



The Presence of an Advanced Gastrointestinal (GI)/Minimally Invasive Surgery (MIS) Fellowship Program Does Not Impact Short-Term Patient Outcomes Following Fundoplication or Esophagomyotomy

Donald K. Groves¹ · Maria S. Altieri¹ · Brianne Sullivan¹ · Jie Yang¹ · Mark A. Talamini¹ · Aurora D. Pryor¹

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Abstract

Introduction The current surgical landscape reflects a continual trend towards sub-specialization, evidenced by an increasing number of US surgeons who pursue fellowship training after residency. Despite this growing trend, however, the effect of advanced gastrointestinal (GI)/minimally invasive surgery (MIS) fellowship programs on patient outcomes following foregut/esophageal operations remains unclear. This study looks at two representative foregut surgeries (laparoscopic fundoplication and esophagomyotomy) performed in New York State (NYS), comparing hospitals which do and do not possess a GI/MIS fellowship program, to examine the effect of such a program on perioperative outcomes. We also aimed to identify any patient or hospital factors which might influence perioperative outcomes.

Methods The SPARCS database was examined for all patients who underwent a foregut procedure (specifically, either an esophagomyotomy or a laparoscopic fundoplication) between 2012 and 2014. We compared the following outcomes between institutions with and without a GI/MIS fellowship program: 30-day readmission, hospital length of stay (LOS), and development of any major complication.

Results There were 3175 foregut procedures recorded from 2012 to 2014. Just below one third ($n = 1041$; 32.8%) were performed in hospitals possessing a GI/MIS fellowship program. Among our entire included study population, 154 patients (4.85%) had a single 30-day readmission, with no observed difference in readmission between hospitals with and without a GI/MIS fellowship program, even after controlling for potential confounding factors ($p = 0.6406$ and $p = 0.2511$, respectively). Additionally, when controlling for potential confounders, the presence/absence of a GI/MIS fellowship program was found to have no association with risk of having a major complication ($p = 0.1163$) or LOS ($p = 0.7562$). Our study revealed that postoperative outcomes were significantly influenced by patient race and payment method. Asians and Medicare patients had the highest risk of suffering a severe complication (10.00 and 7.44%; $p = 0.0311$ and $p = 0.0036$, respectively)—with race retaining significance even after adjusting for potential confounders ($p = 0.0276$). Asians and uninsured patients demonstrated the highest readmission rates (15.00 and 12.50%; $p = 0.0129$ and $p = 0.0012$, respectively)—with both race and payment method retaining significance after adjustment ($p = 0.0362$ and $p = 0.0257$, respectively). Lastly, payment method was significantly associated with postoperative LOS ($p < 0.0001$), with Medicaid patients experiencing the longest LOS (mean 3.99 days) and those with commercial insurance experiencing the shortest (mean 1.66 days), a relationship which retained significance even after adjusting for potential confounders ($p < 0.0001$).

Conclusion The presence of a GI/MIS fellowship program does not impact short-term patient outcomes following laparoscopic fundoplication or esophagomyotomy (two representative foregut procedures). Presence of such a fellowship should not play a role in choosing a surgeon. Additionally, in these foregut procedures, patient race (particularly Asian race) and payment method were found to be independently associated with postoperative outcomes, including postoperative LOS.

All the above-listed authors satisfy the criteria for authorship as detailed in the guidelines by the International Committee of Medical Journal Editors (ICMJE).

✉ Donald K. Groves
donaldgrovesmd@gmail.com

¹ Division of Bariatric, Foregut, and Advanced Gastrointestinal Surgery, Stony Brook University, Stony Brook, NY, USA

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Background

There has been an undeniable paradigm shift in surgery over the past 30 years. The days of the general surgeon are becoming a thing of history as residents increasingly pursue subspecialty training to become surgical specialists.¹ This translates into longer surgical training by means of fellowship programs, which are completed in addition to surgical residency. Recently, as outcome measures have become a heavy focus, an important question has surfaced: How does the presence of surgery fellowship programs effect patient outcomes?

Mixed results have been reported when approaching this question regarding general surgery residency programs. As one can expect, operations involving surgical trainees are reported to have longer operating times, an observation consistent across many studies.^{2–30} Multiple authors have reported that cases involving residents demonstrated slightly lower mortality rates at the expense of slightly higher morbidity rates, and although several studies found these differences to be substantial,^{18,20,28,31} others determined they were likely clinically insignificant.^{3,4,22,32} Further still, some studies have concluded that resident involvement imparts no adverse effect, positing instead that complication rates are actually lower in such cases.^{10,13,14,33,34} However, these findings remain mixed, with some studies instead noting an increased complication rate with resident involvement.^{4,6,12,18–20,26,28,30–32,35–39}

Fellowships incorporate higher level surgical trainees, and may in fact have a higher level of surgical assistant than may be seen in the community setting. However, determining the effect of surgical fellowship programs on patient outcomes is not a straightforward task, as many variables can potentially confound the findings of such large-scale outcome-based research, including the presence of cross-sectional populations, the diversity of referral and practice patterns, and the limitations inherent to research databases, among other variables. Additionally, not all databases specify the level of surgical trainee assistants (e.g., PGY1 to fellow), or address the degree to which a trainee's experience (i.e., year in a surgical training program) effects patient outcomes. Furthermore, there is sparse available literature which specifically evaluates the outcomes of surgical fellow involvement in foregut surgeries.

The goal of this study was to evaluate surgical outcomes after foregut surgery, comparing hospitals which possess a GI/MIS fellowship program to those which do not, specifically looking at 30-day readmission, hospital length of stay (LOS), and development of any major complications. The foregut

surgeries included in our analysis were two esophageal procedures—esophagomyotomy and laparoscopic fundoplication. Because GI/MIS fellowship training is, and will continue to be, an integral part of many hospital programs, we sought to determine if the presence of a GI/MIS fellowship program was associated with patient outcomes. We also sought to determine the extent to which other patient and hospital factors (e.g., race and payment method, among others) confounded the fellowship effect or demonstrated an association with postoperative outcomes.

Methods

Following the Institutional Review Board approval, our patient population was identified by utilizing the New York State (NYS) Statewide Planning and Research Cooperative System (SPARCS) administrative database, a comprehensive longitudinal database involving mandatory reporting of all instances of patient treatment and procedures in NYS. Our population included patients who underwent a foregut/esophageal procedure (specifically defined as either an esophagomyotomy or a laparoscopic fundoplication) between 2012 and 2014, using respective ICD-9 codes for inpatient procedures (primary procedure codes 44.66, 44.67, and 42.70) and CPT codes for outpatient procedures (43,280, 43,281, and 4382). Patients with missing information, age < 18 years, and duplicate records were excluded from the analysis. Hospitals from this cohort possessing a GI/MIS fellowship program were identified from the Fellowship Council website ($n = 12$).

The above procedures were compared between hospitals possessing a GI/MIS fellowship program and those without such a program. Covariates included age, sex, race, and presence of any comorbidity, payment method, inpatient/outpatient procedure, hospital region, hospital academic status, and hospital volume. To select the above variables for inclusion, all patients' characteristics and comorbidities were first checked using univariate analysis to determine the presence (if any) of a significant association with any of our study outcomes (see below). Any variables found to be significant in the univariate analysis (with a significance level of 0.1) were further included in the multivariable regression models (see next paragraph). Outcomes analyzed included 30-day readmission, LOS, and development of any major complication. Thirty-day readmission rate was defined as the presence/absence of at least one 30-day readmission. LOS was defined

as the number of days between admission date and discharge date for the index operation of interest. A major complication was defined as the presence of any of the following: abscess, dehiscence, hemorrhage (with or without reoperation), mechanical ventilation, tracheostomy, anastomotic leak, pneumonia, pulmonary edema, pulmonary embolus, respiratory failure, respiratory arrest, cardiac arrest, cardiac complications, myocardial infarction, renal failure, shock, surgical error, liver disease, or in-hospital death. All NYS hospitals are required to submit inpatient and outpatient data to the SPARCS database, therefore, enabling it to accurately record all NYS readmissions.

Chi-square tests with exact p values based on Monte Carlo simulation were utilized to compare categorical variables between groups of *hospitals possessing a GI/MIS fellowship program vs those which do not and between academic vs nonacademic hospitals as defined by the presence of an undergraduate medical program*. Univariate generalized linear-mixed models were used to fit the data to estimate the marginal association between possible covariates: *30-day readmission, LOS, and presence of any major complication. Facilities and the operating physicians* were considered two random effects to account for the clustering nature of patients from the same facility or the same physician. Univariate logistic regression models with firth bias correction were fit when zero cell counts existed in the contingency table of two categorical variables (which otherwise resulted in model fitting issues). *Hospitals possessing a GI/MIS fellowship program vs those which do not, academic vs nonacademic hospitals, and any variables significant in the univariate analysis (with a significance level of 0.1) were further included in the multivariable regression models*. We utilized the presence of *any comorbidity* and of *any complication* instead of any specific comorbidity/complication because many individual comorbidities/complications were found to have sufficiently small p -values in univariate models. Log transformation was applied on (LOS + 1) to satisfy the normality assumption for linear mixed models. Due to the small number of events, no further multivariable models were utilized in analyzing the *presence/absence of any major complication and the 30-day readmission rates between academic vs nonacademic hospitals*.⁴⁰ Statistical analysis was performed using SAS 9.3 with the significance level set at 0.05 (SAS Institute, Inc., Cary, NC).

Results

There were 3175 foregut surgeries performed between 2012 and 2014 in NYS: nearly two thirds of these ($n = 2134$; 67.21%) were performed in hospitals which did not possess a GI/MIS fellowship program, while the remaining one third ($n = 1041$; 32.79%) were performed at hospitals which did

possess such a program. Of the 1041 cases in the latter group, 516 (49.57%) were performed at academic institutions and the remaining 525 cases (50.43%) at nonacademic hospitals. Inpatient procedures comprised approximately two thirds of the total operations ($n = 2186$; 68.85%) while the remaining one third ($n = 989$; 31.15%) were performed in the outpatient/ambulatory setting.

Importantly, regarding our key outcomes of interest, our analysis found no significant difference in outcomes between hospitals which possess a GI/MIS fellowship program and those which do not. These findings held true both before and after controlling for potential confounding variables—specifically finding no significant difference in the 30-day hospital readmission ($p = 0.6406$ and $p = 0.2511$, respectively), LOS ($p = 0.8064$ and $p = 0.7562$, respectively), and development of any severe complication ($p = 0.9887$ and $p = 0.1163$, respectively).

The following covariates were found to be significantly associated with the development of a severe postoperative complication, and these marginal associations were statistically significant: age ($p < 0.0001$), race ($p = 0.0311$), payment method ($p = 0.0036$), inpatient/outpatient status ($p = 0.0005$), and presence of any comorbidity ($p < 0.0001$). Specifically, Asian race and Medicare patients had the highest risk of suffering a severe complication (10.00 and 7.44%; $p = 0.0311$ and $p = 0.0036$, respectively). After controlling for other potential confounding variables, only inpatient/outpatient status (OR = 39.77 for inpatients vs outpatients; 95% CI = 5.18–5118.74; $p = 0.0079$), race ($p = 0.0276$), and the presence/absence of any comorbidity (see below) retained statistical significance as risk factors for developing a severe postoperative complication. Patients without any comorbidities were significantly less likely to suffer a severe postoperative complication compared to those with a comorbidity both for our overall study population (OR 0.33; 95% CI 0.18–0.57; $p = 0.0001$; see Table 1) as well as for the subset of patients who underwent their operation at a hospital with a GI/MIS fellowship (OR 0.28; 95% CI 0.1–0.65; $p = 0.0057$; see Table 2).

Of the 3175 total patients included in our study, the vast majority of them ($n = 3021$; 95.15%) were not readmitted within 30 days from the index operation date, while only a minority ($n = 154$; 4.85%) had a single hospital readmission within this postoperative time interval. None of the patients in our study were readmitted more than once within 30 days after surgery. Our analysis demonstrated that the factors significantly associated with a 30-day hospital readmission based on univariate data analysis were the following: race ($p = 0.0129$; highest to lowest: Asian > Black > Hispanic > Caucasian > other, respectively), payment method ($p = 0.0012$; highest to lowest: Uninsured > Medicare > Medicaid > Commercial Insurance, respectively), presence of any comorbidity ($p < 0.0001$), inpatient/outpatient status ($p < 0.0001$; higher

Table 1 Risk of a severe complication in all patients undergoing foregut surgery based on a multivariable regression model

Variable	Level	OR	95% CI	<i>p</i> value*
GI/MIS fellowship	Presence vs absence of GI/MIS fellowship	0.705	0.45–1.09	0.1163
Age	18–24 vs 25–34	0.390	0–3.62	0.3219
	18–24 vs 35–44	0.536	0–4.61	
	18–24 vs 45–54	0.259	0–1.94	
	18–24 vs > 55	0.268	0–1.98	
	25–34 vs 35–44	1.373	0.42–4.25	
	25–34 vs 45–54	0.664	0.23–1.58	
	25–34 vs > 55	0.688	0.25–1.57	
	35–44 vs 45–54	0.483	0.2–1.05	
	35–44 vs > 55	0.501	0.21–1.03	
	45–54 vs > 55	1.036	0.65–1.62	
Inpatient/outpatient	Inpatient vs outpatient	<i>39.767</i>	<i>5.18–5118.74</i>	<i>0.0079</i>
Payment method (i.e., insurance)	Commercial vs Medicaid	0.553	0.27–1.29	0.4232
	Commercial vs Medicare	0.833	0.57–1.22	
	Commercial vs other	0.705	0.16–6.63	
	Medicaid vs Medicare	1.507	0.63–3.23	
Race	Medicaid vs other	1.276	0.25–12.91	0.0276
	Medicare vs other	0.846	0.19–7.99	
	Asian vs black	1.511	0.27–5.99	
	Asian vs Hispanic	3.401	0.58–14.98	
	Asian vs other	5.410	0.94–22.53	
	Asian vs white	2.674	0.51–9.38	
	Black vs Hispanic	2.251	0.91–6.02	
	Black vs other	<i>3.580</i>	1.53–8.76	
	Black vs white	1.770	0.93–3.15	
	Hispanic vs other	1.591	0.57–4.29	
Average hospital volume (cases/year)	Hispanic vs white	0.786	0.33–1.6	0.1782
	Other vs white	<i>0.494</i>	0.23–0.93	
	< 16 vs 16–56	0.839	0.57–1.24	
Any comorbidity	< 16 vs > 56	1.411	0.72–2.82	0.0001
	16–56 vs > 56	1.682	0.94–3.14	
Any comorbidity	No vs yes	<i>0.331</i>	0.18–0.57	<i>0.0001</i>

Values in italics are statistically significant

OR estimated odds ratio, CI confidence interval

**p* value based on Wald test (from multiple logistic regression) with firth bias correction

with inpatient status), average hospital volume ($p < 0.0001$; readmission rate inversely proportional to hospital volume), and development of any severe complication ($p = 0.0047$). After adjusting for possible confounders, however, the only factors which retained statistical significance for increasing the risk of readmission were the presence of any comorbidity (OR = 0.53 if absent vs present; 95% CI = 0.31–0.86; $p = 0.0129$), surgery performed at a lower volume hospital ($p = 0.0008$), and race ($p = 0.0362$; see Table 3). Interestingly, when evaluating only the subset of patients who underwent their operation at a hospital with a GI/MIS fellowship, patients with commercial insurance were found to have a statistically

significantly lower risk of 30-day hospital readmission than other patients (see Tables 4 and 5).

Additionally, when considering the subset of hospitals from our study which possessed a GI/MIS fellowship program ($n = 12$), analysis demonstrated no significant difference between the outcomes from academic vs non-academic hospitals, both before and after controlling for other potential confounding factors (30-day readmission rates with $p = 0.4679$ and $p = 0.8987$, respectively; LOS with $p = 0.3466$ and $p = 0.8733$, respectively; development of a severe complication with $p = 0.9527$ and $p = 0.2621$, respectively) (Table 6).

Table 2 Risk of a severe complication in patients undergoing foregut surgery at hospitals with a GI/MIS fellowship program

Variable	Level	OR	95% CI	<i>p</i> value*
Academic hospital	No vs yes	0.708	0.38–1.3	0.2621
Payment method (i.e., insurance)	Commercial vs Medicaid	0.308	0.11–1.06	0.0698
	Commercial vs Medicare	0.571	0.3–1.08	
	Commercial vs other	0.224	0.05–2.18	
	Medicaid vs Medicare	1.851	0.55–5.15	
	Medicaid vs other	0.727	0.11–8.07	
	Medicare vs other	0.393	0.08–3.82	
Any comorbidity	Absent vs present	0.279	0.1–0.65	0.0057

Values in italics are statistically significant

OR estimated odds ratio, CI confidence interval

**p* value based on multivariable logistic regression

The following factors were found to significantly affect postoperative LOS: age ($p < 0.0001$), sex ($p = 0.0187$), payment method ($p < 0.0001$), geographic region ($p = 0.0134$), inpatient/outpatient status ($p < 0.0001$), presence of any comorbidity ($p < 0.0001$), and presence of any severe complication ($p < 0.0001$, respectively). Specifically examining LOS based on payment method, we found the following

relationship, from longest LOS to shortest: Medicaid > Medicare > Uninsured > Commercial insurance (mean of 3.99, 3.39, 1.88, and 1.66 days, respectively). Controlling for other variables, the following factors retained statistical significance: age (younger age associated with shorter LOS; $p < 0.0001$), inpatient/outpatient status (inpatient operations associated with longer LOS; $p < 0.0001$), payment method

Table 3 Risk for a 30-day hospital readmission after undergoing foregut surgery

Variable	Level	OR	95% CI	<i>p</i> value*
GI/MIS fellowship	Presence vs absence of GI/MIS fellowship	1.256	0.84–1.86	0.2511
Inpatient/outpatient	Outpatient vs inpatient	0.918	0.48–1.76	0.7919
Payment method (i.e., insurance)	Commercial vs Medicaid	0.671	0.32–1.6	0.0257
	Commercial vs Medicare	0.643	0.45–0.92	
	Commercial vs other	0.288	0.1–1.12	
	Medicaid vs Medicare	0.959	0.4–2.02	
	Medicaid vs other	0.430	0.11–1.93	
	Medicare vs other	0.448	0.15–1.75	
Race	Asian vs black	2.781	0.65–9.58	0.0362
	Asian vs Hispanic	3.677	0.85–12.85	
	Asian vs other	6.382	1.5–21.74	
	Asian vs white	4.358	1.1–13.19	
	Black vs Hispanic	1.323	0.6–2.97	
	Black vs other	2.295	1.06–4.95	
	Black vs white	1.567	0.84–2.73	
	Hispanic vs other	1.736	0.78–3.81	
	Hispanic vs white	1.185	0.61–2.12	
Average hospital volume (cases/year)	Low vs medium	1.405	0.96–2.06	0.0008
	Low vs high	2.918	1.68–5.22	
	Medium vs high	2.076	1.23–3.62	
Any comorbidity	Absent vs present	0.531	0.31–0.86	0.0129
Any complication	Absent vs present	0.731	0.49–1.13	0.1432

Low overall average hospital volume is < 16 cases/year. Medium overall average hospital volume is 16–56 cases/year. High overall average hospital volume is > 56 cases/year. Values in italics are statistically significant

OR estimated odds ratio, CI confidence interval

**p* value based on multiple logistic regression with firth bias correction

Table 4 Risk for a 30-day hospital readmission in patients undergoing foregut surgery at hospitals with a GI/MIS fellowship program after adjusting for *accumulated* hospital volume

Variable	Level	OR	95% CI	p value
Academic hospital	No vs yes	0.960	0.5–1.79	0.8987
Payment method (i.e., insurance)	Commercial vs. Medicaid	<i>0.291</i>	0.1–0.99	<i>0.0011</i>
	Commercial vs. Medicare	<i>0.505</i>	0.27–0.93	
	Commercial vs. other	<i>0.091</i>	0.03–0.39	
	Medicaid vs. Medicare	1.738	0.52–4.8	
	Medicaid vs. other	0.313	0.06–1.68	
	Medicare vs. other	<i>0.180</i>	0.05–0.78	
Accumulated hospital volume (total cases)	Low vs. medium	0.701	0.37–1.3	<i>0.0235</i>
	Low vs. high	2.228	0.97–5.41	
	Medium vs. high	<i>3.180</i>	1.41–7.66	
Any comorbidity	Absent vs. present	0.651	0.32–1.26	0.2111

Low accumulated hospital volume is < 36 total cases. Medium accumulated hospital volume is 36–131 total cases. High accumulated hospital volume is > 131 total cases. Values in italics are statistically significant

OR estimated odds ratio, CI confidence interval

(with commercial insurance associated with shorter LOS compared to Medicare or Medicaid patients, $p < 0.0001$), region ($p = 0.0002$), presence of any comorbidity (shorter LOS if absent; $p < 0.0001$), and presence of any complication (shorter LOS if absent; $p < 0.0001$).

Discussion

Patient outcomes have become an increasingly heavy focus of research, and for good reason. With a constant emphasis on patient care, outcome research provides a metric by which different hospital systems and surgeons can compare their results to each other, as well as to established acceptable standards after any given operation, ultimately to highlight areas of potential improvement. Our study sought to address if/how

patients would be affected by the presence of a GI/MIS fellow. The presence of a fellowship program acts as a surrogate in our study for GI/MIS fellow involvement in the selected foregut operations of interest (i.e., for laparoscopic fundoplication and for esophagomyotomy), with the results of our study intended to provide insight into the effect of fellow involvement on such procedures. We were also interested in discovering whether any other patient or hospital factors were associated with surgical outcomes after these foregut procedures.

Our analysis found no difference in patient outcomes after foregut surgery involving a GI/MIS fellow compared to those without, supporting the results of similar studies (discussed below). Lay people typically have greater reservations about receiving care from a surgical trainee compared to directly from an experienced attending physician, due to a perceived inferiority of care. Consequently, the results of our study are

Table 5 Risk for a 30-day hospital readmission in patients undergoing foregut surgery at hospitals with a GI/MIS fellowship program after adjusting for *average* hospital volume

Variable	Level	OR	95% CI	p value
Academic hospital?	No vs yes	1.915	0.75–4.74	0.1599
Payment method (i.e., insurance)	Commercial vs Medicaid	0.299	0.11–1.02	<i>0.0007</i>
	Commercial vs Medicare	<i>0.490</i>	0.26–0.91	
	Commercial vs other	<i>0.084</i>	0.02–0.36	
	Medicaid vs Medicare	1.640	0.48–4.58	
	Medicaid vs other	0.281	0.05–1.52	
	Medicare vs other	<i>0.171</i>	0.05–0.74	
Average hospital volume (cases/year)	Low vs medium	0.924	0.43–1.92	<i>0.0051</i>
	Low vs high	<i>4.273</i>	1.72–10.27	
	Medium vs high	<i>4.626</i>	1.44–14.82	
Any comorbidity	Absent vs present	0.568	0.28–1.1	0.1012

Low GI/MIS average hospital volume is < 50 cases/year. Medium GI/MIS average hospital volume is 50–142 cases/year. High GI/MIS average hospital volume is > 142 cases/year. Values in italics are statistically significant. Note that the annual case numbers which define these groups differ (are higher) than those which define the similarly labeled groups in Table 3

OR estimated odds ratio, CI confidence interval

Table 6 Estimated difference in LOS based on fitted linear mixed model for patients undergoing foregut surgery at hospitals with a GI/MIS fellowship

Variable	Level	Estimated difference* in log (LOS + 1)	<i>p</i> value1	<i>p</i> value2
GI-MIS fellowship	GI-MIS fellowship vs no fellowship	−0.0148	0.7562	0.7562
Age	35–44 vs > 55	−0.0859	0.0002	< 0.0001
	18–24 vs > 55	−0.1549	0.0003	
	25–34 vs > 55	−0.0847	0.0021	
	45–54 vs > 55	−0.0587	0.0035	
	18–24 vs 45–54	−0.0962	0.0266	
	18–24 vs 35–44	−0.0689	0.1186	
	18–24 vs 25–34	−0.0701	0.1293	
	35–44 vs 45–54	−0.0273	0.2587	
	25–34 vs 45–54	−0.0261	0.3528	
	25–34 vs 35–44	0.00120	0.9674	
Sex	Female vs male	0.00259	0.8694	0.8694
Inpatient/outpatient	Inpatient vs outpatient	0.6525	< 0.0001	< 0.0001
Payment method (i.e., insurance)	Commercial vs Medicaid	−0.1331	0.0011	< 0.0001
	Medicaid vs other	0.1721	0.0713	
	Medicare vs other	0.1175	0.1840	
	Medicaid vs Medicare	0.0546	0.1980	
	Commercial vs other	0.0390	0.6559	
	Commercial vs Medicare	−0.0784	< 0.0001	
Region	11 (Long island) vs 3 + 4 (Mid/North)	−0.238	0.0004	0.0002
	3 + 4 (Mid/North) vs 6 + 7 + 8 + 9 + 10 (NYC area)	0.1838	0.0005	
	1 + 2 (east) vs 11 (Long island)	0.2370	0.0017	
	1 + 2 (east) vs 6 + 7 + 8 + 9 + 10 (NYC area)	0.1823	0.0040	
	3 + 4 (Mid/North) vs 5 (close to NYC)	0.1747	0.0196	
	1 + 2 (east) vs 5 (close to NYC)	0.1732	0.0371	
	11 (Long island) vs 6 + 7 + 8 + 9 + 10 (NYC area)	−0.0547	0.3657	
	11 (Long island) vs 5 (close to NYC)	−0.0638	0.4360	
	5 (close to NYC) vs 6 + 7 + 8 + 9 + 10 (NYC area)	0.00906	0.8963	
	1 + 2 (east) vs 3 + 4 (Mid/North)	−0.0015	0.9831	
Any comorbidity	Absent vs present	−0.1062	< 0.0001	< 0.0001
Any complication	Absent vs present	−0.6567	< 0.0001	< 0.0001

Values in bold are statistically significant

OR estimated odds ratio, CI confidence interval

1 *p* value1 based on Student's *t* test comparing estimate with 0

2 *p* value2 based on Wald test from multivariable linear mixed model with facilities and physicians as clustering effect comparing if there is any significant difference among different levels in one variable

*Log transformation was performed on (LOS + 1) to meet normality assumption

important because they enable us to confidently reassure patients that their care and outcomes will not be compromised by the involvement of a surgical fellow.

We did find, however, that patient outcomes were associated with multiple patient or hospital factors. Some of these associations were not surprising, such as the presence of any comorbidity associated with a higher risk for a severe complication, 30-day readmission, and increased LOS. The observed outcome differences associated with patient race and payment method, however, are not as readily intuitive (see discussion below).

In the evaluation of the GI/MIS fellowship programs themselves, we did not observe a difference in patient outcomes between academic and nonacademic hospitals. There still exists such diversity among the different training programs both within NYS and across the country, however, that we believe further research is necessary before any conclusions on program superiority or equivalence can be confidently stated.

Many studies have similarly investigated the effect of surgical trainee involvement on patient outcomes, most of which have taken advantage of the American College of Surgeons National Surgical Quality Improvement Program (NSQIP) database,

demonstrating mixed results.^{2–12,15,16,18–21,31,32,34,41–44} For example, a study by Aminian et al., which included over 10,000 patients, sought to determine the impact of bariatric fellow involvement on bariatric surgery outcomes. They similarly found no difference in complication rates with fellow involvement in laparoscopic sleeve gastrectomy (LSG) operations. Interestingly, they noted fellow involvement was associated with higher complication rates after laparoscopic Roux-en-Y gastric bypass (LRYGB) surgeries. Also differing from our findings, Aminian et al. found that when compared to the same surgeries performed by the attending alone, bariatric fellow involvement resulted in higher readmission rates for both LRYGB & LSG.² Fellow involvement was further shown to result in longer operative times. These findings highlight the difficulty in drawing generalized conclusions regarding the effect of fellowship involvement on surgical outcomes, illustrating instead that the relationship and effect may vary depending on the specific surgical procedure. In an earlier study by Bhayani et al., fellow involvement in LRYGB was similarly associated with increased morbidity rates; however, the morbidity rates improved as fellows progressed further along in their training (i.e., during their second 6 months of fellowship compared to their first 6 months).⁴³ Their finding that increased training results in improved morbidity rates after laparoscopic bariatric procedures appears to be isolated to fellowship training; however, a recent study by Kuckelman et al. found no significant difference in leak rates after LRYGB & LSG when comparing chief vs junior residents (at a single tertiary care center).⁴⁵

Pace et al. found no significant difference in morbidity when laparoscopic splenectomies were performed with a MIS fellow compared to those performed with the attending alone, again supporting the likely case-dependent relationship between fellow involvement and surgical outcomes.⁴⁶ A similar study by Whealon et al. evaluated the effect of resident involvement on complex minimally invasive laparoscopic surgery cases, specifically exploring surgical outcomes after laparoscopic colectomy, paraesophageal hernia repair, and anti-reflux operations. Compared to cases performed without a resident, those which involved a resident did not significantly differ with respect to 30-day serious complication rates or LOS, findings which mirror those of our study.²⁴ These findings are further supported by a fundamental earlier study by Davis et al., which looked at approximately 80,000 patients who underwent one of six index laparoscopic procedures of varying difficulty, and used subset analysis to determine the presence (if any) of outcome differences based on the level of the involved surgical trainee (i.e., junior resident, senior resident, or fellow), compared to cases performed without a trainee present. They found that more technically difficult procedures (e.g., LRYGB and laparoscopic fundoplication) were significantly longer with senior residents (PGY3-5) and even longer with fellows,³ a finding replicated by Ross et al. in evaluating laparoscopic ventral hernia repairs.¹⁶ Longer operative times did not correlate with worse outcomes, however,

as most of the above studies which demonstrated longer operative times with trainee involvement exhibited similar morbidity and mortality rates (when compared to cases without trainee involvement). Furthermore, among cases involving surgical trainees (e.g. resident/fellow), Davis et al. concluded that any observed differences in outcomes when comparing between trainees at different levels of training were clinically insignificant,³ a conclusion reinforced by studies from Advani et al., Kuckelman et al., and Carr et al.^{12,45,47} Mortality rates were not found to be different with trainee involvement in any of these studies.^{2,3,16,24,43,45,47}

Based on reviewing the literature at the time of this study, the authors were unable to find any papers which specifically evaluated the effect on patient outcomes in hospitals with advanced GI/MIS fellowship programs. The available literature is sparse with respect to the effects of surgical fellow participation on patient outcomes, and any similar papers either focused on bariatric surgery operations, or included a wider range of operations, or had too small of a patient population. MIS fellowships vary widely, and each program places a different level of emphasis on hernia repair operations, bariatric surgeries, and advanced GI operations (the focus of our paper). Not only was our study unique in specifically addressing advanced GI operations, but we were able to evaluate the effect of these training programs using data drawn from every hospital and surgical center in NYS to produce a large patient population of over 3000 people. Some other strengths of our study are the explicitly defined operations of interest (to avoid any ambiguity associated with the phrase “Advanced GI/MIS”), and the study’s clear primary outcomes. Additionally, given the nature and timeframe of our study outcomes and our utilization of the SPARCS database, our data is more resistant to loss to follow-up than studies which rely on hospital chart review or databases which do not require mandatory reporting.

Furthermore, the available literature is sparse with respect to the effect of race or payment method on patient outcomes after a given surgery, and our authors were unable to find any papers specifically addressing these after esophagomyotomy and/or after laparoscopic fundoplication. Most papers addressing a patient’s race or payment method (i.e., type of insurance) instead focus on patient access to care, or access to one of multiple different surgical options.^{48–52} Also, on reviewing the available literature, most of these papers are in the fields of orthopedic surgery,^{50,53,54} otolaryngology,^{55,56} or bariatric surgery.^{57,58} The few available papers addressing race and/or payment status which do pose a similar research question to ours—i.e., “When investigating a defined operation(s), which factors might influence the postoperative outcomes?”—have largely elected to address only race^{54–56,58–60} or payment status, but rarely both.^{53,57,61,62} Of the few papers which address both race and payment status, none of their analyses include the effect (if any) of surgical trainee participation on

postoperative outcomes. Consequently, our present study, which includes race and payment method in our analysis, along with a multitude of other patient and hospital factors (e.g., patient sex, age, GI/MIS fellowship program presence, hospital geographical region, hospital volume, inpatient/outpatient surgery, and a plethora of different patient comorbidities and social factors) provides a substantially more complete analysis than other available studies, translating into more reliable conclusions.

Despite these strengths, however, our study still has several limitations, some of which are attributable to the study's design and some to its use of an administrative database. As a retrospective cohort study, no power analysis is appropriate in this study. All observed information, such as a patient's characteristics and comorbidities, has been considered a potential confounding factor. Administrative databases possess multiple inherent limitations—they may contain errors, lack clinically rich data, and lack detailed operation information (e.g., attending surgeon skill/involvement, operation duration, blood loss, or other operative variables). As a result, there might be unobserved confounding variables affecting our study results which were not considered during our analysis. A specific limitation of the SPARCS database is its failure to continue following patients if they leave NYS and receive further care elsewhere. This caveat is countered by the database's ability to capture ED visits and hospital readmissions to different hospitals within NYS which might otherwise be overlooked. The degree to which these factors would influence our study's outcomes are likely negligible given the 30-day time period, and the comparable loss of patients from both study populations; however, the exact impact of these factors remains unknown. Regarding hospitals selected for comparison in our analysis, we only compared hospitals which possess an MIS fellowship against those which do not; this analysis does not take into account the presence/absence of other surgical trainees (i.e., residents) or of medical students. Our study does not account for hospitals which lack their own MIS fellowship, but which host rotating MIS fellows.

Additionally, our analysis can be further confounded by differences in attending surgeon training (e.g., MIS fellowship-trained might be performing these operations at hospitals without an MIS fellowship, or non-fellowship-trained surgeons might have sufficient experience to comfortably perform the same operations at hospitals with/without an MIS training program, etc.). To elaborate on this latter scenario, some surgeons (e.g., thoracic surgeons and/or surgical oncologists) might possess the necessary skill set and experience to comfortably perform laparoscopic fundoplication and/or esophagomyotomies, even without completing a dedicated MIS fellowship training program.

Similar potential confounding variables pertain to each fellow's unique training background (in terms of fund of

knowledge, technical ability, adaptability, motivation, interpersonal skills, etc.). These backgrounds are based on each fellow's experiences prior to and during residency, and have not been controlled for in our analysis. Furthermore, our study does not evaluate the degree of intraoperative and postoperative fellow involvement, or confirm the involvement at all, factors which are important to consider but difficult to control. To elaborate, for cases in which a fellow was scrubbed, we were not able to clarify the degree of fellow, attending or other trainee involvement. Regarding the postoperative period, it is also unknown what level of trainee or attending was actively involved in any/every issue that arose.

Lastly, as the study only evaluates outcomes for NYS, the results might not generalize to all GI/MIS fellowship programs across the USA. Further research is therefore recommended to investigate whether the trends and outcomes we observed for foregut operations performed in NYS still hold true for those performed throughout the rest of the country.

As modern surgical practice continues to trend towards specialization instead of general practice, GI/MIS fellowships are a popular training option. From our analysis, we can claim that fellowship training does not adversely affect patient outcomes. It is important for surgical training programs to be aware of the potential impact trainee involvement might have on patient outcomes, as patient safety is always the priority. This awareness allows the programs to continually adjust surgical training so trainees can achieve the best possible training experience without compromising patient care.

Conclusion

Patients undergoing foregut surgery (specifically laparoscopic fundoplication or esophagomyotomy) should be reassured that their care will not be effected by the involvement of a GI/MIS fellow, and that hospitals with and without such fellowship programs exhibit remarkably similar outcomes (in terms of serious complication rates, LOS, and 30-day readmission rates). Patient outcomes are, however, independently associated with patient race and payment method, and these associations extend beyond a differential access to care. Asian race is associated with the highest postoperative complication rates and 30-day readmission rates, whereas commercial insurance is associated with the lowest 30-day readmission rates and the shortest postoperative LOS. Further research is recommended to assure that such observations hold true on the national level in addition to our NYS population.

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