Hispanic in 1.6%. Approximately half of the procedures (50.2%) were conducted in female patients. Among the procedures included, 10,808 (49.6%) were performed with the patients under general anesthesia.

### ASA risk assessment

Of the 21,807 reports received during the study period, 12.7% did not include ASA classification. ASA class was reported as class I in 10,372 (54.5% in those reporting ASA, 47.6% overall), class II in 7813 (41.0% in those reporting ASA, 35.8% overall), class III in 806 (4.2% in those reporting ASA, 3.7% overall), and class IV in 43 (0.2% in those reporting ASA, 0.2% overall). Documentation of ASA class was not associated with sex (Table 3). However, procedures with undocumented ASA class had a higher proportion of fellows present than procedures in which ASA was documented (30.6% vs 16.8;  $P < .001$ ). Procedure reports generated for colonoscopies done with the patient under general anesthesia had a higher rate of ASA documentation than did those with other sedation types (89.3% vs 85.3%;  $P < .001$ ). When we examined indications for procedures in which ASA was documented, a higher proportion had hematochezia, Crohn's disease, and ulcerative colitis, whereas the prevalence of anemia was lower. With a range of 8% to 99%, there was significant variation in reporting of ASA classification among the 14 sites.

### Procedure duration

Colonoscopy time was documented in 69.2% ( $n = 15,086$ ) of cases. One site did not report colonoscopy time in any procedures. The overall mean colonoscopy duration was 31.7 minutes (SD = 14.4). When we excluded procedures that did not reach at least the cecum, overall mean colonoscopy duration was 32.6 (SD = 14.2) minutes, with a range of 5 to 120 minutes among the 13 reporting sites. In 10,076 colonoscopies that reached the ileum and documented duration, overall mean colonoscopy duration was 32.0 minutes (SD = 13.9 minutes).

Duration was associated with age because colonoscopies performed in patients aged <5 years reported a mean of 30.2 minutes, shorter than colonoscopies in patients aged 6 to 10 years (31.5 minutes;  $P = .001$ ), patients aged 11 to 15 years (32.2 minutes;  $P < .001$ ), and patients aged >16 years (31.9 minutes;  $P < .001$ ). Colonoscopies performed with the patient under general

**TABLE 3. Comparison of colonoscopy procedures with and without an ASA class documented in pediatric patients undergoing colonoscopy between January 1, 2000 and December 31, 2011 in 14 sites of the PEDS-CORI registry**

Variable	Documented (%)	Not documented (%)	P value
Total	19,034	2773	
Age group, y			
0-5	2814 (14.8)	407 (14.7)	.01
6-10	4146 (21.8)	667 (24.1)	
11-15	7512 (39.5)	1097 (39.6)	
16-21	4562 (24.0)	602 (21.7)	
Sex			
Female	9507 (49.9)	1429 (51.5)	.12
Male	9527 (50.1)	1344 (48.5)	
Fellow			
Present	3199 (16.8)	849 (30.6)	< .001
Absent	15,835 (83.2)	1924 (69.4)	
Sedation type			
General anesthesia	9648 (50.7)	1160 (41.8)	< .001
Other sedation	9386 (49.3)	1613 (58.2)	

PEDS-CORI, Pediatric Endoscopy Database System—Clinical Outcomes Research Initiative; ASA, American Society of Anesthesiologists Physical Status Classification System.

anesthesia reported a longer duration as compared with colonoscopies performed with conscious sedation (32.1 minutes vs 31.3 minutes;  $P < .01$ ). Colonoscopies performed with excellent and/or good bowel preparation were associated with shorter colonoscopy time (30.7 minutes) as compared with fair bowel preparation (34.7 minutes;  $P < .01$ ) or poor bowel preparation (33.4 minutes;  $P < .01$ ). Colonoscopy duration was not associated with sex ( $P = .85$ ). The presence of a fellow was associated with longer procedures (37.3 vs 30.2 minutes;  $P < .001$ ). Colonoscopies with polypectomy were associated with longer procedure duration (40.0 vs 31.2 minutes;  $P < .001$ ). Colonoscopies that did not include biopsies were associated with shorter colonoscopy time as compared with colonoscopies with at least one biopsy specimen taken (29.7 vs 31.2 minutes;  $P < .001$ ). There was significant variation in the mean duration of colonoscopy completion among the 13 sites, with a range of 21.5 minutes to 39.3 minutes (Fig. 1). Documentation rates also varied from 21.7% to 99.5% among the 13 sites reporting duration.

### Ileal intubation

The overall ileal intubation rate was 69.4%, and cecal intubation alone was achieved in an additional 15.6%, combining for 85% either cecum or ileum intubation. Thus, 15% of colonoscopy procedures did not include the cecum or ileum. When we excluded the proportion

of procedures not intended to reach the ileum (11.8%), the overall ileal intubation rate increased to 84.0%. Therefore, overall 30.6% of colonoscopies did not include inspection of the terminal ileum, and 16% did not reach the ileum when intended. Procedures in which the ileum was not examined were more commonly performed in younger patients and in those with higher ASA classes. Patients aged <5 years had a significantly lower ileal intubation rate compared with patients aged 6 years or older (48.7% vs 73.0%;  $P < .01$ ). Patients with ASA class IV had an ileal intubation rate of just 37.2%, which was significantly lower than ASA class III (55.3%;  $P = .03$ ) or ASA class II (71.8%;  $P < .0001$ ). Procedures done with patients under general anesthesia were associated with an ileal intubation rate of 76%, whereas other sedation types (intravenous sedation) had a significantly lower intubation rate of 63% ( $P < .001$ ). Procedures done in male patients achieved an intubation rate of 68%, significantly lower than the 71% rate seen in female patients ( $P < .001$ ). The presence of a fellow was not associated with ileal intubation ( $P = .072$ ). Reports from colonoscopies done with poor bowel preparation reported a lower rate of ileal intubation than bowel preparations described as excellent, good, or fair (72% vs 43%;  $P < .001$ ). In the most common indications, the rate of ileal examination varied from 63.9% to 75.3% (77.0% and 85.8% when limited to those intended to reach the ileum), depending on procedure indication (Table 4). Overall ileal intubation rates ranged from 25% to 84.5% among the 14 sites (Fig. 2).

We performed a comparison of colonoscopy procedures with and without ileal or cecal intubation to analyze factors accounting for a combined 85% ileal and cecal intubation rate. The additional analysis revealed that the presence of a fellow was associated with lower combined ileal and/or cecal intubation (81.1% vs 85.8%;  $P < .01$ ). Age, sex, ASA class, and sedation type analysis remained unchanged from the ileal intubation associations described earlier.

### Bowel preparation quality

Bowel preparation quality was documented in 43.7% ( $n = 9527$ ) of cases. When bowel preparation was reported, the quality was described as excellent, good, or fair in 90.3%. Documentation of bowel preparation quality was associated with age and ASA class. Procedures performed in patients aged >16 years had higher documentation rates than procedures performed in children aged <5 years (45.8% vs 40.5%;  $P < .0001$ ). Procedures with preparation documented had a lower proportion of fellows involved than procedures with no preparation documented (13.1% vs 22.6%;  $P < .01$ ). Patient sex and unplanned events were not associated with bowel preparation documentation.

Adequate bowel preparation (described as excellent, good, or fair) was reported in 90.3% ( $n = 8600$ ) of cases. Bowel preparation was described as excellent or good in

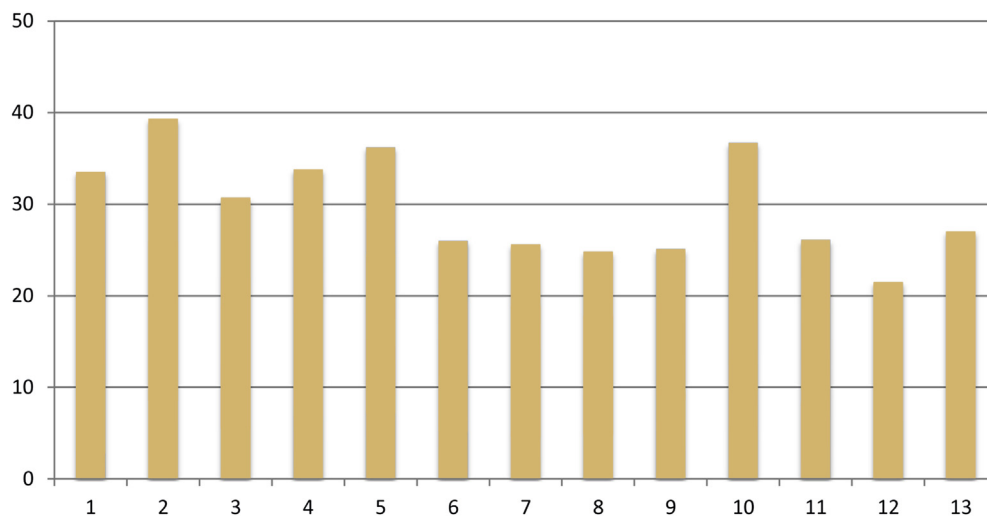


Figure 1. Colonoscopy time by center in minutes.

**TABLE 4. Comparison of colonoscopy procedures with (yes) and without (no) ileal intubation in pediatric patients undergoing colonoscopy between January 1, 2000 and December 31, 2011 in 14 sites of the PEDS-CORI registry**

Variable	No (%)	Yes (%)	P value
Total	6677	15,130	
Age group, y			
0-5	1651 (24.7)	1570 (10.4)	< .001
6-10	1367 (20.5)	3446 (22.8)	
11-15	2298 (34.4)	6311 (41.7)	
16-21	1361 (20.4)	3803 (25.1)	
Sex			
Female	3206 (48.0)	7730 (51.1)	< .001
Male	3471 (52.0)	7400 (48.9)	
ASA classification			
I	3102 (46.5)	7270 (48.1)	< .001
II	2207 (33.1)	5606 (37.1)	
III	360 (5.4)	446 (3.0)	
IV	27 (0.4)	16 (0.1)	
Unknown	981 (14.7)	1792 (11.8)	
Fellow			
Present	1287 (19.3)	2761 (18.3)	.07
Absent	5390 (80.7)	12,369 (81.7)	
Sedation type			
General anesthesia	2626 (39.3)	8182 (54.1)	<.001
Other sedation	4051 (60.7)	6948 (45.9)	

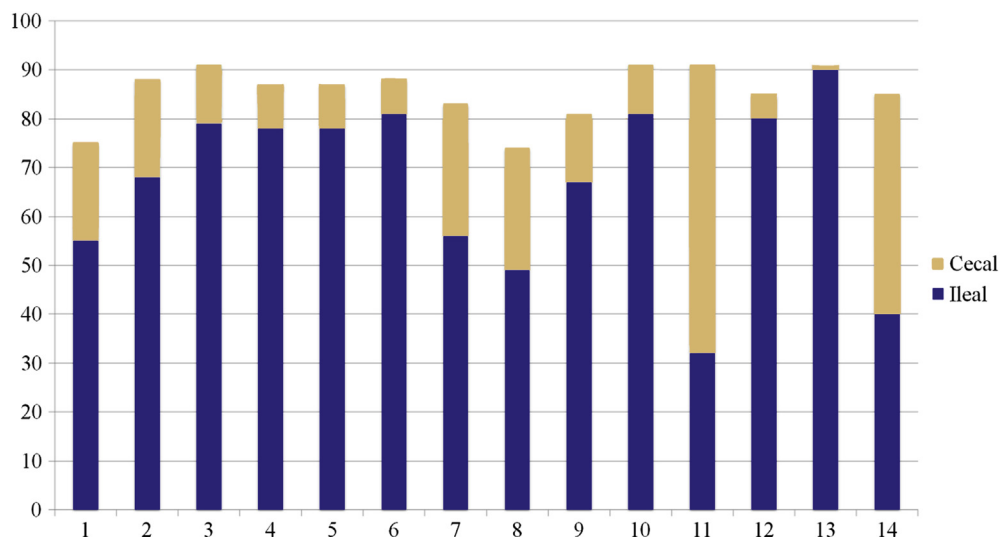
PEDS-CORI, Pediatric Endoscopy Database System—Clinical Outcomes Research Initiative; ASA, American Society of Anesthesiologists Physical Status Classification System.

7049 colonoscopies (74.0%), fair in 1551 colonoscopies (16.3%), and poor in 927 colonoscopies (9.7%). Poor bowel preparation quality was associated with younger

patient age and higher ASA class (Table 5). Procedures performed in patients aged <5 years had a higher rate of poor bowel preparation than procedures performed in children aged >5 years (14.1% vs 9.0%;  $P < .001$ ). Among procedures in which ASA class and preparation were documented, ASA class III or IV had significantly higher rates of poor bowel preparation than procedures performed with ASA class I or II (17.0% vs 9.2%;  $P < .001$ ). Procedures done with the patient under general anesthesia were associated with poor preparation in 8.7% of cases, whereas other sedation types (intravenous sedation) had a significantly higher rate of 10.8% ( $P < .001$ ). Adequate bowel preparation was associated with colonoscopies performed for abdominal pain ( $P = .001$ ) and diarrhea ( $P < .001$ ). Female sex was associated with a higher rate of excellent and/or good bowel preparation as compared with male sex (83.0% vs 80.8%;  $P < .01$ ). The presence of a fellow trainee and unplanned events were not associated with bowel preparation quality. Among the 14 sites, adequate bowel preparation was reported with a range of 69.6% to 96.8%. Documentation rates also varied from 5.2% to 76.7% among the 14 sites.

### Adverse events and/or interventions

There were 138 procedures (0.63%, 95% confidence interval, 0.53-0.74), with at least one adverse event recorded. Among procedures with adverse events, 54% reported GI adverse events, 41% reported cardiopulmonary adverse events, and 6.5% reported miscellaneous adverse events. The most common adverse event was GI bleeding (reported among 58, 42.0% of those with an adverse event), followed by transient hypoxia (reported among 13, 9.4% of those with an adverse event). No perforations or deaths were recorded. Twenty-two procedures (15.9%) with an adverse event reported more than one event type.



**Figure 2.** Percentage of cecal and ileal intubation rates by center.

Unplanned interventions were reported in 65 procedures (47.1%) with adverse events reported ( $n = 138$ ). The most common intervention was administration of oxygen during the procedure (reported among 58.0% of those with an intervention). Cardiopulmonary resuscitation was not reported for any patient. Among the 14 sites, adverse events were reported with a range of 0.3% to 1.3%. Intervention rates also varied from 0.0% to 0.7% among the 14 sites.

### Endoscopist characteristics

Analysis of specific endoscopist characteristics (eg, sex, colonoscopy volume, year graduated from medical school) included 120 endoscopists with at least 10 colonoscopies during the study period. Endoscopists who graduated after the year 2000 had a higher ileal intubation rate (86%) than endoscopists who graduated before 1990 (Table 6). Additionally, endoscopists who graduated between 1990 and 1999 had a higher ileal intubation rate (78%) than endoscopists who graduated before 1980 (51%). Mean duration of colonoscopy was shorter in endoscopists with at least 200 colonoscopies than those with less than 50 (30.2 minutes vs 40.5 minutes;  $P < .01$ ). There were no other significant associations between specific endoscopist characteristics and unplanned events, preparation documentation, or adequate preparation.

### DISCUSSION

Our results reveal that even with a structured report generator, the documentation of quality indicators was inconsistent, and practice patterns were highly variable. Several of the quality indicators are important in determining the comprehensiveness of the examination,

including documentation of bowel preparation quality (absent in 56%) and inspection of the terminal ileum (absent in 30%). Other indicators are involved in the assessment of procedure risk, including documentation of ASA class (absent in 12.7%) and procedure duration (absent in 30.8%). Without this information in the report, a reviewer could not confirm whether the examination was complete and adequate. However, the fact that endoscopists did not consistently capture quality measures in the report writer is not necessarily surprising, given that there are no widely accepted quality measures specific to pediatric endoscopy. Also, we observed considerable variation in the practice of endoscopy among the 14 sites in our registry. Our study revealed gaps in quality and areas of suboptimal performance. For example, 16% of colonoscopies did not include examination of the terminal ileum when intended.

Procedure indication is required for completion of the report in PEDS-CORI, thus, indication was available for all included colonoscopies. The most common indications for colonoscopy were abdominal pain, lower GI bleeding, and diarrhea in our cohort of 21,807 colonoscopies. Previous studies have confirmed that colonoscopy often is used in the evaluation of abdominal pain.<sup>1</sup> However, clinical guidelines do not list abdominal pain as a standard indication for colonoscopy in children.<sup>5</sup> Among the 4803 colonoscopies performed for abdominal pain, just 1790 (37.3%) listed other secondary indications. Clinical outcomes such as diagnostic yield and management impact have not been studied in children undergoing colonoscopy primarily for abdominal pain symptoms. There is a strong need for studies examining clinical outcomes after diagnostic colonoscopy in children to uncover the value of specific indications.

The ASA classification was not documented in 12.7% (2769) of reports. Although this indicator does not directly

**TABLE 5. Comparison of colonoscopy procedures with and without adequate bowel preparation in pediatric patients undergoing colonoscopy between January 1, 2000 and December 31, 2011 in 14 sites of the PEDS-CORI registry**

Bowel preparation result	Excellent/good, no. (%)	Fair, no. (%)	Poor, no. (%)	P value
Total	7049	1551	927	
Age group, y				
0-5	867 (12.3)	255 (16.4)	184 (19.9)	< .0001
6-10	1545 (21.9)	321 (20.7)	186 (20.1)	
11-15	2800 (39.7)	645 (41.6)	358 (38.6)	
16-21	1837 (26.1)	330 (21.3)	199 (21.5)	
Sex				
Female	3579 (50.8)	726 (46.8)	450 (48.5)	.01
Male	3470 (49.2)	825 (53.2)	477 (51.5)	
ASA classification				
I	3349 (47.5)	776 (50.0)	452 (48.8)	< .0001
II	3297 (46.8)	622 (40.1)	359 (38.7)	
III	254 (3.6)	71 (4.6)	65 (7.0)	
IV	8 (0.1)	4 (0.3)	4 (0.4)	
Unknown	141 (2.0)	78 (5.0)	47 (5.1)	
Fellow				
Present	934 (13.3)	213 (13.7)	121 (13.1)	.85
Absent	6115 (86.8)	1338 (86.3)	806 (87.0)	
Sedation type				
General anesthesia	3836 (54.4)	775 (50.0)	442 (47.7)	< .0001
Other sedation	3213 (45.6)	776 (50.0)	485 (52.3)	

PEDS-CORI, Pediatric Endoscopy Database System—Clinical Outcomes Research Initiative; ASA, American Society of Anesthesiologists Physical Status Classification System.

reflect examination quality, adult studies have shown ASA class is an important surrogate of comorbidity and associated with adverse events.<sup>6,7</sup> Additionally, ASA class is associated with adverse events during upper endoscopy in children.<sup>8</sup> Therefore, ASA class is valuable for preprocedure risk assessment and should be assessed and recorded.

Completeness of colonoscopy in children has been reported in several small series, with cecal intubation rates varying from 84% to 92%.<sup>9-11</sup> An 83% ileal intubation rate was reported in one pediatric study including 60 colonoscopies.<sup>11</sup> The absence of the terminal ileum inspection during colonoscopy could result in unnecessary repeat examinations. The majority of children (61.2%) undergo colonoscopy for the evaluation of lower GI bleeding, abdominal pain, or diarrhea.<sup>1</sup> Examination and biopsy of the terminal ileum during colonoscopy is crucial because of the possibility of inflammatory bowel disease with these

symptoms. In children, isolated ileal inflammation may occur in the presence of a normal colon in approximately 9% of patients with Crohn's disease.<sup>12</sup> Clinical guidelines reinforce that intubation of the terminal ileum with terminal ileum biopsies should be attempted in every child suspected of inflammatory bowel disease.<sup>13</sup> Adult studies also suggest that ileoscopy with biopsy is useful in patients presenting with symptoms of inflammatory bowel disease to recognize isolated ileal disease and evaluate patients with pancolitis.<sup>14</sup> However, the diagnostic yield of colonoscopy for various indications in children has not been well-studied. Ileal intubation may not be required in certain instances (eg, painless rectal bleeding with juvenile polyp in rectum). Additionally, to date, no specific data demonstrate a variation in detection or staging of inflammatory bowel disease based on the extent of the colonoscopy. However, the available evidence and clinical experience imply that omission of ileal examination during pediatric colonoscopy may lead to unnecessary repeat examinations, suboptimal diagnostic yield, and medical mismanagement because of missed findings. Our data show that adequate bowel preparation translates into increases in ileal intubation rates. We suggest that the goal for ileal intubation rates be set at 90% for all colonoscopies in children. Endoscopist characteristic analysis showed that more recently trained endoscopists (who graduated after the year 2000) are approaching this target.

The utility of procedure duration as a quality indicator in pediatric colonoscopy is unclear. Although adult studies show a relationship between withdrawal time and adenoma detection,<sup>15</sup> colonoscopy in children is generally not performed for adenoma detection. Adult data indicate that duration of colonoscopy is not associated with perforation.<sup>16</sup> However, the relationship between more common adverse events (eg, respiratory distress, bleeding) and colonoscopy duration has not been well-studied. Prolonged procedures may be associated with adverse events such as respiratory distress in children. Recent data in children suggest that anesthesia exposure may trigger an injury in the developing brain, resulting in long-term neurobehavioral consequences.<sup>17</sup> Furthermore, these neurobehavioral risks may increase with longer duration of anesthesia exposure.<sup>18</sup> Prolonged procedures would be suboptimal from a patient satisfaction standpoint, thus may be empirically considered a patient-centered quality metric. In colonoscopies reaching at least the cecum, the mean colonoscopy duration was 32.6 minutes. With an SD of 14.2 minutes, we propose that prolonged colonoscopies be defined as longer than 45 minutes for diagnostic colonoscopies. By this tentative definition, our current cohort included 1578 prolonged procedures (7.2%). In adult colonoscopies reaching the cecum, mean colonoscopy duration has been reported to be about 15.8 minutes.<sup>19</sup> Our analysis of endoscopist characteristics showed that endoscopists with higher colonoscopy volume tend to perform the procedure more rapidly. Thus,

**TABLE 6. Endoscopist characteristics and quality measures for colonoscopies performed in pediatric patients undergoing colonoscopy between January 1, 2000 and December 31, 2011 in 14 sites of the PEDS-CORI registry**

Provider characteristic	Total (no.)	Mean duration (min)	P value	Mean proportion with preparation documented	P value	Mean proportion with adequate preparation	P value	Mean proportion that reached ileum	P value
Sex									
Female	36	33.8	.89	.39	.89	.91	.06	.68	.88
Male	81	34.1		.41		.82		.67	
Unknown	3	36.6		.34		.93		.647	
Year graduated from medical school									
Before 1980	21	33.7	.27	.50	.02	.84	.57	.50	< .01
1980-1989	39	32.2		.35		.88		.66	
1990-1999	26	37.9		.31		.82		.78	
2000-2005	16	34.2		.59		.91		.86	
Unknown	18	33.5		.36		.81		.58	
Volume category									
Low (<50)	33	40.5	< .01	.45	.12	.79	.05	.61	.18
Middle (50-200)	47	30.2		.33		.85		.68	
High (>200)	40	33.3		.45		.90		.71	

PEDS-CORI, Pediatric Endoscopy Database System—Clinical Outcomes Research Initiative.

it is possible that adult gastroenterologists perform the procedure more rapidly because of higher volumes than pediatric gastroenterologists. Although we found that colonoscopy duration was associated with type of anesthesia, the actual time disparity (ie, <1 minute) may not be clinically significant.

In adult patients, reporting the quality of the bowel preparation is a required component of the colonoscopy report.<sup>20</sup> We found that bowel preparation quality was documented in just 43.7% of pediatric colonoscopy reports. The use of a “required” field during procedure documentation may increase documentation levels of bowel preparation in pediatrics. In adult patients, studies have shown that inadequate bowel preparation is associated with longer procedure time, lower cecal intubation rates, and increased cautery risk.<sup>21</sup> Our data confirm that inadequate bowel preparation is associated with longer procedure time and lower ileal intubation rates in children. We found that adequate preparation was achieved in 90% of cases. In adults, the recommended benchmark is to achieve adequate bowel preparation in 85% or more of all colonoscopies.<sup>22</sup> However, conclusions about the rate of adequate preparation in children is limited by missing data in the current study.

The current study is the largest attempt to measure pediatric colonoscopy quality. The data obtained from PEDS-CORI also serve as the endoscopy report for the patient’s medical records, providing an incentive for accuracy and completeness. Additionally, because the data generally are entered immediately after the endoscopist has completed the procedure, the study should be less susceptible

to poor documentation because of recall failure. However, our study is biased toward finding high rates of completion of quality indicators because each physician used a structured report generator that provided a field for completion of the specific indicator. It is possible that physicians using unstructured reports may be less likely to record possible quality indicators. Our findings reflect only immediate adverse events, and therefore overall adverse events (eg, 30-day) are likely to be underestimated. Conclusions about the state of current practice may be limited by missing data on quality measures in the current study. However the number of colonoscopies we were able to analyze is significant even when we exclude those procedures that did not have documentation. Specifically, although 56% of colonoscopies did not include bowel preparation quality, our study still included bowel preparation data on 9527 colonoscopies.

Adult studies clearly suggest that the potential benefits of colonoscopy depend on the quality of the examination.<sup>2</sup> These data identify key areas for quality improvement and highlight the need for improving medical documentation of endoscopy in children. We suggest indicators and benchmarks to define quality GI endoscopy in children, with the goal of improving documentation and performance. Future studies also should focus on interventions to narrow the degree of variation in practice and connect quality indicators with clinical outcomes. The use of required fields during procedure documentation may increase documentation levels. A thorough examination of upper endoscopy practice in pediatrics may be valuable, because the majority of GI procedures in children (62%)



are upper endoscopies.<sup>3</sup> In conclusion, our multicenter data revealed significant variations in practice, inconsistent documentation, and underperformance in quality indicators of pediatric colonoscopy. Establishing guidelines with continuous measurement of quality indicators by using central registries could lead to a process of quality improvement in the practice of pediatric endoscopy.

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