Published in final edited form as:
Gastrointest Endosc. 2013 July ; 78(1): 47–54.e1. doi:10.1016/j.gie.2013.03.168.

Diagnostic yield of EGD in children: a retrospective single-center study of 1000 cases

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Abstract

Background—Pediatric EGD is increasingly being used, but few studies have recently evaluated the diagnostic yield.

Objective—To assess the association between presenting clinical symptoms and the likelihood of significant endoscopic and histologic abnormalities for initial diagnostic endoscopy.

Design—Retrospective cohort study.

Setting—Large, tertiary care children's hospital.

Patients—One thousand patients, ages 1 month to 18 years, who underwent initial diagnostic EGD in 2009 and 2010.

Interventions—None.

Main Outcome Measures—Endoscopic and histologic abnormalities.

Results—The most common primary indications for endoscopy were generalized abdominal pain (28.7%), gastroesophageal reflux (11.7%), and failure to thrive (9.5%). The overall prevalence of an endoscopic abnormality was 34.7% and of a histologic abnormality, 40.4%. The highest rates of endoscopic abnormalities were found in patients with strictures on upper GI radiology (100%), foreign body (88%), and GI bleeding (57%). The highest rates of histologic abnormalities were in patients with positive celiac screening (91%), foreign body (88%), dysphagia (51%), and GI bleeding (49%), and the lowest rates of histologic abnormalities were miscellaneous indications (17%), strictures on radiology (25%), and reflux (26%). Females and patients < 1 year of age had lower rates of abnormal histologic abnormalities.

DISCLOSURE: The following author received research support for this study from the Primary Care Research Fellowship at the University of Colorado School of Medicine: J. A. Feinstein. All authors disclosed no financial relationships relevant to this publication.

Limitations—Retrospective nature of the study, limitation to a single tertiary care center, and simplification of complex patient presentations to a single indication.

Conclusions—Rates of endoscopic and histologic abnormalities from EGD vary based on age and indication for endoscopy, and this should be factored into the decision to proceed with initial endoscopy along with consideration of adverse event rates and effects of anesthesia.

Although composite national data are lacking, data from individual centers suggest that the number of endoscopic studies performed in children has been steadily increasing over time. A study by Franciosi et al[1] demonstrated a 12-fold increase in the number of EGDs performed per 100,000 children in the Philadelphia area between 1985 and 2005. In considering whether or not to perform an EGD, a physician must balance the cost, diagnostic yield, and risks to the child. Although the frequency of pediatric EGD has greatly increased, few recent studies have reevaluated the diagnostic yield of current endoscopy practices, leaving physicians without key information to inform their decisions on whether to recommend and perform EGD for specific clinical indications.

When EGD was first implemented in pediatric gastroenterology in the 1970s, multiple studies were published that discussed indications and findings.[2,3] In the time since these studies were published, pediatric gastroenterology practice has evolved in many ways, including the description of eosinophilic esophagitis and the recognition of *Helicobacter pylori* as the predominant cause of ulcers in children. Several more recent studies have identified certain patient factors that affect diagnostic yield. In the case of abdominal pain, a study of EGD in 1191 patients found an overall rate of diagnostic abnormalities of 38%.[4] Male sex, older age, and vomiting correlated with increased diagnostic yield, but the presence of underlying disease such as constipation or reflux did not.[4] In 2008, Noble et al[5] found an overall rate of endoscopic and histologic abnormalities in 346 EGDs of 55%. In their study, age older than 13 years, vomiting, and hypoalbuminemia were predictive of positive findings.[5] A recent study in children younger than 1 year of age revealed esophagitis in 28% of 431 EGDs, gastritis in 21% of 431 EGDs, and various enteropathic features in 74% of 588 cases (either duodenum or terminal ileum).[6] Poor correlation was found between reflux symptoms and esophagitis.[6] Therefore, further studies are needed to clarify which patient characteristics and which indications have the highest diagnostic yield.

In the current era of limited resources, high-deductible insurance plans, and greater emphasis on improved quality and safety, physicians and families must carefully weigh the risks versus the potential benefits before proceeding with any invasive procedure. In 2007, Thakkar et al[7] reported an immediate adverse event rate of 2.3% for EGD in children. In 1997, Balsells et al[8] found a major and minor immediate adverse event rate of 0.36% (in 1653 diagnostic and procedural upper endoscopies) with 1 perforation in a patient undergoing esophageal dilation. Intermediate and long-term adverse events have not been well characterized and are often minimized when discussing risks with parents. Samer Ammar et al[9] interviewed 393 patients by phone 30 days after EGD, and 165 (42%) reported adverse events, including sore throat or hoarseness (34.6%), fatigue (6.6%), cough (4.1%), or other issues. Ten patients sought medical care,[9] highlighting the potential for increased costs associated with these procedures. In addition to adverse events from the procedure

itself, studies have raised the question of long-term effects from anesthesia. In a retrospective cohort study, Wilder et al[10] found that 2 or more episodes of general anesthesia before the age of 2 years increased the risk of learning disabilities.

Based on the knowledge gap regarding EGD practices in the United States, we conceptualized a study to better delineate the clinical indications for endoscopy and their relationship to the presence of gross endoscopic abnormalities and histologic abnormalities in 1000 pediatric patients who underwent their first diagnostic endoscopy. We hypothesized that the great majority of upper endoscopies would be normal, especially in cases where the primary indication was relatively nonspecific, such as abdominal pain.

METHODS

Study design

We conducted a retrospective cohort study and identified 1000 cases through chart review of 1642 sequential EGDs performed at Children's Hospital Colorado, a large, tertiary freestanding hospital, between January 2009 and March 2010. This study was approved by the Colorado Multiple Institutional Review Board on November 17, 2010.

Patient selection

The patient selection process was designed to identify patients undergoing initial diagnostic endoscopy. To be included, patients had to have had at least 1 biopsy sample taken from any location (esophagus, stomach, duodenum). Exclusion criteria included patient age younger than 1 month or age 19 years and older. Patients could not have undergone EGD with biopsy sampling within the past 5 years. This was determined by reviewing the electronic medical record, which was fully implemented in 2004, and by reviewing clinic notes for a history of endoscopy. The endoscopy could not be a follow-up for a known GI condition, which excluded 1 patient with Peutz-Jegher syndrome, 2 with tracheoesophageal fistula, and 6 with inflammatory bowel disease.

We reviewed 1642 upper endoscopies to obtain the eligible 1000 cases. The most common reason for exclusion was prior endoscopy (334 patients); other reasons were patient was already in the study (143 patients), biopsy samples were not taken (126 patients), age 19 years or older (30 patients), and known GI condition (9 patients). Although there was no standard protocol for collection of biopsy specimens, our general practice is to obtain 2 biopsy specimens from the duodenum, 1 from the antrum, 1 from the gastric body, 2 from the distal esophagus, and 2 from the proximal esophagus, regardless of any visual abnormalities.

Data collection

A single researcher reviewed all charts. The reviewer recorded patient age, sex, physician referring the patient for endoscopy, the top 3 indications for endoscopy, the endoscopist, endoscopic abnormalities, the pathologist, and histologic abnormalities. The indications for endoscopy were ranked according to perceived importance by the history and assessment.

All endoscopic findings were noted, including erythema, white plaques, ridging, or edema among others.

Predictor variables

The reviewer determined the primary indication for endoscopy plus 2 additional indications based on the electronic record. Categories of indications were generalized abdominal pain, positive celiac antibodies of any type, diarrhea, dysphagia or odynophagia, emesis, epigastric pain, feeding issues (most often feeding refusal), foreign body, failure to thrive or weight loss, GI bleeding (macroscopic or microscopic), gastroesophageal reflux symptoms, stricture on upper GI series, suspicion for *H pylori* (most often because of positive *H pylori* antibodies), immunosuppressed patients, history of atopy, or other miscellaneous causes.

Outcome variables

Positive endoscopic and histologic abnormalities were grouped into categories, such as esophagitis, eosinophilic esophagitis, infectious, and other for the esophagus with similar classification in the stomach and duodenum. A pediatric gastroenterologist reviewed all endoscopic abnormalities to ensure correct categorization. All histologic abnormalities were reviewed by an independent pathologist for determination of clinical importance. For example, very mild gastritis, esophagitis, and duodenitis were not considered clinically significant and thus were not included. The histologic definition for eosinophilic esophagitis was greater than 15 eosinophils per high-powered field in any location in the esophagus. If there was a question of clinical importance, the microscopic slides were reviewed by the pathologist.

Statistical analysis

All analyses were performed using Stata 12.1 (College Station, TX) statistical software. We considered $P < .05$ to be statistically significant. After generating descriptive counts and proportions for variables of interest, we performed bivariate c^2 analyses to identify variables associated with positive endoscopic or histologic abnormalities. We then used multivariable logistic regression to assess the relationship between the indication for endoscopy and the presence of a positive endoscopic or histologic abnormality, adjusting a priori for patient age and gender.[5] Additional covariates were considered if bivariate $P < .20$, and a variable was retained based on the Wald statistic and if nested model comparisons using likelihood ratio tests demonstrated significant improvement in fit. The sample size only permitted for testing of main effects. Also, because endoscopic and histologic abnormalities depend on interpretation by the relevant clinician, who may each have different knowledge and technical experience, we needed to account for the impact of differences between clinicians on the study outcomes. Thus, in addition to the fixed-effect models, we fit analogous mixed-effect logistic regression models to add a random intercept at the level of the endoscopist (n = 10) or pathologist (n = 3).[11] We selected the final models based on likelihood ratio and Akaike Information Criteria fit statistics.

RESULTS

Of the 1000 subjects, 49% were boys and most were older than age 1 year (Table 1). The most common primary indications for endoscopy were generalized abdominal pain (28.7%), gastroesophageal reflux (11.7%), failure to thrive (9.5%), diarrhea (8.8%), emesis (8.6%), and epigastric pain (8.5%). The overall prevalence of any endoscopic abnormality was 34.7%, with findings occurring in the esophagus in 17% of patients, stomach 15.4%, and duodenum 9.9% (patients could have >1 finding). The overall prevalence of any histologic abnormality was 40.4%, with pathologic abnormalities occurring in the esophagus in 21.9% of patients, stomach in 24.6%, and duodenum in 10.7% (patients could have >1 finding). Thirty patients did not have esophageal biopsy samples taken, 22 patients had no gastric biopsy samples taken, and 22 patients had no duodenal biopsy samples taken. Most patients had >1 indication for endoscopy recorded, but the number of indications did not affect the rates of endoscopic ($P = .113$) or histologic abnormalities ($P = .175$). The referring GI provider did not substantially change the proportion of endoscopic ($P = .506$) or histologic abnormalities ($P = .208$). However, the endoscopist was associated with the presence of endoscopic abnormalities ($P< .001$) but not histologic abnormalities ($P = .218$). After review by an independent pathologist, the pathologist was not significantly associated with the presence of histologic abnormalities ($P = .129$).

Table 2 displays endoscopic and histologic abnormalities by sex, age, and indication. Without adjustment for other variables, no significant difference was found between boys and girls in the presence of endoscopic and histologic abnormalities ($P = .17$ and $P = .067$, respectively). Rates of abnormalities did vary by age and indication. By bivariate analysis, patients aged 13 to 18 years were most likely to have an endoscopic abnormality ($P < .001$), whereas those aged 5 to 12 years were most likely to have a histologic abnormality ($P = .002$). Basic concordance comparing presence of an endoscopic abnormality with presence of a histologic abnormality was 83.5% in the esophagus, 79.6% in the stomach, and 89.3% in the duodenum, for an overall concordance of 62.1%. Further analysis of the concordance data will be presented in an upcoming article (Sheiko M, Feinstein JA, Capocelli K, et al, unpublished data).

The highest rates of endoscopic abnormalities were found in patients with a stricture on upper GI series (100%), foreign body (88%), GI bleeding (57%), dysphagia (56%), and positive celiac screening (52%). The lowest rates of endoscopic abnormalities were in patients with feeding issues (14%), miscellaneous indications (17%), and failure to thrive (20%). The highest rates of histologic abnormalities were in patients with positive celiac screening (91%), foreign body (88%), dysphagia (51%), GI bleeding (49%), and epigastric pain (38%). The lowest rates of histologic abnormalities were in patients with miscellaneous indications (17%), stricture on upper GI (25%), and reflux (26%). Specific endoscopic and histologic abnormalities at each location are displayed in Table 3. Appendix 1 (available online at www.giejournal.org) lists the “other” findings for endoscopic and histologic abnormalities. For the 3 most common indications, the 4 most frequent histologic abnormalities are displayed in Table 4.

Odds ratios (ORs) for rates of endoscopic abnormalities, adjusting for patient characteristics and accounting for clustering at the level of the endoscopist, are displayed in Table 2. Compared with boys, girls demonstrated a trend toward lower rates of endoscopic abnormalities (OR, 0.84; 95% CI, 0.62-1.13). When compared with children younger than age 1 year, patients aged 13 to 18 years were most likely to have endoscopic abnormalities (OR, 3.46; 95% CI, 1.58-7.54), followed by those aged 5 to 12 years (OR, 2.27; 95% CI, 1.04-4.93). Compared with patients with generalized abdominal pain, endoscopic abnormalities were more likely in patients with positive celiac antibodies (OR, 3.43; 95% CI, 1.94-6.05), dysphagia (OR, 3.31; 95% CI, 1.91-5.71), and GI bleeding (OR, 3.54; 95% CI, 1.98-6.33).

ORs for rates of histologic abnormalities, adjusting for patient characteristics, are also displayed in Table 2. Compared with boys, girls were less likely to have a histologic abnormality (OR, 0.75; 95% CI, 0.55-0.99). Compared with patients younger than age 1 year, histologic abnormalities were more likely in patients aged 5 to 12 years (OR, 2.50; 95% CI, 1.23-5.11) and 13 to 18 years (OR, 2.48; 95% CI, 1.21-5.10). Compared with children with generalized abdominal pain, histologic abnormalities were more likely in patients with positive celiac antibodies (OR, 20.62, 95% CI, 8.55-49.76), dysphagia (OR, 1.82; 95% CI, 1.08-3.08), and GI bleeding (OR, 1.83; 95% CI, 1.05-3.19).

DISCUSSION

The ability to perform diagnostic endoscopy, in both adults and children, has been one of the defining characteristics of the current era of gastroenterology. It has undoubtedly expanded our understanding of the pathophysiology of common GI disorders in children and has been a tremendous tool in the management of patients. As the availability and utility of endoscopy in the pediatric population has increased over the past 3 decades, the volume of procedures performed has paralleled that rise. Consequently, decisions regarding the appropriate indications and timing of endoscopic procedures in children have evolved over time and arguably remain more of an art than a science. More critical review of the use of this tool is needed to maximize efficacy and minimize risk.

The current study illustrates the limitations of diagnostic EGD in the workup of many of the most common GI complaints in children. In 60% of cases there were no abnormal histologic abnormalities in any of the sites biopsied during endoscopy and in 65% no endoscopic abnormalities. In this series, the most common indication for endoscopy was abdominal pain, which yielded a rate of abnormal findings of only 35%. Dhroove et al[12] found an even more limited role for endoscopy in the workup of abdominal pain, with only 9.7% having abnormal findings. Although other studies show somewhat higher rates of clinically meaningful findings,[4,5] further research is needed to identify patients with the highest risk for treatable etiologies diagnosed by endoscopy. Furthermore, greater discussion is needed to come to a consensus regarding what is, in fact, an acceptable diagnostic yield for endoscopy in children that takes into account both the costs and the risks of the procedure. Although there will undoubtedly be a wide spectrum of opinions regarding what constitutes an acceptable rate of normal endoscopy, with greater focus on this issue quality measures

may be established, similar to those regarding rates of normal appendectomies in pediatric surgery.[13]

In addition, the low yield of abnormal findings in children younger than age 12 months, specifically in those evaluated for failure to thrive, feeding problems, and reflux, bears consideration of placing a higher bar on determination of when endoscopy is indicated. These results are quite different from the results obtained by Volonaki et al,[6] who found much higher rates of abnormalities overall. These differences are likely accounted for by differences in the practice of medicine between the United States and the United Kingdom, where they are less likely to proceed to endoscopy. However, Volonaki et al[6] also found low correlation between reflux symptoms and esophagitis. A greater degree of skepticism becomes even more appropriate in light of findings that have shown an association between exposure to inhaled anesthesia in children younger than age 2 and learning disorders.[10,14] This finding has been supported by numerous animal models showing neurodegeneration or neuronal apoptosis occurs in primates, rats, and guinea pigs after exposure to inhaled anesthetics.[15-17] Many pediatric endoscopy centers routinely use inhaled anesthesia to perform EGD, especially in younger children. These risks in combination with the infrequent immediate risks from anesthesia and the procedure itself should lead to more hesitancy to proceed with EGD.

Conversely, indications associated with extremely high rates of pathologic abnormalities may offer yet another opportunity to avoid unnecessary endoscopic procedures. In the current study, 91.3% of patients undergoing endoscopy for elevated titers suspicious for celiac disease had pathologic abnormalities, with these almost exclusively consisting of the duodenal abnormalities of celiac disease. Although the specific criteria used to define positive titers was not examined in this study, the positive predictive value of this indication closely parallels the reported positive predictive value of tissue transglutaminase IgA titer,[18] which is the most commonly used screening test for celiac disease in children. As a result, the OR for having an abnormal histologic finding when endoscopy was performed for this indication was greater than 20, compared with endoscopy performed for abdominal pain. This leads to questions regarding the necessity of smallbowel biopsy to establish the diagnosis of celiac disease, as has been the established practice recommended in the guidelines set out by the European Society of Pediatric Gastroenterology, Hepatology and Nutrition in both 1970[19] and 1990.[20]

Given the high degree of sensitivity and specificity of modern serologic assays, there has been a call among pediatric gastroenterologists for the diagnostic criteria for celiac disease to be reexamined.[21] As a result, an expert panel was convened to revise the European Society of Pediatric Gastroenterology, Hepatology and Nutrition guidelines; this panel proposed that pediatric patients with clinical signs and symptoms of celiac disease and very high tissue transglutaminase IgA titers (>10 times the upper limit of normal) may be diagnosed without duodenal biopsies.[22] Small-bowel biopsy is still recommended for asymptomatic patients with elevated titers and symptomatic patients with less pronounced elevation in titers. If this standard was applied to our study population and many of these suspected celiac patients did not undergo endoscopy, the rate of positive findings would be further decreased.

The results further illustrate the variability in the classification of endoscopic abnormalities by pediatric gastroenterologists, even within the same practice group. This study found a significant difference in the rate of abnormal findings between endoscopists across a large population of patients, suggesting a high degree of subjectivity in the determination of normal versus abnormal. This is contrasted by the high uniformity across pathologists in rates of histologic abnormalities. This disparity highlights the need for greater standardization within the pediatric gastroenterology community for the classification and grading of endoscopic abnormalities. Further study examining the degree of correlation between endoscopic and histologic abnormalities in the pediatric population would also be helpful in identifying the endoscopic features that are most predictive of microscopic pathology.

There are several clear limitations to the current study. First and foremost, this was a retrospective analysis of diagnostic EGD with a subjective determination of the primary indication for endoscopy, based on chart review. However, secondary and tertiary indications were also recorded and subanalysis inclusive of these did not significantly alter results. Nevertheless, drawing absolute conclusions regarding the diagnostic yield of EGD for specific indications based on this methodology may oversimplify the complexities of evaluating patients presenting with multiple GI complaints. The heterogeneous patient population ranging from age 1 month to 18 years also makes it more difficult to draw absolute conclusions for certain indications. Furthermore, one may question how likely it is that endoscopic abnormalities of nonspecific esophagitis, gastritis, or duodenitis on endoscopy result in substantial changes in medical management. In this sense, these results may tend to overestimate the diagnostic yield, rather than underestimate it. Recognizing that this study was performed at a single tertiary care, large academic hospital may further limit the applicability of these results to other types of practices, where different standards and incentives for performing endoscopy may exist. Multicenter prospective studies, which clearly delineate and prioritize endoscopy indications, subdivide patients into different age ranges, and document subsequent changes in medical management, would be helpful in addressing these limitations.

As the American healthcare system looks for strategies to decrease costs and optimize resources while retaining or improving quality of care for patients, critical reviews of the use of invasive diagnostic tests become increasingly pertinent. The implementation of Accountable Care Organizations, responsible for the health management of entire populations of patients, will undoubtedly reward healthcare systems that make the most efficient use of resources, rather than the traditional “fee for service” model. Recognition of these changes should be an impetus to examine current practices and find ways to improve safety, outcomes, and expense. In the interim, having more accurate data regarding the likelihood of discovering abnormal mucosal pathology on EGD is helpful for pediatric primary caregivers and pediatric gastroenterologists in counseling parents and referring the most appropriate patients for endoscopy.

CONCLUSION

This large, retrospective study supports the modest diagnostic yield of diagnostic EGD in children with many of the most common GI complaints, such as abdominal pain, reflux, failure to thrive, and feeding problems, as well as in children younger than 12 months of age. The limited utility of endoscopy for these indications was not surprising and was similar to other studies in children. What was more unexpected was the large degree of variability in identification and classification of endoscopic abnormalities across endoscopists, in contrast to the uniformity of histologic abnormalities across pathologists. This variability supports the practice of obtaining routine biopsy specimens in pediatric endoscopies, regardless of the endoscopic appearance. Further study is needed to standardize the preprocedural evaluation and to identify patients with the highest potential to discover changes that will alter medical management. In addition, better characterization of the true risks and costs associated with pediatric endoscopy is needed to more appropriately balance the risk-to-benefit ratio in children.

APPENDIX 1

Other Endoscopic and Histologic Abnormalities Esophageal Endoscopic Abnormalities

Stricture-13 patients

Findings suggestive of infection-7 patients

Mild nodularity-3 patients

Food impaction with mild esophageal ridging-2 patients

External compression of the esophagus-2 patients

Foreign body with erosions-2 patients

Varices

Esophageal inlet patch

Mallory-Weiss Tear

Submucosal esophageal mass

Polyp

Gastric Endoscopic Abnormalities

Hiatal hernia-4 patients

Narrowed pylorus-2 patients

Trace blood-2 patients

Portal hypertensive gastropathy

Loose Nissen

Speckling of the antrum

Vascular polyps

5 mm nodule

Duodenal Endoscopic Abnormalities

Nodularity-15 patients

White papules-2 patients

Pallor-2 patients

Polyp

Esophageal Histologic Abnormalities

Fungal esophagitis-8 patients

Herpes esophagitis-3 patients

Squamous papilloma with positive HPV

Apoptosis consistent with graft versus host disease

Submucosal fibrosis

Gastric Histologic Abnormalities

Apoptosis consistent with graft versus host disease

Mucosal edema

Increased lamina propria eosinophilia (50 eosinophils/hpf)

Reactive glands

Duodenal Histologic Abnormalities

Mild increased eosinophilia and inflammation-2 patients Cryptosporidiosis

Polyp showing prominent benign lymphoid aggregate

Apoptosis consistent with graft versus host disease

Abbreviations

CI	confidence interval
OR	odds ratio

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Take-home Message

- Pediatric EGDs are increasing in frequency; however, little is known about current indications or diagnostic yield.
- Rates of endoscopic and histologic findings from EGD were increased in children older than age 1 year, decreased in girls, and varied by primary indication for endoscopy, which should be factored into the decision to proceed with initial endoscopy.

TABLE 1

Demographics of study population

Characteristic	Percent of total (N = 1000)
Sex	
Male	49.2
Female	50.8
Age	
<1 y	6.6
1-4 y	23.3
5-12 y	35.4
13-18 y	34.7
Primary indication listed on chart	
Abdominal pain	28.7
Reflux	11.7
Failure to thrive	9.5
Diarrhea	8.8
Emesis	8.6
Epigastric pain	8.5
Celiac antibodies	6.9
Dysphagia	7.3
GI bleeding	6.7
Foreign body	1.6
Feeding issues	0.7
Other	0.6
Stricture	0.4
Number of indications listed on chart	
1	19.4
2	38.1
3	42.5
Endoscopic abnormalities	
Yes	34.7
Histologic abnormalities	
Yes	40.4

TABLE 2

Relationships of patient characteristics to presence of endoscopic and histologic abnormalities

	N	Endoscopic abnormality present (%)	OR of endoscopic abnormality* (95% CI)	Histologic abnormality present (%)	OR of histologic abnormality† (95% CI)
Sex					
Male	492	36.8	1.00 (ref)	43.3	1.00 (ref)
Female	508	32.7	0.84 (0.62-1.13)	37.6	0.75 (0.55-0.99)
Age‡					
<1 y	66	16.7	1.00 (ref)	19.7	1.00 (ref)
1-4 y	233	30.0	2.04 (0.94-4.42)	38.2	1.94 (0.95-3.93)
5-12 y	354	34.2	2.27 (1.04-4.93)	44.9	2.50 (1.23-5.11)
13-18 y	347	41.8	3.46 (1.58-7.54)	41.2	2.48 (1.21-5.10)
Indication‡					
Abdominal pain	287	28.9	1.00 (ref)	35.2	1.00 (ref)
Reflux	117	23.9	0.93 (0.54-1.59)	25.6	0.72 (0.43-1.20)
Failure to thrive	95	20.0	0.83 (0.44-1.57)	33.7	1.16 (0.66-2.03)
Diarrhea	88	28.4	1.05 (0.60-1.85)	34.1	1.02 (0.60-1.73)
Emesis	86	31.4	1.29 (0.74-2.26)	32.6	0.92 (0.54-1.56)
Epigastric pain	85	35.3	1.17 (0.69-2.00)	37.6	1.11 (0.67-1.84)
Dysphagia	73	56.2	3.31 (1.91-5.71)	50.7	1.82 (1.08-3.08)
Celiac antibodies	69	52.2	3.43 (1.94-6.05)	91.3	20.62 (8.55-49.76)
GI bleeding	67	56.7	3.54 (1.98-6.33)	49.2	1.83 (1.05-3.19)
Foreign body	16	87.5	–	87.5	–
Feeding issues	7	14.3	–	28.6	–
Other	6	16.7	–	16.7	–
Stricture	4	100.0	–	25.0	–

*Final logistic model includes sex, age, and indication, with a random intercept to account for differences between multiple endoscopists; “Feeding issues,” “foreign body,” “stricture on upper GI series,” and “other” categories were removed because of inadequate cell size resulting in unstable estimates.

†Final logistic model includes sex, age, and indication, without a random intercept.

‡Unadjusted bivariate relationship between variable and each outcome (endoscopic or histologic abnormality) significant at $P < .05$.

TABLE 3
Endoscopic and histologic abnormalities by location

Location*	Abnormality	Endoscopy (%) (N = 1000)	Histology (%) (N = 1000)
Esophagus	Esophagitis	9.5	12.0
	Eosinophilic esophagitis	5.4	7.6
	Other	2.4	1.5
	None	82.7	78.9
Stomach	Gastritis	10.4	21.3
	Antral nodularity/*H pylori*	3.7	2.4
	Other	1.4	0.4
	None	84.5	75.9
Duodenum	Duodenitis	4.8	3.5
	Celiac	2.9	6.5
	Other	2.2	0.5
	None	90.1	89.5

*Note that subjects could have abnormalities in >1 location.

TABLE 4
Histologic abnormalities by top 3 indications for endoscopy

Location abnormality*	Abdominal pain (N = 287)	Reflux (N = 117)	Failure to thrive (N = 95)
Esophagus			
Esophagitis	11.5	12.8	14.7
Eosinophilic esophagitis	7.0	2.6	7.4
Other	0.4	0.0	1.1
None	81.1	84.6	76.8
Stomach			
Gastritis	22.3	12.8	22.1
H pylori	3.8	0.9	0.0
Other	0.0	0.9	0.0
None	73.9	85.4	77.9
Duodenum			
Duodenitis	3.5	1.7	1.7
Celiac	1.1	2.6	2.6
Other	0.7	0.0	0.0
None	94.7	95.7	95.7

Values are percent with abnormality.

* Note that subjects could have abnormalities in >1 location.