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# The Impact Of Acute Care Surgery on Appendicitis Outcomes: Results from a National Sample of University Affiliated Hospitals

**John C. Madore, BS**, **Courtney E. Collins, MD**, **M. Didem Ayturk, MS**, and **Heena P. Santry, MD MS**

Department of Surgery (JCM, CEC, MDA, HPS) at the University of Massachusetts Medical School, Worcester, MA, USA; Surgery and Department of Quantitative Health Sciences (DA, HPS) at the University of Massachusetts Medical School, Worcester, MA, USA

## Abstract

**Background—**Acute appendicitis is the most common indication for emergency general surgery (EGS) in the US. We examined the role of acute care surgery (ACS) on interventions and outcomes for acute appendicitis at a national sample of university-affiliated hospitals.

**Methods—**We surveyed senior surgeons responsible for EGS coverage at University HealthSystems Consortium (UHC) hospitals, representing >90% of university-affiliated hospitals in the US. The survey elicited data on resources allocated for EGS during 2013. Responses were linked to UHC outcomes data by unique hospital identifiers. Patients treated at hospitals reporting hybrid models for EGS coverage were excluded. Differences in interventions and outcomes between patients with acute appendicitis treated at ACS hospitals vs. hospitals with a general surgeon on-call model (GSOC) were analyzed using univariate comparisons and multivariable logistic regression models adjusted for patient demographics, clinical acuity, and hospital characteristics.

**Results—**We found 122 hospitals meeting criteria for analysis where 2,565 patients were treated for acute appendicitis. 48% of hospitals had an ACS model (N =1414), and 52% had a GSOC model (N=1151). Hospitals with ACS models were more likely to treat minority patients with greater severity of illness than GSOC models. Patients treated at ACS hospitals were more likely to undergo laparoscopic appendectomy. In multivariable modeling of patients who had surgery (N=2,258), patients treated at ACS hospitals had 1.86 [95%CI 1.23,2.80] greater odds of undergoing laparoscopic appendectomy.

**Conclusion—**In an era when laparoscopic appendectomy is increasingly accepted for treating uncomplicated acute appendicitis, particularly in low risk patients, it is concerning that patients

john.madore@umassmed.edu (J.C.M.);. courtney.collins@umassmemorial.org (C.E.C.);. didem.ayturk@umassmed.edu (M.D.A.);. heena.santry@umassmemorial.org (H.P.S.);. **Address for correspondence:** Heena P. Santry, MD MS, Department of Surgery, Room S3-731, 55 Lake Avenue North, Worcester, MA 01655, USA; Fax number: 508-856-4224; telephone: 508-856-1168. john.madore@umassmed.edu.

**Author Contribution statement:**

John Madore: Literature search, study design, data collection, data analysis, data interpretation, writing, critical revision

Courtney Collins: Literature search, study design, data collection

Didem Ayturk: Data analysis

Heena Santry: Dr. Santry is the mentor our group; literature search, study design, data collection, data analysis, data interpretation, critical revision

treated at GSOC model hospitals are more likely to undergo traditional open surgery despite having less severity of illness at the time of presentation. Furthermore, hospitals with ACS are functioning as safety net hospitals for vulnerable patients with acute appendicitis.

**Level of Evidence—**III

### Keywords

Acute Care Surgery; acute appendicitis; safety-net; outcomes; quality

## Introduction

Emergency general surgery (EGS) admissions are sharply increasing in hospitals across the United States (1). The most common indication for EGS in the United States remains acute appendicitis (2). A worsening crisis in access to care for EGS in the latter part of the 20th century led, in part, to the emergence of acute care surgery (ACS) as a model of caring for EGS patients (3), many of whom will present with acute appendicitis. This new model of care was presumed to improve outcomes compared to the traditional method of covering EGS with an on call general surgeon (4, 5, 6). Since ACS was first conceptualized as a novel model of care, several single-center retrospective studies have shown improved outcomes after implementation of ACS for a number of non-trauma surgical emergencies including appendicitis (7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17).

Appendicitis is a time-sensitive disease. Initial inflammatory acute appendicitis will progress to appendiceal rupture and abscess formation if the disease is allowed to follow its natural course (18). While recent literature has suggested a role for non-operative management of acute appendicitis, early surgical source control is still the standard of care, in particular for non-ruptured appendicitis or early rupture without phlegmon or abscess formation (19). Studies examining the impact of ACS on outcomes for acute appendicitis have found a number of benefits including decreases in time to operating room, rate of rupture, complication rates, and hospital lengths of stay (7, 8, 9). One study, however, found equivalent outcomes for time to operating room and the rates of perforation before and after the implementation of ACS (10).

To date, there are no national studies measuring the impact of ACS implementation on outcomes for acute appendicitis across hospitals. We sought to examine the role of ACS in outcomes for acute appendicitis by linking outcomes data from a national quality collaboration with a national survey of university affiliated hospitals. We hypothesized that acute appendicitis patients treated at hospitals with ACS models would experience better outcomes than patients treated at hospitals with a general surgeon on call (GSOC) model for EGS coverage.

## Methods

We conducted a survey of University Health Systems Consortium Hospitals (UHC). UHC is a cost and quality improvement collaborative, with participation from 90% of all US academic centers and over 200 of their affiliated hospitals (20). Participating hospitals share their billing data in the UHC clinical data base resource manager (CDB/RM). The CDB/RM captures 100% of the patients treated at these centers and provides the following information: synthetic hospital and surgeon identifiers including specialty, unique patient visit identifiers, patient demographics, financials, procedural and diagnostic information.

Using exploratory data acquired from a qualitative study interviewing surgeons responsible for acute care surgery at 18 teaching hospitals (21, 22), we developed and tested a survey instrument in an iterative fashion creating an 8-page questionnaire that included items on resources allocated for EGS care at UHC hospitals. The survey was implemented using a hybrid postal and email methodology targeting a single senior surgeon at each hospital who would be able to respond to queries regarding the structures and processes for EGS care at their hospital as described previously (30). The survey was implemented from June 2013 to November 2013. The survey and linkage to subsequent outcomes data was deemed exempt by our institutional review board.

Survey data were compiled and analyzed. Of 319 hospitals surveyed, 258 responded for an 81% response rate. Responses to survey data were anonymously linked to CDB/RM data by unique hospital identifiers. All patient data were de-identified. Because some health systems report data across their individual hospitals and we surveyed individual hospitals specifically to measure their differences in EGS practices, these hospitals (N = 113) were excluded from data linkage. Thus, the final analyses presented here represent 122 individual UHC hospitals. The survey was conducted in the first half of the calendar year; therefore we linked to outcomes data for the first full quarter of data available after the close of the survey. Due to the rapidly evolving nature of ACS, we were concerned that survey responses might not be applicable many quarters after the survey closed; thus only one quarter of data was analyzed. Patients admitted to these hospitals with appendicitis were identified by ICD-9 diagnosis codes (540, 5400, 5401, 5409).

We measured the impact of the presence of an ACS model (vs GSOC) on aggregate outcomes for appendicitis including intervention (open appendectomy [ICD-9 = 47.09], laparoscopic appendectomy [ICD-9 = 47.01], radiologically-placed drains [ICD-9 = 47.2], or none) (see Appendix 1), need for ICU care, morbidity (any complication, specific complications), mortality, overall length of stay (LOS), and total charges. CDB/RM calculates costs using institutional specific cost-to-charge ratios obtained from the department-level Medicare cost reports. Federally reported area wage indexes are used to account for regional and center specific cost variations that are not directly attributable to a center.

First, we conducted univariate comparisons using Chi squared tests of association to compare categorical variables, t tests for normally distributed continuous variables, and Wilcoxon rank sum tests for non-normally distributed continuous variables. Next, we conducted multivariable analyses where the primary unit of analysis was the hospital, with patients clustered within hospitals. The main predictor variable of interest was the type of EGS care model (ACS vs GSOC) in each multivariable analysis. Dichotomous outcomes such as mortality or any complication were analyzed using multiple logistic regression (fit by general estimating equations to account for patient clustering within randomly selected hospitals). For continuous outcomes such as LOS and total charges we used mixed models, treating hospital as a random effect. Covariates included in the models encompassed hospital characteristics (number of beds, practice setting, location, teaching status, trauma center verification) as reported in the survey that were different between care models (see Appendix 2), and patient demographic and clinical variables as reported in CDB/RM (age, race, sex, insurance-type, illness severity that differed across care models or interventions/ outcomes in univariate analyses).

UHC's severity of illness (SOI) score has been used previously for both risk adjustment and predicted resource allocation (23). This method of risk assessment has been verified and validated by the Agency for Healthcare Research and Quality (AHRQ) (24). SOI accounts for a number of patient variables and weights them in the context of patient illness, including other co-morbid conditions, age and diagnoses.

## Results

We found 2565 patients with appendicitis treated in the 3rd quarter of 2013 at 122 eligible UHC hospitals. 48% of hospitals responded that an ACS model was in place (N =1414 patients with appendicitis), and 52% responded that a GSOC model was in place (N=1151 patients with appendicitis).

Overall, appendicitis patients at our hospitals were 55% male with a median age of 40 years [IQR 27, 54]. 65% of patients were of white race. 49% of patients were privately insured. The majority of appendicitis patients presented with minor SOI (51%).

Table 1 shows patient characteristics by type of EGS care model. ACS hospitals were more likely to treat black and Hispanic patients, while GSOC hospitals were more likely to treat white and Asian patients. GSOC hospitals were also more likely to treat privately insured patients, while patients who were insured through Medicaid, other governmental insurance, or were uninsured were more likely to be treated at ACS hospitals. Additionally, patients with minor SOI were slightly more likely to be treated at GSOC hospitals, while patients with moderate, major, and extreme SOI were more likely to be treated at ACS hospitals, but these minor differences did not reach statistical significance.

Overall, 90.1% of appendicitis patients underwent some intervention. 15.3% underwent open appendectomy, 72.9% underwent laparoscopic appendectomy, and 1.9% underwent radiologically-guided drain placement. Patients who underwent both a radiologically placed drain and either approach to appendectomy during the same hospitalization equaled <10 patients per combined intervention and are not discussed further.

Table 2 shows differences in patient characteristics by type of operative intervention. Younger patients, those with minor severity of illness, and those treated at ACS hospitals were more likely to undergo laparoscopic appendectomy. We also examined the same association for need for ICU care, hospital LOS of greater or less than one day, and charges incurred greater than $8000. Older patients (20.2% vs 8.5%, $p < 0.0001$), those on Medicare (31.2% vs 11.6%, $p < 0.0001$, those with higher SOI (32.1% vs 3%, $p < 0.0001$), and those treated with open appendectomy (32.1% vs 14.5%, $p < 0.0001$) were more likely to require intensive care (data not shown). Similarly, older patients (12.6% vs 4.3%, p < 0.0001), those on Medicare (17.4% vs 5.9%, p < 0.0001), those with higher SOI (7.2% vs 0.4%, p < 0.0001), and those treated with open appendectomy (20.5% vs 8.4%, p < 0.0001), were more likely to have LOS >1 day (data not shown). In terms of total charges, after dividing the total charges at the median of $8,000, we again found that older patients (11.1% vs 6.9%, p < 0.0001), those on Medicare (15.6% vs 9.3%, p < 0.0001), those with higher SOI (7.1% vs 1.5%, p < 0.0001), and those treated with open appendectomy (17.4% vs 13.2%, p < 0.0001), were more likely to incur higher charges (data not shown).

Table 3 represents these differences in interventions by type of model. Patients treated at GSOC hospitals were more likely to undergo open appendectomy as opposed to laparoscopic appendectomy compared to patients treated at ACS hospitals. Proportions of patients without any intervention or with a drain only were not different across care models. Need for intensive care, LOS, and complications did not differ across models; however, total charges were higher at ACS hospitals.

In multivariable modeling of patients who had surgery (N=2,258), patients treated at ACS hospitals had 1.86 [95% CI 1.23 - 2.80] greater odds of undergoing laparoscopic appendectomy. (Table 4). However, in multivariable modeling adjusted for type of intervention, any complication (for LOS and charges), age, race, primary insurance, severity of illness, and hospital characteristics there were no differences in LOS, complications, or charges between ACS hospitals and GSOC hospitals.

## Discussion

Acute appendicitis is one of the most common indications for EGS in the US, and patients with acute appendicitis are treated at both GSOC and ACS model hospitals (1-3). Our analysis demonstrates that patients treated at ACS hospitals, after adjusting for both hospital and patient confounders, are more likely to undergo laparoscopic appendectomy compared to those treated at hospitals with GSOC models. However, this difference in type of surgery performed was not associated with other outcome differences such as LOS and complications.

Laparoscopic appendectomy has previously been reported as comparable to conventional open appendectomy for the management of acute appendicitis (25, 26). However, meta-analyses have found laparoscopic appendectomy has considerable benefits over open appendectomy, including shorter hospital LOS and lower complications rates, as well as quicker postoperative recovery (25, 26). Some have proposed that laparoscopic appendectomy should be used as the surgical approach to acute appendicitis unless laparoscopy as a technique itself is not possible or is contraindicated in a given patient (25, 26). Our results from a national sample of university-affiliated hospitals suggests that patients treated at hospitals with a more traditional approach to EGS coverage may not be receiving what is increasingly considered the gold standard intervention for acute appendicitis. However, unlike the meta-analyses, we found no associated benefits in outcomes. Our lack of identifying such outcome differences may be attributable to the short duration of our outcomes data (the quarter closest to completion of our survey). Notably, since UHC is an administrative database, we did not have measures of speed of post-operative recovery beyond the index hospitalization.

We also found that patients with minority backgrounds, who were under- or uninsured, or who had higher illness severity were more likely to be treated at ACS hospitals. These findings are consistent with other reports suggesting that hospitals with ACS models function as broad safety-net hospitals to both otherwise underserved sociodemographic groups and more severely ill patients (27, 28). This is likely due to the fact that hospitals adopting ACS are more likely to take on that role across many diagnoses (e.g. urban, larger inpatient bed capacity, higher trauma center verification) (29, 30).

Additionally, there remains debate as to whether ACS is more costly than the GSOC model. One study concluded that ACS model adoption led to decreased hospital costs in the surgical treatment of gallbladder disease (31). Other studies have reported that large, urban, teaching, Level 1 trauma hospitals with a substantial population of ACS patients were more likely to have higher charges compared to rural hospitals and those without defined ACS departments (32, 33). Our univariate analysis suggests that appendicitis patients treated at ACS hospitals incurred higher total charges compared to patients treated at GSOC hospitals; however, this difference did not persist in our multivariable analysis adjusting for type of intervention, any complication, age, race, primary insurance, severity of illness, and hospital characteristics.. This finding suggests that the higher costs at safety-net hospitals may be associated with serving a more underserved or severely ill patient population (27).

Our study does have some limitations. First, our survey is subject to limitations inherent to all surveys such as response bias and construct bias. Second, our outcomes data were derived from billing data and as such we are missing important clinical information which may play a role in selection of operative intervention, if any, for acute appendicitis. Additionally, other factors may have influenced the treatment of appendicitis in terms of laparoscopic or open approach for surgeons at ACS vs. GSOC hospitals besides those inherent to the hospital model, including average time in practice of surgeons, or history of previous surgeries which were data that we did not measure. Furthermore, our analytic model assumed that appendicitis patients treated at each respective hospital received care from a single surgical team which may not have always been the case and might result in misclassification. However, we minimized this effect by eliminating hospitals with a hybrid approach to EGS from our study. Finally, we linked our data for only a quarter of outcomes due to the fact that adoption of ACS was an ongoing phenomenon and we wanted to avoid biasing results toward the null by misclassifying as GSOC hospitals that had implemented ACS more recently than our survey.

Despite these limitations, to our knowledge this is the first national analysis describing the impact of ACS on appendicitis interventions and outcomes. These findings critically add to the national discussion at a time when access to timely and high quality care for acute appendicitis and other non-trauma general surgery emergencies remains an issue, particularly given a rapidly declining general surgery workforce (1-3). In an era when laparoscopic appendectomy is increasingly accepted as the gold standard for treating uncomplicated acute appendicitis, particularly in low risk patients, it is concerning that patients treated at GSOC hospitals are more likely to undergo traditional open surgery despite having less severity of illness at the time of presentation. Furthermore, our findings indicated that hospitals implementating ACS are providing much needed care to vulnerable patients with acute appendicitis, who might otherwise fall through our social safety net, without incurring excess costs.

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**Table 1**

Characteristics of patients with acute appendicitis treated at 122 University HealthSystems Consortium Hospitals based on type of care model for emergency general surgery patients. (N=2,565)

| Patient Characteristics | General Surgeon On-call Model (N=1,151) | Acute Care Surgery model (N=1,414) | *p* value* |
|---|---|---|---|
| Female | 533 (46.3) | 622 (44.0) | 0.2404 |
| *Age (years)* | | | 0.0011 |
| 18-25, N (%) | 238 (20.7) | 346 (24.5) | |
| 26-45, N (%) | 407 (35.4) | 549 (38.8) | |
| 46-65, N (%) | 373 (32.4) | 397 (28.1) | |
| 66-85, N (%) | 116 (10.1) | 114 (8.1) | |
| >85, N (%) | 17 (1.5) | 8 (0.6) | |
| *Race* | | | 0.0126 |
| White, N (%) | 771 (67) | 887 (62.7) | |
| Black, N (%) | 102 (8.9) | 187 (13.2) | |
| Hispanic, N (%) | 189 (16.4) | 237 (16.8) | |
| Asian, N (%) | 53 (4.6) | 60 (4.2) | |
| Other, N (%) | 36 (3.1) | 43 (3) | |
| *Insurance* | | | <0.0001 |
| Private, N (%) | 572 (49.7) | 680 (48.1) | |
| Medicaid, N (%) | 165 (14.3) | 215 (15.2) | |
| Medicare, N (%) | 158 (13.7) | 160 (11.3) | |
| Other Government, N (%) | 18 (1.6) | 31 (2.2) | |
| Other, N (%) | 100 (8.7) | 76 (5.4) | |
| Uninsured, N (%) | 138 (12) | 252 (17.8) | |
| *Severity of Illness* | | | 0.1608 |
| Minor, N (%) | 601 (52.2) | 702 (49.6) | |
| Moderate, N (%) | 507 (44.0) | 637 (45.0) | |
| Major, N (%) | 41 (3.6) | 68 (4.8) | |
| Extreme, N (%) | 2 (0.2) | 7 (0.5) | |

*Pearson chi-squared test of association or non-parametric tests of comparison of medians or t-tests for means

## Table 2

Association between characteristics of patients with acute appendicitis treated at 122 University HealthSystems Consortium Hospitals and operative interventions. (N=2,565)

| Patient Characteristics | Open appendectomy, N = 390 | Laparoscopic appendectomy, N = 1867 | IR drain only, N =48 | No intervention, N = 256 | *p* value* |
|---|---|---|---|---|---|
| Female | 170 (43.6) | 855 (45.8) | 19 (39.6) | 110 (43) | 0.6188 |
| *Age (years)* | | | | | <.0001 |
| 18-25, N (%) | 62 (15.9) | 466 (25) | 12 (25) | 43 (16.8) | |
| 26-45, N (%) | 128 (32.8) | 739 (39.6) | 13 (27.1) | 75 (29.3) | |
| 46-65, N (%) | 153 (39.2) | 503 (26.9) | 16 (33.3) | 97 (37.9) | |
| 66-85, N (%) | 41 (10.5) | 146 (7.8) | 7 (14.6) | 35 (13.7) | |
| >85, N (%) | 6 (1.5) | 13 (0.7) | 0 | 6 (2.3) | |
| *Race* | | | | | 0.0963 |
| White, N (%) | 263 (67.4) | 1210 (64.8) | 32 (66.7) | 150 (58.6) | |
| Black, N (%) | 37 (9.5) | 203 (10.9) | 6 (12.5) | 42 (16.4) | |
| Hispanic, N (%) | 61 (15.6) | 310 (16.6) | 5 (10.4) | 49 (19.1) | |
| Asian, N (%) | 12 (3.1) | 89 (4.8) | 2 (4.2) | 10 (3.9) | |
| Other, N (%) | 17 (4.4) | 55 (2.9) | 3 (6.3) | 5 (2) | |
| *Insurance* | | | | | <.0001 |
| Private, N (%) | 160 (41) | 973 (52.1) | 16 (33.3) | 104 (40.6) | |
| Medicaid, N (%) | 57 (14.6) | 270 (14.5) | 8 (16.7) | 43 (16.8) | |
| Medicare, N (%) | 63 (16.2) | 193 (10.3) | 8 (16.7) | 53 (20.7) | |
| Other Government, N (%) | 10 (2.6) | 32 (1.7) | 3 (6.3) | 4 (1.6) | |
| Other, N (%) | 31 (7.9) | 125 (6.7) | 4 (8.3) | 16 (6.3) | |
| Uninsured, N (%) | 69 (17.7) | 274 (14.7) | 9 (18.8) | 36 (14.1) | |
| *Severity of Illness* | | | | | <.0001^^ |
| Minor, N (%) | 165 (42.3) | 1090 (58.4) | 0 | 48 (18.8) | |
| Moderate, N (%) | 190 (48.7) | 714 (38.2) | 48 (100) | 188 (73.4) | |
| Major, N (%) | 30 (7.7) | 61 (3.3) | 0 | 18 (7) | |
| Extreme, N (%) | 5 (1.3) | 2 (0.1) | 0 | 2 (0.8) | |
| *Type of EGS** model* | | | | | <.0001 |
| ACS** | 166 (42.6) | 1072 (57.4) | 29 (60.4) | 144 (56.3) | |
| GSOC** | 224 (57.4) | 795 (42.6) | 19 (39.6) | 112 (43.8) | |

-Note that 4 frequencies are missing for this table N=2561, lap+IR (2) and open+IR (2).

* Pearson chi-squared test of association or non-parametric tests of comparison of medians or t-tests for means

** EGS = emergency general surgery; ACS = acute care surgery; GSOC = general surgeon on call

^^ P-value for severity of illness comparison is based on three groups (Open appendectomy, Laparoscopic appendectomy, and none) due to lack of frequencies on IR-drain only group.

**Table 3**

Interventions and Outcomes of patients with acute appendicitis treated at 122 University HealthSystems Consortium Hospitals based on type of care model for emergency general surgery patients.

| | General Surgeon On-call Model N = 1,151 | Acute Care Surgery Model N =1,414 | *p* value* |
|---|---|---|---|
| *Intervention* | | | |
| Open appendectomy, N (%) | 224 (19.5) | 167 (11.8) | <0.0001 |
| Laparoscopic appendectomy, N (%) | 795 (69.1) | 1072 (75.8) | <0.0001 |
| IR drain only, N (%) | 19 (1.7) | 29 (2.1) | 0.4570 |
| None, N (%) | 112 (9.7) | 143 (10.1) | 0.7475 |
| Required intensive care, N (%) | 47 (4.1) | 61 (4.2) | 0.7759 |
| Hospital LOS (days), median (IQR) | 2 (1, 4) | 2 (1, 3) | 0.1122 |
| Any major complication, N (%) | 17 (1.4) | 13 (0.9) | 0.1914 |
| Total number complications (mean) | 1.2 | 1.0 | 0.3322 |
| In-hospital mortality, N (%)** | — | — | |
| Total charges ($), median (IQR) | 8,032 (6,262, 11,438) | 8,798 (6,737, 12,444) | <0.0001 |

*Pearson chi-squared test of association or non-parametric tests of comparison of medians or t-tests for means

**N<10 therefore not reported

**Table 4**

Effect of EGS care model* on interventions and outcomes for acute appendicitis at 122 University HealthSystems Consortium Hospitals in multivariable modeling.

| | | ***95% CI*** |
|---|---|---|
| Laparoscopic appendectomy (vs. open)[1] | AOR 1.86 | 1.23, 2.80 |
| Required intensive care (vs. none)[2] | AOR 1.7 | 0.67, 4.30 |
| Mean difference in Total Hospital LOS (days), (SE)[3] | 0.12 (0.23)** | |
| Mean difference in Total Charges ($), (SE)[4] | 821 (1054)** | |

*ACS model hospitals (58 hospitals with a total of 1,414 patients with acute appendicitis) compared to GSOC model hospitals (64 hospitals with a total of 1,151 patients with acute appendicitis)

[1]Multiple logistic regression (fit by general estimating equations to account for patient clustering within randomly selected hospitals) adjusted for age, race, primary insurance, severity of illness, and hospital characteristics (location, teaching status, setting, bedsize, trauma verification status) (N=2258)

[2]Multiple logistic regression (fit by general estimating equations to account for patient clustering within randomly selected hospitals) adjusted for type of intervention, any complication, age, race, primary insurance, severity of illness, and hospital characteristics (location, teaching status, setting, bedsize, trauma verification status) (N=2,561, 2 patients with lap+IR, 2 patients with open+IR deleted from the model)

[3]Mixed linear regression models, treating hospital as a random effect adjusted for type of intervention, any complication, age, race, primary insurance, severity of illness, and hospital characteristics (location, teaching status, setting, bedsize, trauma verification status) (N=2,561, 2 patients with lap+IR, 2 patients with open+IR deleted from the model)

[4]Mixed linear regression models, treating hospital as a random effect adjusted for type of intervention, any complication, age, race, primary insurance, severity of illness, and hospital characteristics (location, teaching status, setting, bedsize, trauma verification status) (N=2,561, 2 patients with lap+IR, 2 patient with open+IR deleted from the model).

** Even though adjusted for type of intervention, any complication, age, race, primary insurance, severity of illness, and hospital characteristics, ACS model itself is not significant to explain the variability.

## Appendix 1

ICD-9 Codes for Diagnosis and Treatment of Acute appendicitis

| Variable Name | ICD-9 code | ICD-9 descriptor |
|---|---|---|
| *Diagnosis* | | |
| **Appendicitis** | 540 | Appendicitis (acute) with: perforation, peritonitis (generalized), rupture: fulminating, gangrenous, obstructive<br>Cecitis (acute) with: perforation, peritonitis (generalized), rupture<br>Rupture of appendix<br>Excludes: acute appendicitis with peritoneal abscess (540.1) |
| | 540.1 | Abscess of appendix<br>With generalized peritonitis |
| | 540.9 | Acute: appendicitis without mention of perforation, peritonitis, or rupture: fulminating, gangrenous, inflamed, obstructive<br>cecitis without mention of perforation, peritonitis, or rupture |
| *Treatment* | | |
| **Appendectomy (open)** | 47.0x | Excludes: incidental appendectomy, so described laparoscopic (47.11), other (47.19) |
| | 47.09 | Other appendectomy |
| **Laparoscopic appendectomy** | 47.01 | Laparoscopic appendectomy |
| **Drainage of appendiceal abscess** | 47.2 | Drainage of appendiceal abscess<br>Excludes: that with appendectomy (47.0) |

## Appendix 2

Comparison of Hospital Characteristics by Patient Care Model*

| | General Surgeon On-call Model (N=1354) | Acute Care Surgery Model (N=1048) | p-value** |
|---|---|---|---|
| Setting, N (%) | | | |
| University-based | 216 | 1138 | <.0001 |
| Community-based | 698 | 35 | |
| State/County/City/Public | 134 | 134 | |
| Other | 0 | 47 | |
| Location, N (%) | | | |
| Urban | 487 | 1167 | <.0001 |
| Suburban | 370 | 118 | |
| Rural | 191 | 69 | |
| Teaching Status, N (%) | | | |
| Teaching | 812 | 1347 | <.0001 |
| Non-teaching | 236 | 7 | |
| Trauma Center Verification, N (%) | | | |
| Level 1 | 208 | 1312 | <.0001 |
| Level 2 | 120 | 21 | |
| Level 3 | 87 | 7 | |
| Not a designated trauma center | 633 | 14 | |
| Inpatient Bed Capacity, N (%) | | | |
| >500 | 235 | 946 | <.0001 |
| 401-500 | 165 | 227 | |
| 301-400 | 291 | 117 | |
| 201-300 | 105 | 57 | |
| 101-200 | 135 | 7 | |
| < 100 | 0 | 117 | |

** Pearson $Chi^2$ Test of Association