Published in final edited form as:

J Surg Educ. 2016 ; 73(4): 609–615. doi:10.1016/j.jsurg.2016.02.010.

Declining operative experience for junior level residents: Is this an unintended consequence of minimally invasive surgery?

Matthew G. Mullen, MD^A, Elise P. Salerno, MD^A, Alex D. Michaels, MD^A, Traci L. Hedrick, MD^A, Min-Woong Sohn, PhD^B, Philip W. Smith, MD^A, Bruce D. Schirmer, MD^A, and Charles M. Friel, MD^A

^ADepartment of Surgery, University of Virginia, P.O. Box 800709, Charlottesville, VA. USA

^BDepartment of Public Health Sciences, Health System Old Medical School Room 3874, University of Virginia, Charlottesville VA. USA

Abstract

Introduction—Our group has previously demonstrated an upward shift from junior to senior resident participation in common general surgery operations, traditionally performed by junior level residents. The objective of this study was to evaluate if this trend would correct over time. We hypothesized that junior resident case volume would improve.

Methods—A sample of essential laparoscopic and open general surgery procedures (appendectomy, inguinal herniorrhaphy, cholecystectomy, and partial colectomy) was chosen for analysis. The ACS NSQIP Participant Use Files were queried for these procedures between 2005–2012. Cases were stratified by participating resident post-graduate year (PGY) with ‘junior resident’ defined as PGY1–3. Logistic regression was performed to determine change in junior resident participation for each type of procedure over time.

Results—185,335 cases were included in the study. For three of the operations we considered, the prevalence of laparoscopic surgery increased from 2005–2012 (all $p < 0.001$). Cholecystectomy was an exception, which showed an unchanged proportion of cases performed laparoscopically across the study period ($p = 0.119$). Junior resident participation decreased by 4.5%/year ($p < 0.001$) for laparoscopic procedures and by 6.2%/year ($p < 0.001$) for open procedures. The proportion of laparoscopic surgeries performed by junior level residents decreased for appendectomy by 2.6%/year ($p < 0.001$) and cholecystectomy by 6.1%/year ($p < 0.001$), whereas it was unchanged for inguinal herniorrhaphy ($p = 0.75$) and increased for partial colectomy by 3.9%/year ($p = 0.003$). A decline in junior resident participation was seen for all open surgeries, with appendectomy decreasing by 9.4%/year ($p < 0.001$), cholecystectomy by 4.1%/year ($p < 0.002$), inguinal herniorrhaphy by 10%/year ($p < 0.001$) and partial colectomy by 2.9%/year ($p < 0.004$).

Conclusions—Along with the proliferation of laparoscopy for common general surgical procedures there has been a concomitant reduction in the participation of junior level residents. As previously thought, familiarity with laparoscopy has not translated to redistribution of basic

Correspondence to: Charles M. Friel, MD, Department of Surgery, University of Virginia Health System, P.O. Box 800709, Charlottesville, VA 22908-0709, Phone: 434-243-9970, Fax: 434-924-2520, cmf2x@virginia.edu.

The authors have no financial disclosures or conflicts of interest relevant to this manuscript.

operations from senior to junior residents. This trend has significant implications for general surgery resident education.

Keywords

Residency training; laparoscopy; surgery; education; junior resident; operative volume; surgical residency

Introduction

There exists growing concern that general surgery residents feel unprepared to practice independently in a broad general surgery practice at the completion of residency.^{1, 2} At present, 80% of graduating residents choose to pursue further fellowship training. A recent poll of fellowship program directors reveals that nearly 25% graduating general surgery chief residents lack the required skill and experience to operate independently.³ Though this issue is multifactorial, diminished operative experience likely contributes to a decline in resident confidence in the operating room. Work hour restrictions limit the time residents spend operating, and the omnipresent litigious nature of American medicine has driven surgical educators to oftentimes perform so-called “critical portions” of operations.⁴

Minimally invasive surgery has become the standard of care for many common operations including appendectomy, cholecystectomy, and colectomy. Laparoscopy has several advantages over open surgery, including a marked reduction in the rate of incisional hernia, postoperative wound infection, and postoperative length of stay. Additionally, excellent cosmetic outcomes and earlier return to regular activities have contributed to the proliferation of laparoscopic technique at a majority of medical institutions.⁵ A recent national review found that 37% of cases logged by general surgery residents are done laparoscopically, when there is an option to perform the case open or laparoscopic.⁶ In 2008, our group had shown the rise in laparoscopic surgery to be accompanied by a reduction in junior resident participation in what, as open operations, previously would have been junior level cases.⁷ The general response from the surgical community has been that this issue would correct over time, and the distribution of cases to junior residents would normalize. The assumption has been that increasing familiarity with laparoscopic technique would make surgical educators as comfortable performing laparoscopic operations with junior residents as they previously had been with open appendectomy, hernia repair, and cholecystectomy.

In this study we sought to evaluate continuing trends in case distribution among junior and senior residents. We chose essential laparoscopic and open general surgery procedures and queried a large, generalizable national database. We hypothesized that the trend of decreasing junior resident operative experience would resolve over the eight years following our initial study.

Materials and Methods

An observational, multi-institutional, cohort study was conducted through query of the Participant Use Data File (PUF) available to participants of the American College of

Surgeons National Surgical Quality Improvement Program (ACS NSQIP). The PUF is a nationwide, robust and comprehensive dataset designed to improve the quality of surgical care. The dataset captures 30-day complications and mortality following major surgical procedures. Cases included in ACS NSQIP are identified by current procedural terminology [CPT] code and recorded by surgical clinical reviewers specific at each participating site. Cases are excluded if the patient is under 18 years of age. Important for this study, if more than 3 laparoscopic cholecystectomies or inguinal herniorrhaphies are performed at a participating institution in an 8-day period, the additional cases are excluded from the dataset. ACS NSQIP PUF methodology and risk-stratification are described elsewhere.⁸ Data were analyzed on cases of laparoscopic and open appendectomy (CPT codes 44970 and 44950), inguinal hernia repair (CPT codes 49650 and 49505), cholecystectomy (CPT codes 47562 and 47600) and partial colectomy (CPT codes 44204 and 44140) from 2005–2012. Appendectomy, cholecystectomy and hernia repair were selected to represent procedures which have historically been designated as ‘junior resident level’ cases when performed open. Colectomy was included as an example of a more complex surgical procedure, which we did not anticipate to show an increase in junior resident participation over time.

Cases were stratified according to the level of resident performing the case. In the NSQIP PUF, resident level is recorded as Post-Graduate Year [PGY] representing the number of years since a resident graduated from medical school. We defined “junior” residents as PGY 1–3 and “senior” residents as PGY 4 and greater. Cases that did not include resident level were excluded from analysis.

Logistic regression with SPSS Statistics Version 22.0 (IBM, Armonk NY) and Stata SE Version 14.0 (StataCorp, College Station TX) was used to determine the impact of time on the proportion of cases performed laparoscopically (vs. open), and the likelihood that a junior resident would perform each type of procedure. Results were analyzed as the annual change in odds. The Institutional Review Board at the University of Virginia approved the study protocol.

Results

A total of 414,965 cases were performed during the study period of which 185,335 (44.7%) included PGY level data and were analyzed. The number of cases included for each operation and total number of cases included per year are illustrated in Table 1.

The percent of all cases performed by junior residents stratified by procedure type each year is illustrated in Table 2. Over the eight-year period, the proportion of operations performed laparoscopically increased for all procedure combined (Figure 1). The percent of each procedure performed laparoscopic and open each year is displayed in Table 3. Each year, the likelihood that a surgery would be performed laparoscopically increased for appendectomy, inguinal herniorrhaphy and colectomy (Table 4). The percent of cholecystectomies performed laparoscopically remained unchanged over the study period.

The proportion of all included cases performed by junior residents over the studied time period is illustrated in Figure 2. Likelihood of junior resident participation in all procedures decreased by 5.3% per year ($n=185,335$; OR = 0.947; 95% CI, 0.942 – 0.951; $p<0.001$). As shown in Figure 3, the likelihood of junior residents performing laparoscopic operations decreased for appendectomy by 2.6% per year ($n= 47,423$; OR = 0.974; 95% CI, 0.963 – 0.984; $p<0.001$) and cholecystectomy by 6.2% per year ($n= 55,057$; OR = 0.938; 95% CI, 0.930 – 0.947; $p<0.001$), whereas it did not change for inguinal herniorrhaphy ($n=9,229$; OR = 0.996; 95% CI, 0.974 – 1.019; $p=0.747$) and increased for partial colectomy by 3.9% per year ($n=11,141$; OR = 1.039; 95% CI, 1.013 – 1.065; $p=0.003$). The distribution of open operations performed by junior residents decreased for all four procedures. Each year, the likelihood of junior residents performing open operations decreased for appendectomy by 9.4% ($n=8,515$; OR = 0.906; 95% CI, 0.884 – 0.928; $p<0.001$), cholecystectomy by 4.1% ($n=7,496$; OR = 0.959; 95% CI, 0.934 – 0.984; $p<0.002$), inguinal herniorrhaphy by 10.0% ($n=31,273$; OR = 0.900; 95% CI, 0.888 – 0.911; $p<0.001$) and partial colectomy by 2.9% ($n=15,201$; OR = 0.971; 95% CI, 0.952 – 0.991; $p<0.004$). The logistic regression analysis for the above results can be found in the **Appendix**.

Discussion

A large majority of graduating surgical residents chooses to enter fellowship prior to practicing independently, and many hypothesize this is largely due to residents lacking confidence to begin a broad general surgery practice. To address this issue, the American College of Surgeons has developed “Transition to Practice” fellowships.⁹ These programs focus on general surgery procedures required for private practice that residents presumably should have learned during residency training. Moreover, a recent poll of fellowship program directors indicates that respondents estimate 21% of graduated chief residents to be unprepared to operate independently, also estimating that 66% of surgical fellows are unable to perform a major procedure unsupervised for 30 minutes.¹⁰

Work hour restrictions have been found to impact general surgery residents at all levels, however the reported effect on resident case volume has been mixed.¹¹ With the introduction of work hour restrictions in 2003, multiple single-institution studies noted an initial decline in the total number of operative cases logged by graduating residents.^{12–14} However, it appears the total operative volume of graduating chief residents has rebounded since 2005, and several systematic reviews have found that duty hour restrictions may not impact resident operative volume as much as was initially believed.^{11, 15, 16} It is important to note that the number of operations performed 10 times or greater by individual residents has not improved with increased operative volume.¹⁷ A recent study of 121 procedures, described by program directors as essential to general surgery practice, finds that graduating residents only perform 18 of 121 procedures an average of ten times or greater during training.¹⁸ Dennis et al found that restricting intern work hours to 16 hours has resulted in junior residents spending more time rounding on patients, whereas senior residents spend more time in the operating room.¹⁹

This study reveals that laparoscopy continues to affect junior general surgery residents’ participation in common operations, many of which classically have been thought to be

‘junior-level’ cases. Each year, greater proportions of common general surgery procedures are performed in laparoscopic fashion. Across this national dataset from 2005 through 2012, the proportion of partial colectomies performed laparoscopically has increased by 80%. Distribution of laparoscopic procedures performed by junior residents has decreased for both appendectomy and cholecystectomy, and has remained stable for laparoscopic herniorrhaphy. Interestingly, we have noted a slight increase for laparoscopic colectomy, which was included as an example of a more complex, traditionally senior-level case. This finding was unexpected and inconsistent with the trends we noted for basic operations. Junior resident participating in more advanced surgical procedures, including colorectal, thoracic, and hepatobiliary surgery has not been extensively studied and warrants further evaluation. These data also indicate that junior resident participation in open surgeries has decreased dramatically, with 10% overall decline for both open appendectomy and hernia repair. Unexpectedly, for all open and laparoscopic cases combined, we have found a marked decline in the proportion of cases being performed by junior residents from 53.7% in 2005 to 42.5% in 2012.

The reason for diminishing junior resident case volume for the basic general surgery procedures we examined is not truly known. It is possible that these common and technically straightforward cases, traditionally the training ground for junior residents, now require advanced laparoscopic skills and therefore are no longer appropriate for junior-level residents. Malagoni et al studied resident case volume nationally and found a large decline in open cavity surgery and an increased volume of endoscopic and laparoscopic surgery between 2005 and 2011.¹⁷ As the number of open cases declines, senior residents likely feel the need to participate in these traditionally junior level cases due to lack of exposure during their own junior years. It is also likely that laparoscopy has become the preferred approach for these operations, and an open approach is reserved for reoperative patients and more technically complex cases, which may contribute to the upward shift in participating resident level. These factors both likely contribute to the trends noted in this study.

Mattar et al have shown that many graduates of surgical training programs lack advanced laparoscopic skills including knot tying and laparoscopic suturing.¹⁰ Reduced exposure to the operating room as a junior resident likely contributes to this issue. With fewer opportunities to operate during the first three years of residency, the time and necessary repetition required to master advanced laparoscopic techniques are curtailed. Early participation in laparoscopy and increased volume of operating throughout training may improve confidence and comfort of residents as they progress toward independent practice. In 2014, the American Board of Surgery [ABS] has begun requiring that every resident log 250 cases by the completion of the second year of training. Specifically requiring junior residents to log a minimum number of laparoscopic and open cavity cases aims to increase operative volume early in residency. The ABS also now requires that all chief residents record 25 teaching assistant cases prior to graduation. This will undoubtedly improve the participation of junior residents in both laparoscopic and open surgery while giving senior residents opportunities to master their own skills.

If the ABS measures do not prove sufficient, new and supplemental training methods outside the operating room will be needed to advance the skills of early trainees. Surgical simulation

experiences have gained widespread attention nationally across residency programs. Bench models, virtual tools, live animal models, and other opportunities have shown early promise in addressing basic surgical skill acquisition for junior residents.^{20–22} As with any technology, cost of simulation has hindered universal adoption of these resources.

The trend of increasing complexity of historically “basic” operations continues with the growth in popularity of robotic surgery, which has been adopted by a majority of US hospitals⁵. Despite high prevalence of use, few residents receive meaningful training in these evolving techniques. In a survey sent to 240 ACGME approved programs, the most frequent involvement of residents with robotic surgery has involved docking the robot, inserting trocars, and changing instruments.²³ An elaborate and realistic simulation program exists for training on the *Da Vinci* Surgical System (Intuitive Surgical Inc., Sunnyvale CA), which optimistically will promote resident proficiency in robot-assisted surgery and allow for further resident involvement.

While we are confident in the observations noted, a few limitations of the study are worth noting. Individual hospitals are not identified in NSQIP PUF, and trends may differ between community and academic training environments. With national-level data, we are unable to determine if individual residents with poor junior operative experience have high compensatory proportion of cases performed as senior residents. It is important to note that NSQIP PUF provides a sample of the cases performed nationally, and the number of institutions and cases included changes each year. We were unable to assess actual volume of cases performed by junior residents, but only proportions and likelihood that a case will be performed by a junior or senior resident. The resident PGY variable in NSQIP PUF includes only the most senior resident who participates in each case, raising the possibility that junior resident participation was missed in some cases. However, we estimate this to be a minority of cases, as a recent study by Sachs demonstrates a 79% decrease in number of teaching cases between 1999 and 2012.²⁴ Finally, we have observed that the annual number of NSQIP PUF cases capturing PGY data declines from a maximum of 35,409 cases in 2010 to 18,946 and 12,916 cases for 2011 and 2012, respectively. The reason for variable capture of this data point is not clear. The observed trend in junior resident case volume is linear across the entire dataset, and the final two years follow a predictable trajectory consistent with data from 2005–2010. With a minimum of nearly 13,000 cases annually, we are confident that these results are robust.

Conclusions

Contrary to our original hypothesis, there has been a steady decrease in the proportion of several common laparoscopic and open operations performed by junior residents from 2005 to 2012. This observation of an ever-increasing shift of operative experience to the senior years of residency should compel us to improve case volume and find new means of educating our junior trainees. As rising numbers of graduating chief residents perform basic cases in the operating room, report unease at graduation, and are observed by program directors to be incapable of operating independently, the want for timely intervention is clear.

Acknowledgments

Research reported in this publication was supported by the National Institutes of Health under award numbers T32CA163177 (Mullen) and T32AI0074 (Michaels). The content of this manuscript is solely the responsibility of the authors and does not necessarily represent the official views of the National Institutes of Health.

References

1. Nadler A, Ashamalla S, Escallon J, Ahmed N, Wright FC. Career plans and perceptions in readiness to practice of graduating general surgery residents in Canada. *Journal of surgical education*. 2015; 72:205–211. [PubMed: 25457941]
2. Park A, Kavic SM, Lee TH, Heniford BT. Minimally invasive surgery: the evolution of fellowship. *Surgery*. 2007; 142:505–511. discussion 511–503. [PubMed: 17950342]
3. Coleman JJ, Esposito TJ, Rozycki GS, Feliciano DV. Early subspecialization and perceived competence in surgical training: are residents ready? *Journal of the American College of Surgeons*. 2013; 216:764–771. discussion 771–763. [PubMed: 23521960]
4. Jamal MH, Wong S, Whalen TV. Effects of the reduction of surgical residents' work hours and implications for surgical residency programs: a narrative review. *BMC Med Educ*. 2014; 14(Suppl 1):S14. [PubMed: 25560685]
5. Barbash GI, Friedman B, Glied SA, Steiner CA. Factors associated with adoption of robotic surgical technology in US hospitals and relationship to radical prostatectomy procedure volume. *Annals of surgery*. 2014; 259:1–6. [PubMed: 23965894]
6. Richards MK, McAteer JP, Drake FT, Goldin AB, Khandelwal S, Gow KW. A national review of the frequency of minimally invasive surgery among general surgery residents: assessment of ACGME case logs during 2 decades of general surgery resident training. *JAMA Surg*. 2015; 150:169–172. [PubMed: 25548997]
7. Hedrick T, Turrentine F, Sanfey H, Schirmer B, Friel C. Implications of laparoscopy on surgery residency training. *American journal of surgery*. 2009; 197:73–75. [PubMed: 19101247]
8. ACS NSQIP Participant Use File: American College of Surgeons. 2014.
9. Cogbill TH, Shapiro SB. Transition from Training to Surgical Practice. *Surg Clin North Am*. 2016; 96:25–33. [PubMed: 26612017]
10. Mattar SG, Alseidi AA, Jones DB, et al. General surgery residency inadequately prepares trainees for fellowship: results of a survey of fellowship program directors. *Annals of surgery*. 2013; 258:440–449. [PubMed: 24022436]
11. Scally CP, Reames BN, Teman NR, Fritze DM, Minter RM, Gauger PG. Preserving operative volume in the setting of the 2011 ACGME duty hour regulations. *J Surg Educ*. 2014; 71:580–586. [PubMed: 24969673]
12. Kairys JC, McGuire K, Crawford AG, Yeo CJ. Cumulative operative experience is decreasing during general surgery residency: a worrisome trend for surgical trainees? *Journal of the American College of Surgeons*. 2008; 206:804–811. discussion 811–803. [PubMed: 18471701]
13. Carlin AM, Gasevic E, Shepard AD. Effect of the 80-hour work week on resident operative experience in general surgery. *Am J Surg*. 2007; 193:326–329. discussion 329–330. [PubMed: 17320528]
14. Feanny MA, Scott BG, Mattox KL, Hirshberg A. Impact of the 80-hour work week on resident emergency operative experience. *Am J Surg*. 2005; 190:947–949. [PubMed: 16307951]
15. Jamal MH, Rousseau MC, Hanna WC, Doi SA, Meterissian S, Snell L. Effect of the ACGME duty hours restrictions on surgical residents and faculty: a systematic review. *Acad Med*. 2011; 86:34–42. [PubMed: 21099662]
16. Fletcher KE, Reed DA, Arora VM. Patient safety, resident education and resident well-being following implementation of the 2003 ACGME duty hour rules. *J Gen Intern Med*. 2011; 26:907–919. [PubMed: 21369772]
17. Malangoni MA, Biester TW, Jones AT, Klingensmith ME, Lewis FR Jr. Operative experience of surgery residents: trends and challenges. *J Surg Educ*. 2013; 70:783–788. [PubMed: 24209656]

18. Bell RH Jr, Biester TW, Tabuenca A, et al. Operative experience of residents in US general surgery programs: a gap between expectation and experience. *Ann Surg.* 2009; 249:719–724. [PubMed: 19387334]
19. Dennis BM, Long EL, Zamperini KM, Nakayama DK. The effect of the 16-hour intern workday restriction on surgical residents' in-hospital activities. *J Surg Educ.* 2013; 70:800–805. [PubMed: 24209659]
20. Dawe SR, Pena GN, Windsor JA, et al. Systematic review of skills transfer after surgical simulation-based training. *The British journal of surgery.* 2014; 101:1063–1076. [PubMed: 24827930]
21. Hu Y, Goodrich RN, Le IA, et al. Vessel ligation training via an adaptive simulation curriculum. *The Journal of surgical research.* 2015; 196:17–22. [PubMed: 25796112]
22. Nistor A, Jiga L, Georgescu D, et al. Abstract 39: the pig as an ideal training model for perforator flap dissection in living tissue. *Plastic and reconstructive surgery.* 2014; 133:49. [PubMed: 25942150]
23. Farivar BS, Flannagan M, Leitman IM. General surgery residents' perception of robot-assisted procedures during surgical training. *Journal of surgical education.* 2015; 72:235–242. [PubMed: 25451717]
24. Sachs TE, Pawlik TM. See one, do one, and teach none: resident experience as a teaching assistant. *The Journal of surgical research.* 2015; 195:44–51. [PubMed: 25703163]

Figure 1.

Proportion of surgical procedures performed laparoscopically vs. open each year from 2005–2012

Figure 2.
Junior vs. senior resident participation in all procedures, combined open, and combined laparoscopic procedures from 2005–2012

Figure 3.

Top row – Junior vs. senior resident participation in each laparoscopic procedure considered over time

Bottom row – Junior vs. senior resident participation in each open procedure considered over time

Table 1

Number of cases performed each year stratified by resident level

Surgery characteristics	All, N (%)	Resident status, N (%)		P-Value
		Junior	Senior	
Year of operation				
2005	6,601 (3.6%)	3,545 (53.7%)	3,056 (46.3%)	< 0.001
2006	18,545 (10.0%)	9,653 (52.1%)	8,892 (47.9%)	
2007	26,981 (14.6%)	13,688 (50.7%)	13,293 (49.3%)	
2008	31,353 (16.9%)	15,877 (50.6%)	15,476 (49.4%)	
2009	34,584 (18.7%)	17,653 (51.0%)	16,931 (49.0%)	
2010	35,409 (19.1%)	17,175 (48.5%)	18,234 (51.5%)	
2011	18,946 (10.2%)	8,492 (44.8%)	10,454 (55.2%)	
2012	12,916 (7.0%)	5,457 (42.2%)	7,459 (57.8%)	
Total all years	185,335 (100.0%)	91,540 (49.4%)	93,795 (50.6%)	
Procedure name				
Appendectomy	55,938 (30.2%)	28,693 (51.3%)	27,245 (48.7%)	< 0.001
Inguinal herniorrhaphy	40,502 (21.9%)	25,309 (62.5%)	15,193 (37.5%)	
Colecotomy	26,342 (14.2%)	6,571 (24.9%)	19,771 (75.1%)	
Cholecystectomy	62,553 (33.8%)	30,967 (49.5%)	31,586 (50.5%)	< 0.001
Laparoscopic procedure	122,400 (66.0%)	58,363 (47.7%)	64,037 (52.3%)	

Table 2

Percent of cases performed by junior residents by year and procedure type

Year	Appendectomy		Inguinal herniorrhaphy		Colectomy		Cholecystectomy		All	
	Open	Laparoscopic	Open	Laparoscopic	Open	Laparoscopic	Open	Laparoscopic	Open	Laparoscopic
2005	67.5%	49.7%	76.8%	36.3%	32.9%	15.9%	39.0%	54.5%	60.3%	49.5%
2006	61.1%	47.6%	70.8%	43.0%	27.9%	18.8%	39.3%	55.6%	55.3%	50.3%
2007	58.3%	49.2%	71.9%	45.4%	28.1%	21.0%	36.6%	52.8%	55.0%	48.1%
2008	57.4%	52.9%	70.0%	42.5%	25.3%	21.0%	38.5%	52.0%	53.3%	49.1%
2009	59.4%	53.3%	69.4%	46.7%	25.7%	23.7%	39.9%	52.8%	53.2%	49.9%
2010	54.1%	50.9%	66.0%	43.2%	26.9%	24.8%	34.7%	50.3%	50.9%	47.4%
2011	48.2%	46.1%	62.0%	42.4%	27.0%	24.6%	33.3%	45.2%	48.6%	43.2%
2012	42.6%	43.4%	56.0%	41.1%	23.8%	18.9%	30.6%	44.0%	45.1%	41.1%

Table 3

Percent of cases performed open and laparoscopic each year

Year	Appendectomy		Inguinal herniorrhaphy		Cholecystectomy		Colectomy	
	Open	Laparoscopic	Open	Laparoscopic	Open	Laparoscopic	Open	Laparoscopic
2005	29.71%	70.29%	81.91%	18.09%	10.05%	89.95%	70.92%	29.08%
2006	26.43%	73.57%	80.65%	19.35%	10.13%	89.87%	66.07%	33.93%
2007	20.98%	79.02%	80.92%	19.08%	13.70%	86.30%	62.29%	37.71%
2008	17.32%	82.68%	80.45%	19.55%	14.82%	85.18%	61.02%	38.98%
2009	12.86%	87.14%	76.80%	23.20%	13.17%	86.83%	60.01%	39.99%
2010	11.48%	88.52%	74.43%	25.57%	12.93%	87.07%	53.07%	46.93%
2011	10.35%	89.65%	72.54%	27.46%	9.99%	90.01%	52.34%	47.66%
2012	8.34%	91.66%	71.81%	28.19%	10.00%	90.00%	47.73%	52.27%

Table 4

Odds ratio that surgery is performed laparoscopic (Per year, unadjusted)

Surgery	OR (95% CI)	P-value
Appendectomy	1.265 (1.248 – 1.282)	< 0.001
Inguinal herniorrhaphy	1.104 (1.090 – 1.118)	< 0.001
Colectomy	1.133 (1.117 – 1.148)	< 0.001
Cholecystectomy	1.010 (0.997 – 1.023)	0.119
All procedures	1.069 (1.063 – 1.074)	< 0.001