Regionalization of emergency general surgery operations: A simulation study

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BACKGROUND: It has been theorized that a tiered, regionalized system of care for emergency general surgery (EGS) patients—akin to regional trauma systems—would translate into significant survival benefits. Yet data to support this supposition are lacking. The aim of this study was to determine the potential number of lives that could be saved by regionalizing EGS care to higher-volume, lower-mortality EGS institutions.

METHODS: Adult patients who underwent one of 10 common EGS operations were identified in the California Inpatient Database (2010–2011). An algorithm was constructed that "closed" lower-volume, higher-mortality hospitals and referred those patients to higher-volume, lower-mortality institutions ("closure" based on hospital EGS volume-threshold that optimized to 95% probability of survival). Primary outcome was the number of lives saved. Fifty thousand regionalization simulations were completed (5,000 for each operation) employing a bootstrap resampling method to proportionally redistribute patients. Estimates of expected deaths at the higher-volume hospitals were recalculated for every bootstrapped sample.

RESULTS: Of the 165,123 patients who underwent EGS operations over the 2-year period, 17,655 (10.7%) were regionalized to a higher-volume hospital. On average, 128 (48.8%) of lower-volume hospitals were "closed," ranging from 68 (22.0%) hospital closures for appendectomy to 205 (73.2%) for small bowel resection. The simulations demonstrated that EGS regionalization would prevent 9.7% of risk-adjusted EGS deaths, significantly saving lives for every EGS operation: from 30.8 (6.5%) deaths prevented for appendectomy to 122.8 (7.9%) for colectomy. Regionalization prevented 4.6 deaths per 100 EGS patient-transfers, ranging from 1.3 for appendectomy to 8.0 for umbilical hernia repair.

CONCLUSION: This simulation study provides important new insight into the concept of EGS regionalization, suggesting that 1 in 10 risk-adjusted deaths could be prevented by a structured system of EGS care. Future work should expand upon these findings using more complex discrete-event simulation models. (*J Trauma Acute Care Surg.* 2020;88: 366–371. Copyright © 2019 Wolters Kluwer Health, Inc. All rights reserved.)

LEVEL OF EVIDENCE: Therapeutic/Care Management, level IV.

KEY WORDS: Regionalization of EGS operations; simulation study.

The concept of regionalization is founded on the idea that medical and surgical resources should be efficiently allocated, coordinated, and utilized within a well-defined system of care to best optimize patient outcomes for a given geographic region. In our modern medical ecosystem, where value-based care is increasingly being promulgated and endorsed, regionalization in health care is getting a lot of attention. The National Academy of Medicine[1] and the National Quality Forum[2] have both advocated for regionalized approaches to health care, especially for time-sensitive acute medical and surgical conditions. The American College of Surgeons, across multiple surgical disciplines, is likewise advocating for reorganizing and restructuring how and where certain surgical care is delivered, including the integration of surgical care delivery across geographic areas.[3] In addition, major academic hospital systems, including Dartmouth-Hitchcock Medical Center, the University of Michigan Health System, and the Johns Hopkins Hospital and Health System, have banded together to promote regionalization of surgical procedures to higher volume hospitals via the "Take the Volume Pledge" campaign.[4]

In this context, it has been theorized that a tiered, regionalized system of care for emergency general surgery (EGS) patients, with designated and verified "EGS centers," would translate into significant survival benefits for EGS patents.[5–12] Such a system would change how EGS emergencies are triaged and redefine when and where EGS patients are managed. While there are many reasons to believe that a regional EGS system would improve outcomes in EGS patients, including the national crisis in emergency surgical care,[1,13] surgical workforce shortages,[13] and the increased burden on emergency departments to manage surgical patients,[14,15] data to support the widespread implementation of regional EGS systems are lacking.

Building on our prior work which demonstrated a clear relationship between hospital EGS operative volume and mortality outcomes,[9] the aim of the current study was to determine the potential number of deaths that could be prevented by regionalizing EGS care to higher-volume, lower-mortality EGS institutions. Our prior study, similar to the volume-outcome studies in the field of trauma[16–18] which helped to justify the creation of regionalized trauma care, suggested a potential benefit to regionalizing EGS care to higher-volume hospitals. By simulating a variety of different possible regionalization scenarios, the current study sought to provide EGS thought leaders, stakeholders, policymakers, and clinicians with objective data on the effect of a regionalized system of EGS care aimed at preventing EGS deaths.

METHODS

Data Sets and Variables

We conducted a retrospective cohort study of all adult patients (≥18 years) who underwent one of 10 EGS operations in the state of California over a 24-month period, from January 1, 2010, to December 31, 2011. The 10 operations included: appendectomy, cholecystectomy, colectomy, inguinal and femoral hernia repair (analyzed together), lysis of adhesions (LOA, no bowel resections were performed in the LOA group), necrotizing soft tissue infection excision, repair of perforated peptic ulcer (gastric or duodenal ulcers), small bowel resection, umbilical

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hernia repair, and ventral hernia repair. Both laparoscopic and open operations were included; trauma operations were excluded.

For the current analyses, only patients undergoing urgent/emergency operations with specific EGS diagnoses were included. Patients were identified using International Classification of Disease, 9th Edition (ICD-9), procedural codes (the full list of procedural ICD-9 codes can be found in our prior article[9]); only patients who were listed in the State Inpatient Database (SID) data set as having undergone one of the ten operations as a primary core operation were included. The ICD-9 diagnosis codes identified patients with a specific diagnosis of an EGS condition (the full list of diagnosis ICD-9 codes can be found in our prior article[9]).

The patient populations were chosen as they are among most prevalent emergent surgical procedures/diagnoses requiring operative intervention in the United States and have a nontrivial risk of postoperative morbidity and mortality.[19–21] An operation was defined as being performed urgently/emergently if it was associated with an admission not scheduled at least 24 hours in advance, as defined by the SID unscheduled admission variable.

Two data sets were used. The first was the SID for California (data from 2010 and 2011). California is the most populous state in the United States (population of 37 million in 2011), with a diverse population and varied geography, with both urban and rural areas. The SID is part of a family of data sets developed by the Healthcare Cost and Utilization Project, and sponsored by AHRQ.[22] Data abstracted included patient demographics, chronic health conditions, hospital-based metrics, and in-hospital mortality. The second data set was the American Hospital Association (AHA) Annual Survey of Hospitals Database for 2010 and 2011.[23] The same California acute care hospitals in the SID and the AHA were paired, thus enabling risk-adjustment at the hospital level.

Acute care hospitals were the only hospital-type included in the analyses. Dedicated pediatric hospitals, rehabilitation hospitals, and government hospitals such as Veteran's Affairs Hospitals were excluded. Only hospitals performing three or more of a given EGS operation type over the 2 years were included. We rationalized that this would yield a more consistent, less heterogeneous group of hospitals for comparison.

Statistical Analyses and Outcome Measures

In a prior article, we found that survival rates for all adult patients undergoing 10 different EGS operations were significantly improved when their operations were performed at higher volume hospitals.[9] For each of the 10 EGS operations studied, hospital operative volume-thresholds were defined to improve survival; this threshold was the hospital operative volume above which 95% of the hospitals were performing at or above the average mortality rate for that specific operation. By this construct, if a patient were to have an operation at a hospital with an EGS operative volume for that specific surgery greater than the volume-threshold, there would be a 95% chance that patient's mortality risk (as defined by hospital mortality proportion) would be lower than the average risk-adjusted mortality for all hospitals performing that same EGS operation.

Prior to running any simulations, an expected, risk-adjusted, preregionalization, in-hospital death rate was calculated for each hospital in California. To define this expected mortality, we created hierarchical, Bayesian mixed-effects logistic regression models for each operation separately. A mixed-effects model with hospital-specific intercepts has advantages over the more basic random effects model or a purely fixed effects model.[24] First, it includes an adjustment for both patient-level and hospital-level effects; the inclusion of hospital-level attributes reduces the potential confounding of the patient attribute-risk relation.[24] Second, a mixed effects model allows for the accurate inclusion of smaller hospitals into the analysis by more properly calibrating the estimate of expected death. Our methodology for calculating risk-adjusted expected deaths is described in detail in a prior article.[12]

Using our prior study as a starting point, and to assess our primary aim, we constructed an algorithm that "closed" lower-volume, higher-mortality California hospitals and referred the patients to the remaining higher-volume, lower-mortality institutions. Closure of the under-performing institutions was based on the aforementioned hospital EGS volume-thresholds defined in

TABLE 1. Characteristics of 165,123 Patients and 310 Hospitals Impacted by Regionalization-Simulations in California, by Operation Type

	Patient Characteristics			Hospital Characteristics		
Operation	**No. Operations**	**No. Patients "Moved"**	**% of Patients "Moved"**	**No. Hospitals**	**No. Hospitals "Closed"**	**% of Hospitals "Closed"**
Appendectomy	52,905	2,285	4.3	305	68	22.0
Cholecystectomy	69,052	2,668	3.9	310	74	23.9
Colectomy	12,574	4,423	35.2	292	192	65.8
Inguinal and femoral hernia	3,757	483	12.9	265	91	34.3
Lysis of adhesions	9,343	1,110	11.9	292	110	37.7
Necrotizing soft tissue infection excision	2,616	767	29.3	228	126	55.3
Repair of perforated peptic ulcer disease	2,231	1,267	56.8	245	190	77.6
Small bowel resection	7,447	3,450	46.3	280	205	73.2
Umbilical hernia	1,737	470	27.1	209	107	51.2
Ventral hernia	3,461	732	21.1	259	121	46.7
Average (by column)	—	—	24.9	268.5	128.4	48.8
Total	165,123	17,655	—	—	—	—

our prior article[9]: if a given hospital did not achieve the volume-threshold, it was simulated to be closed for that type of operation. Upon closure, patients who had undergone an operation at the closed hospital were then randomly assigned to undergo their operation at a higher-volume hospital, in a manner proportionate to the receiving hospital's initial preregionalization volume; this was the regionalization-simulation. By this construct, the new group of patients undergoing a specific operation type at each postregionalization hospital was equal to: all preregionalization patients at that hospital + new redistributed postregionalization patients at that hospital. Regionalization simulations were completed 5,000 times for each operation, so 50,000 in total, employing a bootstrap resampling method to redistribute patients.

For every bootstrap resampling, an expected postregionalization death rate was recalculated at each hospital remaining in the analysis; this was based on the new group of patients undergoing their operation at each hospital after regionalization. As the expected death rate for each operation at each hospital is partly based on patient-level effects, for every single regionalization simulation, a new expected postregionalization death rate was calculated based on the redistribution of patients to each hospital.

Our primary outcome was the potential number of deaths prevented, aggregated across hospitals. For every bootstrap resampling, the preregionalization death rate was subtracted from the postregionalization date rate to create a delta death rate—the change from preregionalization to postregionalization. If this delta death rate was a negative number, mortality postregionalization decreased; if this difference was a positive number, mortality postregionalization increased. To calculate the number of deaths prevented, the delta death rate was multiplied by the total number of patients undergoing each operation type at each hospital for each simulation. This was done as the final step in the individual simulations, meaning 5,000 times for each of the 10 operations. That number was then averaged to create a mean number of lives saved for every operation.

A two-sided p value less than 0.05 was defined as significant. All statistical analyses were conducting using SAS 9.4 (SAS Institute Inc., Cary, NC). This study was approved by the Human Investigation Committee of the Yale University Human Research Protection Program (HRPP) for biomedical research. The Human Investigation Committee is Yale's Institutional Review Board.

RESULTS

Over the 2-year study period, 165,123 patients underwent one of the ten EGS operations at 310 different acute care hospitals in California (Table 1). Fifty thousand regionalization simulations were run, 5,000 for each operation.

For all operations, 17,655 (10.7%) EGS patients were regionalized to higher-volume hospitals; this represented on average 24.9% of patients undergoing each operation type (Table 1). The range in the total number of patients impacted by regionalization varied by operation type: from 470 patients for umbilical hernia repair to 4423 patients undergoing colon resection; the percentage of patients impacted ranged from 3.9% for cholecystectomy to 56.8% for repair of perforated peptic ulcer disease. In terms of hospitals impacted by regionalization, on average 128 acute care hospitals in California were "closed" for each type of surgery; this represented on average 48.8% of hospitals performing each operation type (Table 1). The range in the total number of hospitals impacted by regionalization varied by operation: from 68 hospital closures for appendectomy to 205 for small bowel resection; the percentage of hospitals impacted ranged from 23.9% for cholecystectomy to 77.6% for repair of perforated peptic ulcer disease.

The simulations demonstrated that EGS regionalization would prevent 586.0 risk-adjusted EGS deaths over the 2 years, equal to 9.7% of the 6047.7 total expected deaths preregionalization. Across operation types, the average percentage of deaths prevented was 12.1% (Table 2). For every EGS operation, regionalization away from lower-volume hospitals and to higher-volume hospitals prevented deaths. The range in the total number of deaths prevented by regionalization varied by operation type: from 30.8 deaths prevented for appendectomy to 122.8 for colectomy; the percentage of deaths prevented ranged from 4.7% for cholecystectomy to 22.2% for umbilical hernia repair. On average, regionalization prevented 4.6 deaths per

TABLE 2. Impact of Regionalization on Preventing Deaths After EGS Operations, Based 50,000 Bootstrap Resampled Simulations

Operation	Number Deaths Prevented, Over 2 Years	Standard Deviation of Average	% of Deaths Prevented	Rate of Deaths Prevented, per 100 Patient Transfers
Appendectomy	30.8	0.1	6.5	1.3
Cholecystectomy	49.1	0.1	4.7	1.8
Colectomy	122.8	0.9	7.9	2.8
Inguinal and femoral hernia	31.5	0.3	12.3	6.5
Lysis of adhesions	62.7	0.5	9.4	5.6
Necrotizing soft tissue infection excision	41.7	0.5	12.1	5.4
Repair of perforated peptic ulcer disease	67.4	0.8	17.0	5.3
Small bowel resection	99.0	0.9	11.0	2.9
Umbilical hernia	37.4	0.4	22.2	8.0
Ventral hernia	43.6	0.4	17.7	6.0
Average (by column)	—	0.5	12.1	4.6
Total	586.0*	—	—	—

* The total number of risk-adjusted deaths was expected to be 6047.7 before regionalization, and 5461.7 after regionalization—a decrease of 9.7%.

100 EGS patient-transfers, ranging from 1.3 deaths prevented per 100 EGS patient-transfers for appendectomy to 8.0 for umbilical hernia repair.

DISCUSSION

This simulation study provides important new insights into the concept of implementing a tiered, regionalized system of care for common general surgery operations performed emergently in adults at acute care hospitals in California. By simulating the "closure" of lower-volume, higher mortality hospitals and transferring those patients to higher-volume, lower-mortality hospitals, 1 of every 10 risk-adjusted deaths for all EGS operations was prevented. Our simulated, structured system of EGS care would, on average, reduce the percentage of risk-adjusted deaths by 12.1% for each operation type. This represents a significant drop in mortality across the different types of EGS operations.

Regionalization has long been a hallmark of trauma care. A regionalized trauma system of care is an organized, coordinated network of healthcare resources that provides a broad spectrum of services and definitive medical/surgical care to the acutely injured trauma patient.[25,26] The services and care start at the scene of the injury by local emergency medical services, and continue from transportation to emergency room to operating room to intensive care unit to hospital floor to rehabilitation to home.[27] The goal of this highly integrated, multilayered system of injury management is to optimize the chances of survival among trauma victims by reducing the risks, deleterious consequences, and overall burden of injury.[25,26]

The trauma system consolidates the care of the most severely injured patients into a small number of hospitals qualified as "trauma centers." Trauma centers have a high level of expertise and readiness, as well as extremely specialized resources required for optimal care of injured patients.[27] The three levels of trauma center classification represent a ranking of the resources available at that center to care for injuries: Level I being the highest level of care, with the greatest readiness and the most resources, while Level III has expertise and readiness below that of Levels I and II but above that of a standard acute care hospital.[25,26] The trauma center designation is extremely specific, requiring a thorough and complete verification for accreditation based on standards and guidelines established by the American College of Surgeons Committee on Trauma.[25,26]

Based on the success of trauma centers at saving the lives of injured patients, advocates have suggested that a regionalized system of care for EGS patients and operations concentrated at designated "EGS centers" would improve outcomes.[5–12] At present, we have a disjointed system of managing this unique, often physiologically abnormal EGS patient population, which has resulted in delays to care, widespread practice variation, and disparate outcomes.[19,28–30] The absence of a well-defined EGS system of care has been compounded by the national crisis in emergency surgical care,[1,13] shortages in on-call surgical coverage throughout the United States,[13] and increased burden on emergency departments to assess, triage, and initially manage surgical patients.[14,15]

We, therefore, set out to inform one extremely important aspect of a tiered, regionalization system of EGS care: the potential to prevent deaths. Our findings suggest that a regionalized system of EGS care can save lives and decrease mortality. This is true of every EGS operation we studied, from lower-complexity, lower-mortality operations (appendectomy and cholecystectomy) to higher-complexity, higher-mortality operations (colectomy and repair perforated peptic ulcers). The prospect of preventing 12.1% of deaths (ranging from 4.7% to 22.2%, depending on the EGS operation; Table 2) would be a beneficial advancement for the field.

Regionalizing care, however, does not come without consequences, and the potential benefit to patients may be to the detriment of some surgeons, staff, operating rooms, and institutions. Accordingly, "closing" hospitals in a simulation study is very different than having actual operations cease in the operating rooms of smaller, lower-volume hospitals in remote settings of California. While the average proportion of hospitals which were simulated to stop performing EGS operations was over 40% (ranging from 22.0% to 77.6%, depending on the EGS operation; Table 1), it may be that only the highest-risk EGS operations should be stopped at some hospitals rather than all EGS operations; in other words, only the highest-risk EGS patients at the extremes of EGS disease should be transferred. Additionally, a regionalized system has the potential to cause delays to surgical therapy due to longer travel times as well as overwhelm the capacity of the postregionalization institutions by increasing their volumes and outstripping their resources. These scenarios may negate the survival benefits of the structured system of EGS care. In this context, the current study represents one additional step on a pathway of investigation for moving EGS away from fragmented delivery systems and toward more coordinated, cooperative, integrated care that prioritizes patient outcomes.

Future work should expand upon these findings using increasingly complex simulation models based on advanced triage algorithms. For example, discrete event simulation models can compare triage criteria, incorporate hospital resources and time to definitive care, and study the impact on access to care for resource-limited populations. In the present study, we were not able to assess if a hospital has an acute care surgery service. This is important, as recent evidence points to the significant mortality benefits of the acute care surgery practice paradigm to manage EGS operative emergencies as compared with the traditional general surgery service model; specifically, the multiinstitutional study found a 31% reduction in 30-day mortality in EGS cases when managed under an acute care surgery service.[31] Accordingly, incorporating such hospital-level attributes into more advanced triage algorithms and simulation models should be explored.

The present study has limitations. First, the patients in our simulations were proportionally yet randomly assigned to new hospitals at which to have their operations; this may not accurately simulate a logical EGS system of care. Second, we used a retrospective administrative data set, and our conclusions are thus constrained by their intrinsic limitations and biases, such as selection bias and misclassification bias. Third, the data are from the state of California, and generalizations to other areas of the United States or to a national level may not be valid.

In conclusion, this regionalization simulation study provides important new insight into the concept of EGS

regionalization, suggesting that 1 in 10 risk-adjusted deaths could be prevented by a structured system of EGS care. Our findings provide EGS thought leaders, stakeholders, policymakers, and clinicians with evidence suggesting a mortality benefit for regionalized EGS care. Future work should expand on these findings by increasing the complexity and decision-making algorithms of the simulation models.

AUTHORSHIP

Study conception and design: R.D.B., M.J.S. participated in R.D.B., N.S., M.J.S. participated in acquisition of data. R.D.B., N.S., M.P.DW., T.M.G., A.A.M., K.M.S., M.J.S., K.A.D. participated in the analysis and interpretation of data. R.D.B., N.S., M.P.DW., T.M.G., A.A.M., K.M.S., M.J.S., K.A.D. participated in drafting of the article. R.D.B., N.S., M.P.DW., T.M.G., A.A.M., K.M.S., M.J.S., K.A.D. participated in critical revisions.

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DISCLOSURE

The authors declare no conflicts of interest.

REFERENCES

1. Committee on the Future of Emergency Care in the United States Health System, Institute of Medicine. *Hospital-Based Emergency Care: At the Breaking Point. Consensus Report*. Washington, DC, USA: National Academies Press; 2007.
2. National Quality Forum. Regionalized emergency care, phase I. *NQF: Regionalized Emergency Care*. Available from: http://www.qualityforum.org/Projects/Regionalized_Emergency_Care__Phase_1.aspx#t=1&s=&p=.2012. Accessed August 28, 2019.
3. Hoyt DB. Looking forward—March 2019. *Bull Am Coll Surg*. 2019;104:9–11.
4. Urbach DR. Pledging to eliminate low-volume surgery. *N Engl J Med*. 2015;373:1388–1390.
5. Meredith JW. How to boil a frog: the American Association for the Surgery of Trauma in changing times. *J Trauma Acute Care Surg*. 2013;74:1–7.
6. Becher RD, Davis KA, Rotondo MF, et al. Ongoing evolution of emergency general surgery as a surgical subspecialty. *J Am Coll Surg*. 2018;226:194–200.
7. Ogola GO, Crandall ML, Shafi S. Variations in outcomes of emergency general surgery patients across hospitals: a call to establish emergency general surgery quality improvement program. *J Trauma Acute Care Surg*. 2018;84:280–286.
8. DeWane MP, Sukumar N, Stolar MJ, et al. Top-tier emergency general surgery hospitals: good at one operation, good at them all. *J Trauma Acute Care Surg*. 2019;87:289–296.
9. Becher RD, DeWane MP, Sukumar N, et al. Hospital volume and operative mortality for general surgery operations performed emergently in adults. *Ann Surg*. Epub ahead of print February 8, 2019. DOI: 10.1097/SLA.0000000000003232.
10. Ogola GO, Haider A, Shafi S. Hospitals with higher volumes of emergency general surgery patients achieve lower mortality rates: a case for establishing designated centers for emergency general surgery. *J Trauma Acute Care Surg*. 2017;82:497–504.
11. DeWane MP, Sukumar N, Stolar MJ, et al. High-performance acute care hospitals: excelling across multiple emergency general surgery operations in the geriatric patient. *J Trauma Acute Care Surg*. 2019;87:140–146.
12. Becher RD, DeWane MP, Sukumar N, et al. Evaluating mortality outlier hospitals to improve the quality of care in emergency general surgery. *J Trauma Acute Care Surg*. 2019;87:297–306.
13. Cofer JB, Burns RP. The developing crisis in the national general surgery workforce. *J Am Coll Surg*. 2008;206:790–795; discussion 795-797.
14. Centers for Disease Control and Prevention. National Hospital Ambulatory Medical Care Survey (NHAMCS): 2010 Emergency Department Summary Tables. *National Center for Health Statistics*. Available from: http://www.cdc.gov/nchs/ahcd/web_tables.htm. Accessed August 29, 2019.
15. Hsia RY, Kellermann AL, Shen Y-C. Factors associated with closures of emergency departments in the United States. *JAMA*. 2011;305:1978–1985.
16. Nathens AB, Jurkovich GJ, Maier RV, et al. Relationship between trauma center volume and outcomes. *JAMA*. 2001;285:1164–1171.
17. Margulies DR, Cryer HG, McArthur DL, et al. Patient volume per surgeon does not predict survival in adult level I trauma centers. *J Trauma*. 2001;50:597–601; discussion 601-603.
18. Richardson JD, Schmieg R, Boaz P, et al. Impact of trauma attending surgeon case volume on outcome: is more better? *J Trauma*. 1998;44:266–271; discussion 271-272.
19. Becher RD, Hoth JJ, Miller PR, et al. A critical assessment of outcomes in emergency versus nonemergency general surgery using the American College of Surgeons National Surgical Quality Improvement Program Database. *Am Surg*. 2011;77:951–959.
20. Shiloach M, Frencher SK, Steeger JE, et al. Toward robust information: data quality and inter-rater reliability in the American College of Surgeons National Surgical Quality Improvement Program. *J Am Coll Surg*. 2010;210:6–16.
21. Schilling PL, Dimick JB, Birkmeyer JD. Prioritizing quality improvement in general surgery. *J Am Coll Surg*. 2008;207:698–704.
22. Healthcare Cost and Utilization Project (HCUP). HCUP state inpatient databases. *Overview of the State Inpatient Databases (SID)*. Available from: https://www.hcup-us.ahrq.gov/sidoverview.jsp. Accessed August 29, 2019.
23. American Hospital Association (AHA). AHA annual survey. *AHA Annual Survey of Hospitals Database*. Available from: https://www.ahadataviewer.com/additional-data-products/AHA-Survey/. Accessed August 29, 2019.
24. Ash A, Fienberg E, Louis T, et al. STATISTICAL ISSUES IN ASSESSING HOSPITAL PERFORMANCE. The COPSS-CMS White Paper. The Committee of Presidents of Statistical Societies (COPSS) and the Center for Medicare and Medicaid Services (CMS). Available from: http://www.cms.gov/Medicare/Quality-Initiatives-Patient-Assessment-Instruments/HospitalQualityInits/Downloads/Statistical-Issues-in-Assessing-Hospital-Performance.pdf. January 27, 2012. Accessed August 29, 2019.
25. American College of Surgeons Committee on Trauma. *Resources for Optimal Care of the Injured Patient: 2006*. Fifth ed. Chicago, IL: American College of Surgeons; 2006.
26. American College of Surgeons Committee on Trauma. *Resources for Optimal Care of the Injured Patient: 2014*. 6th ed. Chicago, IL: American College of Surgeons; 2014.
27. National Foundation for Trauma Care (NFTC). U.S. Trauma Center Crisis: lost in the scramble for terror resources. National Foundation for Trauma Care. Available from: https://www.traumacare.com/download/NFTC_CrisisReport_May04.pdf. May 2004. Accessed August 29, 2019.
28. Lau B, Difronzo LA. An acute care surgery model improves timeliness of care and reduces hospital stay for patients with acute cholecystitis. *Am Surg*. 2011;77:1318–1321.
29. Ingraham AM, Cohen ME, Raval MV, et al. Variation in quality of care after emergency general surgery procedures in the elderly. *J Am Coll Surg*. 2011;212:1039–1048.
30. Akinbami F, Askari R, Steinberg J, et al. Factors affecting morbidity in emergency general surgery. *Am J Surg*. 2011;201:456–462.
31. To KB, Kamdar NS, Patil P, et al. Acute care surgery model and outcomes in emergency general surgery. *J Am Coll Surg*. 2019;228:21–28.e7.