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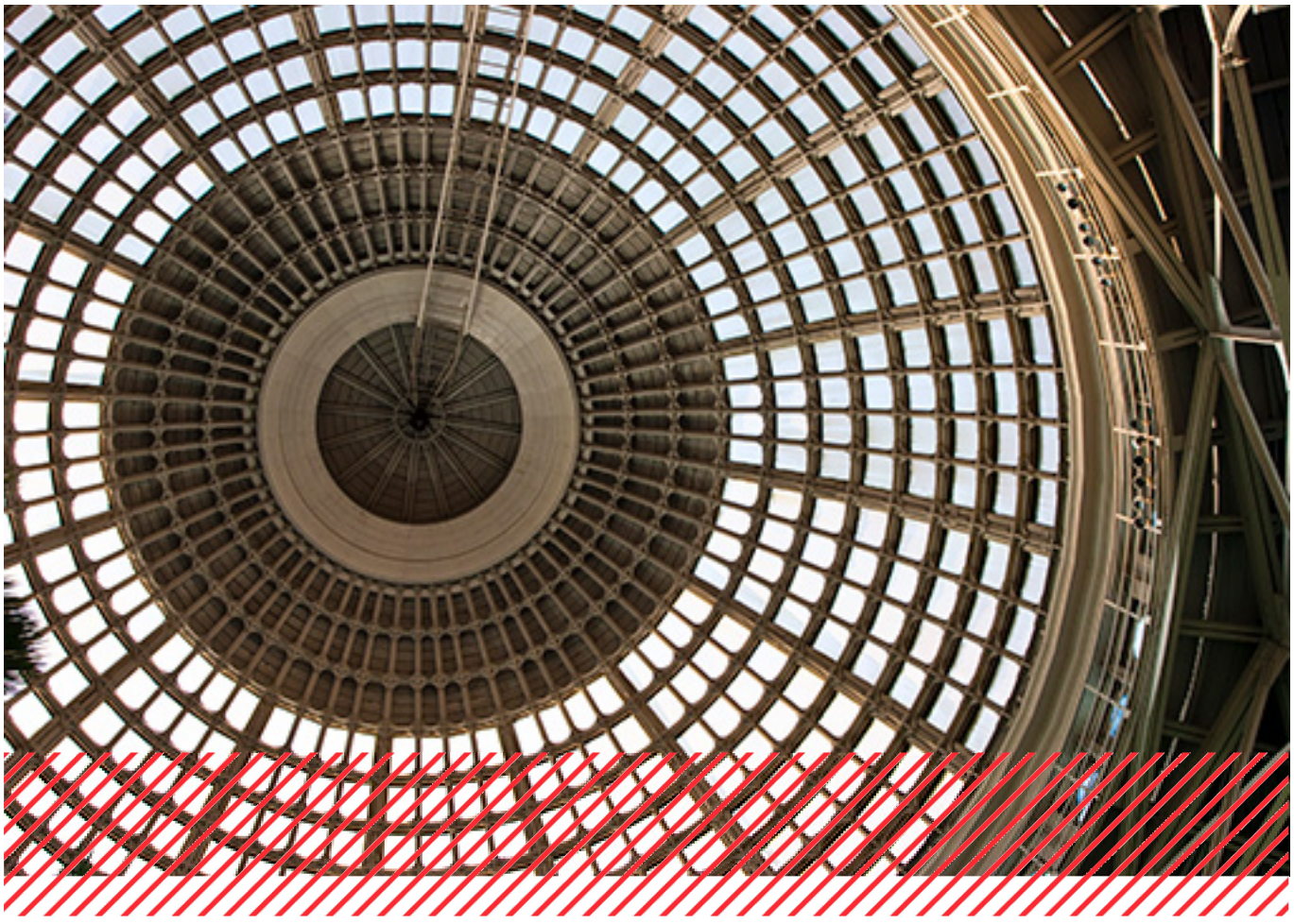
Bilagsrapport

# Højere kvalitet gennem samling af komplekse, specialiserede funktioner

## En litteraturgennemgang af organisatoriske forudsætninger, fordele og udfordringer



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*Højere kvalitet gennem samling af komplekse, specialiserede funktioner – En litteraturgennemgang af organisatoriske forudsætninger, fordele og udfordringer*



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VIVE blev etableret den 1. juli 2017 efter en fusion mellem KORA og SFI. Centeret er en uafhængig statslig institution, som skal levere viden, der bidrager til at udvikle velfærdssamfundet og den offentlige sektor. VIVE beskæftiger sig med de samme emneområder og typer af opgaver som de to hidtidige organisationer.

# Indhold

# Bilag 1 Organisatoriske medierende faktorer

Bilag 1 præsenterer fundene relateret til organisatoriske medierende faktorer i volumen-outcome-relationen. Der er tre tabeller i bilaget, som præsenterer henholdsvis fund om infrastruktur, specialiseringsgrad og processer. Der vil være noget overlap i studierne; særligt vil de indledende litteraturreviews beskæftige sig med både inputdimensioner såsom infrastrukturer og ressourcer (specialiseringsgrader og staff) og med processer.

| Author(s) & clinical area | Objectives & studied organizational factors | Results and comments |
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| **Literature reviews** | | |
| Mesman et al. 2015<br>Systematic review<br>Why do high-volume hospitals achieve better outcomes? A systematic review about intermediate factors in volume-outcome relationships.<br>Health Policy, 119(8):1055-67 | A systematic review about intermediate factors in volume–outcome relationships.<br>To assess the role of process and structural factors. | 27 studies were included. They focused on: Compliance to evidence based processes of care, level of specialization, and hospital level factors.<br>The vast majority of volume–outcome studies do not focus on the underlying mechanism by including process and structural characteristics as explanatory factors in their analysis.<br>The methodological quality of studies is also modest, which makes us question the available evidence for current policies to concentrate care on the basis of volume. |
| **Hospitalsinfrastruktur** | | |
| Ross, Normand, Wang et al. 2010<br>Cross-sectional analyses<br>Acute myocardial infarction, heart failure, or pneumonia<br>US<br>Hospital volume and 30-day mortality for three common medical conditions.<br>N Engl J Med. 25;362(12):1110-8.<br>*Studiet er inkluderet i Mesman et al 2015* | BACKGROUND: The association between hospital volume and the death rate for patients who are hospitalized for acute myocardial infarction, heart failure, or pneumonia remains unclear. It is also not known whether a volume threshold for such an association exists.<br>METHODS: Analyses were adjusted for patients' risk factors and hospital characteristics. | RESULTS: The identified volume thresholds differed according to the teaching status and the hospital's teaching status and capacity to provide cardiovascular revascluar services….. at hospitals that provided revascularization services, the volume threshold was estimated at 432 patients with acute myocardial infarction, 256 patients with heart failure, and 66 patients with pneumonia; at hospitals that did not provide revacularization services, the volume thresholds were 586, 3303, and 162 patients, respectively.<br>CONCLUSIONS: Admission to higher-volume hospitals was associated with a reduction in mortality for acute myocardial infarction, heart failure, and pneumonia, although there was a volume threshold above which an increased condition-specific hospital volume was no longer significantly associated with reduced mortality. |
| Thiemann et al. 1999<br>Acute myocardial infarction<br>US<br>The association between hospital volume and survival after acute myocardial infarction in elderly patients.<br>New England Journal of Medicine, 1999, 340(21), 1640-1648.<br>*Inkluderet i Mesman et al. 2015* | To determine whether hospital volume influences mortality among patients with acute myocardial infarction, we performed a retrospective cohort study, using data from the Cooperative Cardiovascular Project (CCP), which was conducted by the Health Care Financing Administration (HCFA).<br>This cohort was uniquely suited for the analysis of the effects of aspects of the health care delivery system: the nationwide sample comprised nearly 100 percent of el- | In conclusion, we found that in the initial hospital care of patients with acute myocardial infarction, the more experience the hospital had, the better the patient's chance for survival. After comprehensive adjustment for coexisting clinical conditions, the patients in the quartile admitted to the lowest-volume hospitals were 17 percent more likely to die within 30 days after admission than those in the highest-volume quartile (P<0.001), a difference of 2.3 deaths per 100 patients. The capability of the hospitals to perform coronary angiography, angio- |

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| | derly patients with myocardial infarction who had fee-for-service insurance coverage, and the study had extensive clinical data, blinded data abstraction, and reliable long-term follow-up. | plasty, and bypass surgery had no significant effect on survival beyond that associated with increasing volume. In regions with acceptable transport time, survival after acute myocardial infarction might be improved by the use of field triage to transport patients directly to high-volume centers designated for the treatment of cardiac disease.<br><br>The availability of invasive procedures, after adjustment for hospital volume and the physician's specialty, was not associated with a significant survival advantage. For each type of hospital invasive procedure, there was a dose–response relation between hospital volume of patients with myocardial infarction and long-term survival. When hospital volume was treated as a continuous variable, the dose–response relation for survival within 30 days after admission was highly significant at hospitals that did not offer angiography (hazard ratio, 1.38 for a decrease of 5.5 patients with myocardial infarction per week; 95 percent confidence interval, 1.16 to 1.63; P<0.001) and at hospitals that offered only angiography (hazard ratio, 1.19; 95 percent confidence interval, 1.06 to 1.34; P<0.01). The hazard ratio for volume plateaued among hospitals that offered bypass surgery and angioplasty, with borderline statistical significance (hazard ratio, 1.07; 95 percent confidence interval, 1.01 to 1.13; P=0.02).<br><br>No significant survival advantage can be attributed to hospital invasive procedures alone, because there was a substantial overlap of hazard ratios for long-term mortality among hospitals with different technological capability but equivalent volume, a finding confirmed by statistical analysis of interaction. After adjustment for volume, there was no significant association between survival and the hospital's number of beds or teaching status.<br><br>Living in a less populous region as opposed to a metropolitan area was an independent risk factor for short- and long-term mortality |
| Joseph, Morton et al. (2009)<br><br>Pancreatic resection<br><br>US<br><br>Relationship between hospital volume, system clinical resources, and mortality in pancreatic resection.<br><br>Journal of the American College of Surgeons, 208(4), 520-527.<br><br>*Inkluderet i Mesman et al 2015* | Background: The relationship between hospital volume and perioperative mortality in pancreaticoduodenectomy has been well established.<br><br>We studied whether associations exist between hospital volume and hospital clinical resources and between both of these factors to mortality to help explain this relationship. | Study Design: This two-part study reviewed publicly available hospital information from the Leapfrog Group, HealthGrades, and hospital Web sites. Hospitals were evaluated for Leapfrog ICU staffing criteria and Safe Practice Score; HealthGrades five-star rating for complex gastrointestinal procedures and operations; and presence of a general surgery residency, gastroenterology fellowship, and interventional radiology. Evaluation used trend analysis and multiple logistic regression analysis. The second part determined the mortality rate for pancreaticoduodenectomy using inpatient mortality data from the National Inpatient Sample and Leapfrog. Hospitals were categorized by low volume |

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| | | (11/year), strong clinical support (presence of all support factors), and weak clinical support (absence of any factor). Data were correlated by number of pancreatic resections per hospital, hospital system clinical resources, and operative mortality.<br>Results: As hospital volume increased, statistically significant increases occurred in the frequency of hospitals meeting Leapfrog ICU staffing criteria ($p < 0.0001$), Leapfrog Safe Practice Score ($p = 0.0004$), HealthGrades 5-star rating ($p < 0.00001$), general surgery residency ($p < 0.00001$), gastroenterology fellowship ($p < 0.00001$), and interventional radiology services ($p < 0.00001$). No significant relationships were found between resection volume and any one of the clinical support factors and perioperative death. Presence of strong clinical support was associated with lower mortality (odds ratio = 0.32; $p = 0.001$).<br>Conclusions: System clinical resources were more influential in operative mortality for pancreatic resection. This might help explain why high-volume hospitals, low-volume surgeons in high-volume institutions, and some lower-volume hospitals with excellent clinical resources have lower perioperative mortality rates for pancreatic resection. |
| Shortell & Logerfo (1981)<br>Acute myocardial infarction and appendicitis<br>US<br>Hospital Medical Staff Organization and Quality of Care: Results for Myocardial Infarction and Appendectomy<br>Medical Care, Vol.19 (10), p.1041-1055. | This article examines the relationships among hospital structural characteristics, individual physician characteristics, medical staff organization characteristics and quality of care for two conditions: acute myocardial infarction and appendicitis. | Using data obtained from the Commission on Professional and Hospital Activities (CPHA), approximately 50,000 acute myocardial infarction cases and 8,183 appendectomy cases collected from 96 hospitals in the East North Central Region of the country (Illinois, Indiana, Michigan, Ohio and Wisconsin) were examined. These data were merged with medical staff organization and related data on hospital characteristics obtained from the American Hospital Association.<br>The results indicate that such medical staff organization factors as involvement of the medical staff president with the hospital governing board, overall physician participation in hospital decision-making, frequency of medical staff committee meetings and percentage of active staff physicians on contract are positively associated with higher quality-of-care outcomes, independent of the effects of hospital and physician characteristics. Further, the medical staff organization factors appear to be somewhat more strongly associated with higher quality-of-care outcomes than the hospital and physician characteristics. For acute myocardial infarction, higher volume of patients treated per family practitioner and internist and presence of a coronary care unit were also associated with better outcomes. Given the restricted number of conditions studied, the geographically limited sample and the fact that specific variables were not |

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| | | consistently related to quality of care for both conditions, the results are viewed as preliminary. However, they are consistent with and extend other developing findings in this area. They also suggest that more attention needs to be given to the organization of the hospital medical staff and its articulation with the overall hospital decision-making structure and process in attempts to improve outcomes of hospitalization. |
| Billingsley et al. 2007<br>Colon cancer surgery<br>US<br>Surgeon and hospital characteristics as predictors of major adverse outcomes following colon cancer surgery: understanding the volume-outcome relationship.<br>Retrospektivt kohortestudie<br>Arch Surg, 142, 23–31.<br>*Inkluderet I Mesman et al. 2015* | Although numerous studies have demonstrated an association between surgical volume and improved outcome in cancer surgery, the specific structures and mechanisms of care that are associated with volume and lead to improved outcomes remain poorly defined. We hypothesize that there are modifiable surgeon and hospital characteristics that explain observed volume-outcome relationships. | Results: Surgeon volume, but not hospital volume, is a significant predictor of postoperative procedural intervention (adjusted odds ratio for very high–volume surgeons vs low-volume surgeons, 0.79; 95% confidence interval, 0.64-0.98). In the unadjusted analyses, high hospital volume (odds ratio, 0.67; 95% confidence interval, 0.56-0.81) and very high hospital volume (odds ratio, 0.65; 95% confidence interval, 0.54-0.79) is associated with lower postoperative mortality. Postoperative procedural intervention is not a significant mediator of the relationship between hospital volume and mortality. A single variable—the presence of sophisticated clinical services—was the most important explanatory variable underlying the relationship between hospital volume and mortality.<br>Conclusions: Very high surgeon volume is associated with a reduction in surgical complications. However, the association between increasing hospital volume and postoperative mortality appears to derive mainly from a full spectrum of clinical services that may facilitate the prompt recognition and treatment of complications. |
| Hollenbeck et al. 2007a<br>Radical Cystectomy (bladder cancer)<br>US<br>Getting under the hood of the volume-outcome relationship for radical cystectomy.<br>The Journal of Urology, 177(6), 2095-9; discussion 2099.<br>*Inkluderet i Mesman et al. 2015* | To assess whether differences in hospital structure (capacity, staffing and health services) could explain some or all of the volume effect. | MATERIALS AND METHODS: Using the Nationwide Inpatient Sample a 20% sampling of hospital discharges in the United States and the American Hospital Association file we applied International Classification of Diseased, 9th revision, clinical modification procedure codes to identify 1,847 patients who underwent cystectomy for bladder cancer in 2003. Multivariable mixed models were fit to quantify the differences in measures of hospital structure (capacity, staffing and health services) by hospital volume. Separate models were fit to determine the impact of accounting for these differences on the volume-outcome relationship.<br>RESULTS: There were substantial differences in hospital structure according to radical cystectomy volume, including those characterizing capacity, staffing levels and the breadth of available health services. For example, 40.7% of low and 87.8% of high volume hospitals for radical cystectomy offered open heart surgery (OR 10.4, 95% CI 1.3-85.3). After adjusting for case mix patients treated at low volume centers |

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| | | were 3.2 times (95% CI 0.8-13.4) more likely to die postoperatively. Accounting for differences in hospital structure attenuated the volume effect by 59% (OR 1.9, 95% CI 0.4-8.6).<br>CONCLUSIONS: Measurable differences in the availability and breadth of consultative, diagnostic and ancillary services may at least partially explain the association between procedure volume and short-term cystectomy outcomes.<br>There are large differences in the capacity to deliver health care, the degree to which care delivery is monitored (e.g. staffing) and availability of services (consultative, diagnostic and ancillary) according to hospital volume.<br>Future studies should identify the specific processes of care that are the ultimate mediators of patient outcomes. |
| Solomon, Losina, Baron et al. (2002)<br>Total hip replacement<br>US<br>Contribution of hospital characteristics to the volume–outcome relationship: Dislocation and infection following total hip replacement surgery.<br>Arthritis & Rheumatism, Vol.46(9), pp.2436-2444<br>*Inkluderet i Mesman et al 2015* | Objective. Mortality and complication rates after total hip replacement (THR) are inversely associated with the volume of THRs performed at hospitals and by individual surgeons. It is not clear, however, why a higher volume of such procedures is associated with better outcomes. We evaluated the contribution of hospital structural characteristics to the volume–outcome relationship in THR by examining the rates and predictors of postoperative complications. | Results. Of the patients studied, 2.6% experienced an orthopedic adverse event after THR. Sixty-nine percent fewer events occurred in hospitals where >100 THRs in Medicare patients were performed annually, compared with hospitals where <25 THRs were performed. In univariate analyses, several hospital-level factors were associated with a reduced (50%) risk of adverse events, including private (versus public) ownership, membership in the Council of Teaching Hospitals, presence of any residency training program, availability of a dedicated orthopedic nursing unit, and existence of operating rooms with laminar flow exhaust systems. However, the only hospital-level factor associated with adverse events in multivariate models was the use of laminar flow exhaust systems. When surgeon volume was added to the models, it was the strongest predictor of adverse events, with hospital volume and hospital level factors having no appreciable association with adverse events.<br>Conclusion. Hospital-level factors were not independent predictors of the association between hospital volume and orthopedic adverse events. The volume of THRs performed by individual surgeons is the most important determinant of orthopedic complications and should be considered in efforts to improve THR outcomes. |
| **Sygeplejerskeressourcer** | | |
| Wiltse Nicely et al. 2013<br>Abdominal aortic aneurysm repair<br>US<br>Lower mortality for abdominal aortic aneurysm repair in high-volume hospitals is contingent upon nurse staffing.<br>Health Services Research (2013), 48(3) 972-991 | To determine whether and to what extent the lower mortality rates for patients undergoing abdominal aortic aneurysm (AAA) repair in high-volume hospitals is explained by better nursing.<br>To examine whether nursing (nurse staffing, nurse education and nurse practice environment) is a mediator | Favorable nursing practice environments and higher hospital volumes are associated with lower mortality and fewer failures-to-rescue.<br>Nursing is part of the explanation for lower mortality after AAA repair in high-volume hospitals. There is no mortality advantage observed in high-volume hospitals with poor nurse staffing. |

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| | of the hospital volume-outcomes relationship. | |
| Hickey et al. (2010)<br>Congenital heart surgery<br>US<br>The relationship of nurse staffing, skill mix, and magnet recognition to institutional volume and mortality for congenital heart surgery.<br>The Journal of Nursing Administration, 40(5), 226-232.<br>*Inkluderet i Mesman et al 2015* | The aim of this study was to examine the relationship of nurse staffing, skill mix, and Magnet(R) recognition to institutional volume and mortality for congenital heart surgery at children's hospitals. | METHODS: Cases of congenital heart surgery were identified from the 2005-2006 Pediatric Health Information System Database using International Classification of Diseases, Ninth Revision, Clinical Modification codes. The National Association of Children's Hospitals and Related Institution database was used for staffing data and verified by chief nursing officers; Magnet recognition was obtained from the American Nurses Credentialing Center Web site. Relationships among nursing characteristics, volume, and mortality were examined.<br>RESULTS: Among children undergoing congenital heart surgery at major children's hospitals, there was marked variation in intensive care unit (ICU) nursing hours per patient day (14.96-32.31). Variation in ICU nursing skill mix was less extreme (80%-100%); 20 hospitals had 100% registered nurse staffing in ICUs. There was a significant difference in median nursing skill mix between Magnet and non-Magnet hospitals (P = .02). None of the nursing characteristics was associated with mortality. However, higher nursing worked hours was significantly associated with higher volume (rs = 0.39, P = .027). Hospital volume was significantly associated with risk-adjusted mortality.<br>CONCLUSION: Nursing characteristics varied in ICUs in children's hospitals treating congenital heart surgery but were not associated with mortality. There was a significant relationship between ICU nursing worked hours and institutional volume. Nursing skill mix was lower in Magnet hospitals. |
| Sanagou et al. 2016<br>Cardiac surgery<br>Australia<br>Associations of hospital characteristics with nosocomial pneumonia after cardiac surgery can impact on standardized infection rates.<br>Epidemiol Infect., 144(5), pp. 1065-74. | We sought to understand better whether hospital characteristics such as hospital volume, number of hospital beds, registered nurse (RN) staffing, standards for airway management, standards for central line insertion, and rounds with an infectious disease specialist are associated with pneumonia following cardiac surgery. | Methods: This study used information from the Australian and New Zealand Society of Cardiac and Thoracic Surgeons (ANZSCTS) registry of cardiac surgery procedures from 2001 to 2011.<br>Results: Across the 43 000 patients from 16 Australian hospitals, pneumonia incidence rates varied considerably. The development of pneumonia after cardiac surgery was found to be associated (both in crude and adjusted analysis) with two hospital characteristics although the direction of the association was counterintuitive; pneumonia risk was found to be positively associated with the number of RNs/100 ICU admissions and per available ICU bed.<br>Other hospital-level characteristics including hospital volume, number of hospital beds, standards for central line insertion, and rounds with an infectious disease specialist did not exhibit any significant association with pneumonia incidence. |

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| Arkin et al. 2014<br>Aortic valve replacement<br>US<br>The Association of Nurse-to-Patient Ratio with mortality and Preventable Complications Following Aortic Valve Replacement.<br>J Card Surg. 29(2):141-8.<br>*Inkluderet i Mesman et al 2015* | To examine hospital resources associated with patient outcomes for aortic valve replacement (AVR), including inpatient adverse events and mortality.<br>We used the Nationwide Inpatient Sample to identify AVR procedures from 1998 to 2010 and the American Hospital Association Annual Survey to augment hospital characteristics. Primary outcomes included mortality and the development of adverse events, identified using standardized patient safety indicators (PSI). Patient and hospital characteristics associated with PSI development were evaluated using univariate and multivariate analyses. | An estimated 410,157 AVRs at 5009 hospitals were performed in the US between 1998 and 2010. The number of procedures grew annually by 4.72% ($p = 0.0003$) in high volume hospitals, 4.48% in medium volume hospitals ($p < 0.0001$), and 2.03% in low volume hospitals ($p = 0.154$). Mortality was highest in low volume hospitals, 4.70%, decreased from 4.14% to 3.73% in medium and high volume hospitals, respectively ($p = 0.0002$). Rates of PSIs did not vary significantly across volume terciles ($p = 0.254$). Multivariate logistic regression analysis showed low volume hospitals had increased risk of mortality as compared with high volume hospitals (odds ratio [OR]: 1.42; 95% confidence interval [CI]: 1.01 to 2.00), while hospital volume was not associated with adverse events. PSI development was associated with small hospitals as compared with large (OR: 1.63, 95% CI: 1.16 to 2.28) and inversely associated with higher nurse-to-patient ratio (OR: 0.94, 95% CI: 0.90 to 0.99).<br>The volume-outcomes relationship was associated with mortality outcomes but not postoperative complications. We identified structural differences in hospital size, nurses-to-patient ratio, and nursing skill level indicative of high quality outcomes. |
| Smith et al. 2007<br>Gastrectomy<br>US<br>Factors influencing the volume-outcome relationship in gastrectomies: a population-based study.<br>Annals of Surgical Oncology 14(6), 1846–1852. | BACKGROUND: A relationship between hospital procedural volume and patient outcomes has been observed in gastrectomies for primary gastric cancer, but modifiable factors influencing this relationship are not well elaborated.<br>We investigated the influence of not only well-documented, patient-specific factors, but also less-reported, hospital specific factors, which might explain the observed differences between higher- and lower-volume hospitals. | METHODS: We performed a population-based study of 1864 patients undergoing gastrectomy for primary gastric cancers at 214 hospitals. Hospitals were stratified as high-, intermediate-, or low-volume centers. Multivariate models were constructed to evaluate the effect of institutional procedural volume and other hospital- and patient-specific factors on the risk of in-hospital mortality, adverse events, and failure to rescue, defined as mortality after an adverse event.<br>RESULTS: High-volume centers attained an in-hospital mortality rate of 1.0% and failure-to-rescue rate of .7%, both less than one-fifth of that seen at intermediate- and low-volume centers, although adverse event rates were similar across the three volume tiers.<br>We identified two key hospital characteristics that influenced failure to rescue: critical care beds and nurse staffing.<br>In multivariate modeling, treatment at a high-volume hospital decreased the odds of mortality (odds ratio [OR], .22; 95% confidence interval [95% CI], .05-.89), whereas treatment at an institution with a high ratio of licensed vocational nurses per bed increased the odds of mortality (OR, 1.96; 95% CI, 1.04-3.75). Being treated at a hospital with a greater than median number of critical care beds decreased odds of mortality (OR, |

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| | | .46; 95% CI, .25-.81) and failure to rescue (OR, .53; 95% CI, .29-.97).<br>CONCLUSIONS: Undergoing gastrectomy at a high-volume center is associated with lower in-hospital mortality. However, improving the rates of mortality after adverse events and reevaluating nurse staffing ratios may provide avenues by which lower-volume centers can improve mortality rates. |
| Elting et al. (2005)<br>Cystectomy<br>US<br>Correlation between Annual Volume of Cystectomy, Professional Staffing, and Outcomes. A Statewide, Population-Based Study<br>Cancer 2005;104: 975–84.<br>*Inkluderet I Mesman et al 2015* | BACKGROUND. The association between high procedure volume and lower perioperative mortality is well established among cancer patients who undergo cystectomy. However, to the authors' knowledge, the association between volume and perioperative complications has not been studied to date and hospital characteristics contributing to the volume-outcome correlation are unknown. In the current study, the authors studied these associations, emphasizing hospital factors that contribute to the volume-outcome correlation.<br>METHODS. Multiple-variable models of inpatient mortality and complications were developed among all 1302 bladder carcinoma patients who underwent cystectomy between January 1, 1999 and December 31, 2001 in all Texas hospitals. General estimating equations were used to adjust for clustering within the 133 hospitals. Data were obtained from hospital claims, the 2000 U.S. Census, and databases from the Center for Medicare and Medicaid Services and the American Hospital Association. | RESULTS. Complications were reported to occur in 12% of patients, 2.2% of whom died. Mortality was higher in low-volume hospitals compared with high-volume hospitals (3.1% vs. 0.7%; P _ 0.001); mortality in moderate-volume hospitals was reported to be intermediate (2.9%). After adjustment for advanced age and comorbid conditions, treatment in high-volume hospitals was associated with lower risks of mortality (odds ratio [OR] _ 0.35; P _ 0.02) and complications (OR _ 0.53; P _ 0.01). Hospitals with a high registered nurse-to-patient ratio also had a lower mortality risk (OR _ 0.43; P _ 0.04).<br>CONCLUSIONS. Mortality after cystectomy was found to be significantly lower in high-volume hospitals, regardless of patient age. Referral to a hospital performing greater than 10 cystectomies annually is indicated for all patients. However, patients with poor access to a high-volume hospital may derive similar benefit from treatment at a hospital with a high-registered nurse-to-patient ratio. This finding requires further confirmation. |
| **Specialiseringsniveau** | | |
| Dickstein et al. (2006)<br>Ureteral reimplantation in children<br>US<br>The effect of surgeon volume and hospital characteristics on in-hospital outcome after ureteral reimplantation in children.<br>Pediatri Surg Int (2006) 22:417-421<br>*Inkluderet I Mesman et al. 2015* | The purpose of this study was to determine the effects of hospital characteristics and surgeon volume on LOS and hospital charges after ureteral reimplantation in children using data from a nationally representative database. | In conclusion, higher surgeon volume has a significant association with shorter LOS among children undergoing ureteral reimplantation. This effect was independent of children's hospital status and hospital volume. A similar effect of volume on charges was not observed. The current study provides additional evidence that increased surgeon experience is associated with more efficient care after this procedure. Identification of aspects of perioperative care that account for this finding may lead to further improvements in the care of children undergoing ureteral reimplantation. |
| Chen, Cheung & Sosa (2012)<br>Surgeon volume trumps specialty: outcomes from 3596 pediatric cholecystectomies.<br>US<br>Journal of Pediatric Surgery, Vol. 47(4), pp.673-680.<br>*Inkluderet i Mesman 2015* | Background: Laparoscopic cholecystectomy is the standard surgical management of biliary disease in children, but there has been a paucity of studies addressing outcomes after pediatric cholecystectomies, particularly on a national level. We conducted the first study to address the effect of surgeon specialty and volume on clinical and economic | Methods: We conducted a retrospective cross-sectional study using the Health Care Utilization Project Nationwide Inpatient Sample. Children (≤17 years) who underwent laparoscopic cholecystectomy from 2003 to 2007 were selected. Pediatric surgeons performed 90% or higher of their total cases in children. High-volume surgeons were in the top |

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| | outcomes after pediatric cholecystectomies on a population level. | tertile (n ≥ 37 per year) of total cholecystectomies performed. χ2, Analyses of variance, and multivariate linear and logistic regression analyses were used to assess in-hospital complications, median length of hospital stay (LOS), and total hospital costs (2007 dollars).<br>Results: A total of 3596 pediatric cholecystectomies were included. Low-volume surgeons had more complications, longer LOS, and higher costs than high-volume surgeons. After adjustment in multivariate regression, surgeon volume, but not specialty, was an independent predictor of LOS and cost.<br>Conclusions: High-volume surgeons have better outcomes after pediatric cholecystectomy than low-volume surgeons. To optimize outcomes in children after cholecystectomy, surgeon volume and laparoscopic experience should be considered above surgeon specialty. |
| Vernooij et al. (2009)<br>Ovarian cancer treatment<br>The Netherlands<br>Specialized and high-volume care leads to better outcomes of ovarian cancer treatment in the Netherlands<br>Gynecologic Oncology, 112(3), 455-461.<br>*Inkluderet i Mesman 2015* | Objective: We investigated the influence of hospital and gynecologist level of specialization and volume on surgical results and on survival of ovarian cancer patients. | Methods: Data were collected from 1077 ovarian cancer patients treated from 1996 to 2003 in a random sample of 18 Dutch hospitals. Hospitals and gynecologists were classified according to specialization (general, semi-specialized or specialized) and by volume (≤ 6, 7–12, or > 12 cases/year). Outcomes were percentage of adequately staged and optimally debulked patients and length of overall survival. Data were analyzed using multivariable logistic regression (surgical results) and Cox regression (survival).<br>Results: The level of specialization and the volume of hospitals and of gynecologists were strongly related to the proportion of adequately staged patients (adjusted odds ratio (OR) specialized hospitals 3.9 (95% confidence interval (CI) 2.0–7.6); specialized gynecologists 9.5 (95% CI 4.7–19)). Patients with stage III disease had a higher chance of optimal debulking when treated in specialized hospitals (adjusted OR 1.7 (95% CI 1.1–2.7)) or by high volume gynecologists (adjusted OR 2.8 (95% CI 1.4–5.7)). Overall survival was best in patients treated in specialized hospitals and by high-volume gynecologists.<br>Conclusion: The specialization level of hospitals and the surgical volume of gynecologists positively influence outcomes of surgery and survival. Concentration of ovarian cancer care thus seems warranted. |
| Shaw, Santry & Shah (2013)<br>Hepatectomy<br>US<br>Specialization and utilization after hepatectomy in academic medical centers<br>Journal of Surgical Research 185 (2013): 433-440 | Background: Specialized procedures such as hepatectomy are performed by a variety of specialties in surgery.<br>We aimed to determine whether variation exists among utilization of resources, cost, and patient outcomes by specialty, surgeon case | Methods: We queried centers (n = 50) in the University Health Consortium database from 2007–2010 for patients who underwent elective hepatectomy in which specialty was designated general surgeon (n = 2685; 30%) or specialist surgeon (n = 6277; 70%), surgeon volume was designated high volume (>38 cases annually) and center volume was designated high volume (>100 cases |

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| *Inkluderet i Mesman 2015* | volume, and center case volume for hepatectomy. | annually). We then stratified our cohort by primary diagnosis, defined as primary tumor (n = 2241; 25%), secondary tumor (n = 5466; 61%), and benign (n = 1255; 14%).<br>Results: Specialist surgeons performed more cases for primary malignancy (primary 26% versus 15%) while general surgeons operated more for secondary malignancies (67% versus 61%) and benign disease (18% versus 13%). Specialists were associated with a shorter total length of stay (LOS) (5 d versus 6 d; P < 0.01) and lower in-hospital morbidity (7% versus 11%; P < 0.01). Patients treated by high volume surgeons or at high volume centers were less likely to die than those treated by low volume surgeons or at low volume centers, (OR 0.55; 95% CI 0.33–0.89) and (OR 0.44; 95% CI 0.13–0.56).<br>Conclusions: Surgical specialization, surgeon volume and center volume may be important metrics for quality and utilization in complex procedures like hepatectomy. Further studies are necessary to link direct factors related to hospital performance in the changing healthcare environment. |
| Park, Roman & Sosa (2009)<br>Adrenalectomy<br>US<br>Outcomes From 3144 Adrenalectomies in the United States: Which Matters More, Surgeon Volume or Specialty?<br>Archives of Surgery, Vol. 144(11), p.1060.<br>*Inkluderet i Mesman et al 2015* | To assess the effect of surgeon volume and specialty on clinical and economic outcomes after adrenalectomy. Population-based retrospective cohort analysis.<br>Healthcare Cost and Utilization Project Nationwide Inpatient Sample. Adults (≥18 years) undergoing adrenalectomy in the United States (1999-2005). Patient demographic and clinical characteristics, surgeon specialty (general vs urologist), surgeon adrenalectomy volume, and hospital factors were assessed. The X... test, analysis of variance, and multivariate linear and logistic regression were used to assess in-hospital complications, mean hospital length of stay (LOS), and total inpatient hospital costs. | A total of 3144 adrenalectomies were included. Mean patient age was 53.7 years; 58.8% were women and 77.4% white. A higher proportion of general surgeons were high-volume surgeons compared with urologists (34.1% vs 18.2%, P < .001). Low-volume surgeons had more complications (18.2% vs 11.3%, P < .001) and their patients had longer LOS (5.5 vs 3.9 days, P < .001) than did high-volume surgeons; urologists had more complications (18.4% vs 15.2%, P = .03) and higher costs ($13 168 vs $11 732, P = .02) than did general surgeons. After adjustment for patient and provider characteristics in multivariate analyses, surgeon volume, but not specialty, was an independent predictor of complications (odds ratio = 1.5, P < .002) and LOS (1.0-day difference, P < .001). Hospital volume was associated only with LOS (0.8-day difference, P < .007). Surgeon volume, specialty, and hospital volume were not predictors of costs. To optimize outcomes, patients with adrenal disease should be referred to surgeons based on adrenal volume and laparoscopic expertise irrespective of specialty practice. |
| Mercado et al. 2010<br>Ovarian cancer<br>US<br>Quality of care in advanced ovarian cancer: The importance of provider specialty.<br>Gynecologic Oncology, 117(1), 18-22.<br>*Inkluderet i Mesman et al. 2015* | We examined whether surgeon specialty impacts quality of life (as proxied by presence of ostomy) and overall survival for women with advanced ovarian cancer. | METHODS: Stage IIIC/IV ovarian cancer patients were identified using 4 state cancer registries: California, Washington, New York, and Florida and linked records to the corresponding inpatient-hospital discharge file, AMA Masterfile, and 2000 U.S. Census SF4 File. Predictors of receipt of care by a general surgeon and creation of fecal ostomy were analyzed. Multivariate modeling was performed to assess the association of |

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| | | hospital volume (low volume (LV) [0-4 cases], middle volume (MV) [5-9], high volume (HV) [10-19], and very high volume (VHV) [20+]) and surgeon specialty training (gynecologic oncologists/gynecologists, general surgeons, and other specialty) on survival.<br>RESULTS: We identified 31,897 Stage IIIC/IV patients; mean age was 64 years. Treatment of patients by a general surgeon was predicted by LV, rural patient residence, poverty, and high level of comorbidity. Patients had lower hazard of death when treated in higher volume hospitals as compared to LV [VHV hazard ratio (HR)=0.79, P<.0001; HV HR=0.89, P<0.001]. Patients treated by a general surgeon had higher likelihood of an ostomy (OR=4.46, P<.0001) and hazard of death (HR=1.63, P<.0001) compared to gynecologic oncologist/gynecologist.<br>CONCLUSIONS: Advanced stage ovarian cancer patients have better survival when treated by gynecologic oncology/gynecology trained surgeons. Data suggest that referral to these specialists may optimize surgical debulking and minimize the creation of a fecal ostomy.<br>Patients had lower hazard of death when treated in higher volume hospitals. |
| Freeman, Wang et al. (2012)<br>Cardioverter-defibrillator implantation<br>US<br>Physician procedure volume and complications of cardioverter-defibrillator implantation.<br>Circulation, 125(1), 57-64.<br>*Inkluderet i Mesman et al 2015* | We assessed whether the rate of complications after implantable cardioverter-defibrillator (ICD) placement varied with the volume of procedures a physician performed. | METHODS AND RESULTS: We studied 356 515 initial ICD implantations in the National Cardiovascular Data Registry-ICD Registry, performed by 4011 physicians in 1463 hospitals. We examined the relationship between physician annual ICD implantation volume and in-hospital complications, using hierarchical logistic regression to adjust for patient characteristics, implanting physician certification, hospital characteristics, hospital annual procedure volume, and the clustering of patients within hospitals and by physician. We repeated this analysis for ICD subtypes: single chamber, dual chamber, and biventricular. There were 10 994 patients (3.1%) with a complication after ICD implantation, and 1375 died (0.39%). The complication rate decreased with increasing physician procedure volume from 4.6% in the lowest quartile to 2.9% in the highest quartile (P<0.0001), and the mortality rate decreased from 0.72% to 0.36% (P<0.0001). The inverse relationship between physician procedure volume and complications remained significant after adjusting for patient, physician, and hospital characteristics (OR 1.55 for complications in lowest-volume quartile compared with highest; 95% confidence interval, 1.34-1.79; P<0.0001). This inverse relationship was independent of physician specialty and of hospital volume, was consistent across ICD subtypes, and was also evident for in-hospital mortality. |

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| | | CONCLUSION: Physicians who implant more ICDs have lower rates of procedural complications and in-hospital mortality, independent of hospital procedure volume, physician specialty, and ICD type. |
| Billingsley et al. 2008<br>Rectal cancer resection<br>US<br>Does surgeon case volume influence nonfatal adverse outcomes after rectal cancer resection?<br>Journal of the American College of Surgeons, 206(6), 1167-1177.<br>*Inkluderet i Mesman et al 2015* | To assess the relationship between surgeon and hospital volume and major postoperative complications after rectal cancer surgery, and to define other surgeon and hospital characteristics that may explain observed volume-complication relationships. | STUDY DESIGN: This was a retrospective cohort design using data from the Surveillance, Epidemiology, and End Results (SEER) cancer registry program for individuals with stage I to III rectal cancer diagnosed between 1992 and 1999 and treated with resection. The patients' Surveillance, Epidemiology, and End Results data were linked with Medicare claims data from 1991 to 2000. The primary outcomes were 30-day postoperative procedural interventions (PPI) to treat surgical complications, such as reoperation. The association between surgeon volume and PPI was examined using logistic regression modeling with adjustment for covariates.<br>RESULTS: The odds of a rectal cancer patient requiring a PPI is notably less if the operation is performed by one of a small subset of very high volume surgeons (unadjusted odds ratio 0.53; 95% CI 0.31 to 0.92). Board certification in colorectal surgery did not alter the relationship between surgeon volume and PPI, although surgeon age did, with mid-career surgeons having the lowest rates of PPI, regardless of practice volume. When adjusted for surgeon age, surgeon volume is no longer a marked predictor of complications (adjusted odds ratio 0.57; 95% CI 0.30 to 1.09).<br>CONCLUSIONS: Overall, rectal cancer operations are safe, with a low frequency of severe complications. A subset of very high volume rectal surgeons performs these operations with fewer complications that require procedural intervention or reoperation. Surgeon age, as an indicator of experience, also contributes modestly to outcomes. These data do not justify regionalizing rectal cancer care based on safety concerns. |
| Farjah, Flum, Varghese et al. (2009).<br>Pulmonary resection for lung cancer<br>US<br>Surgeon specialty and long-term survival after pulmonary resection for lung cancer.<br>*The Annals of Thoracic Surgery, 87*(4), 995-1004; discussion 1005-6. | BACKGROUND: Long-term outcomes and processes of care in patients undergoing pulmonary resection for lung cancer may vary by surgeon type. Associations between surgeon specialty and processes of care and long-term survival have not been described. | METHODS: A cohort study (1992 through 2002, follow-up through 2005) was conducted using Surveillance, Epidemiology, and End-Results-Medicare data. The American Board of Thoracic Surgery Diplomates list was used to differentiate board-certified thoracic surgeons from general surgeons (GS). Board-certified thoracic surgeons were designated as cardiothoracic surgeons (CTS) if they performed cardiac procedures and as general thoracic surgeons (GTS) if they did not.<br>RESULTS: Among 19,745 patients, 32% were cared for by GTS, 45% by CTS, and 24% by GS. Patient age, comorbidity index, and resection type did not vary by surgeon specialty (all p > 0.10). Compared with GS and CTS, |

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| | | GTS more frequently used positron emission tomography (36% versus 26% versus 26%, respectively; p = 0.005) and lymphadenectomy (33% versus 22% versus 11%, respectively; p < 0.001). After adjustment for patient, disease, and management characteristics, hospital teaching status, and surgeon and hospital volume, patients treated by GTS had an 11% lower hazard of death compared with those who underwent resection by GS (hazard ratio, 0.89; 99% confidence interval, 0.82 to 0.97). The risks of death did not vary significantly between CTS and GS (hazard ratio, 0.94; 99% confidence interval, 0.88 to 1.01) or GTS and CTS (hazard ratio, 0.94; 99% confidence interval, 0.87 to 1.03).<br>General thoratic surgeons were higher-volume surgeons compared with cardiothoratic and general surgeons. General thoratic surgeons and cardiothoratic surgeons more often cared for patients at higher-volume centers compared with general surgeons.<br>CONCLUSIONS: Lung cancer patients treated by GTS had higher long-term survival rates than those treated by GS. General thoracic surgeons performed preoperative and intraoperative staging more often than GS or CTS. |
| Tu, Austin & Johnston (2001)<br>Abdominal aortic aneurysm surgery<br>Canada<br>The influence of surgical specialty training on the outcomes of elective abdominal aortic aneurysm surgery.<br>Journal of Vascular Surgery, Volume 33, Issue 3, Pages 447-452 | Objective: The aim of this study was to determine the independent impact of surgeon speciality training (vascular, cardiac, or general surgery) on the 30-day risk-adjusted mortality rate after elective abdominal aortic aneurysm (AAA) surgery. | Patients and Methods: All patients undergoing elective AAA surgery in Ontario between April 1, 1992, and March 31, 1996, were included. A retrospective cohort study with linked administrative databases was undertaken.<br>Results: The average 30-day mortality rate was 4.1%. Of the 5878 cases studied, 4415 (75.1%) were performed by 63 vascular surgeons, 1193 (20.3%) by 53 general surgeons, and 270 (4.6%) by 14 cardiac surgeons. After the adjustment for potential confounding factors of annual surgeon AAA volume, type of hospital, and patient age, sex, Charlson comorbidity score, and transfer status, the odds of patients dying were 62% higher when the surgery was performed by a general surgeon than when it was performed by a vascular surgeon. Cardiac surgeons' patient outcomes were similar to those of vascular surgeons.<br>General surgeons were much more likely to have lower annual volumes of AAA surgery and higher risk-adjusted mortality rates than vascular surgeons.<br>The overall median annual surgeon volume was seven AAA cases per year. Cardiac surgeons primarily performed CABG surgery, with a median annual volume of 136 cases per year, and performed none of the index procedures shown in Table I that are primarily associated with general surgery. Vascular surgeons were more likely to perform |

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| | | other types of index vascular procedures and performed only four of the index general surgery procedures per year on average. In contrast, general surgeons had a high frequency of performing the index general surgical procedures (median, 103 cases per year) when compared with surgeons in the other two specialities. Over 40% of the vascular and cardiac surgeons operated in teaching hospitals in comparison with only 11% of the general surgeons (P < .001).<br>Conclusions: Patients who undergo elective AAA repair that is performed by vascular or cardiac surgeons have significantly lower mortality rates than patients who have their aneurysms repaired by general surgeons. These results provide evidence that surgical specialty training in vascular procedures leads to better patient outcomes. |
| Hannan et al. (1992).<br>Abdominal aortic aneurysm surgery<br>US<br>A longitudinal analysis of the relationship between in-hospital mortality in new york state and the volume of abdominal aortic aneurysm surgeries performed.<br>Health Services Research, 27(4), 517-542. | To examine the relationship between in-hospital mortality for a patient receiving an abdominal aortic aneurysm resection and the volume of aneurysm operations performed in the previous year at the hospital where the operation took place and by the surgeon performing the operation. | This study uses New York State hospital discharge data to examine the relationship between in-hospital mortality for a patient receiving an abdominal aortic aneurysm resection and the volume of aneurysm operations performed in the previous year at the hospital where the operation took place and by the surgeon performing the operation. Previous research on this topic is extended in several respects: (1) A three-year data base is used to examine the manner in which hospital and surgeon volume jointly affect mortality rate and to examine ruptured and unruptured aneurysms separately; (2) a six-year data base is used to study the "practice makes perfect" hypothesis and the "selective referral" hypothesis; and (3) the degree of specialization of high-volume surgeons is contrasted with that of other surgeons.<br>The results demonstrate a significant inverse relationship between hospital volume and mortality rate for unruptured aneurysms. Further, very few surgeons substantially increased their aneurysm surgery volumes in the six-year study period. Weak selective referral effects were found for both surgeons and hospitals, and higher-volume aneurysm surgeons tended to have much higher specialization rates.<br>High volume aneurysm surgeons tended to specialize more in other operations on the aorta, and generally in other vascular operations, than did low-volume aneurysm surgeons. |
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| McGrath, Leong et al. (2005)<br>Colorectal cancer<br>Australia<br>Surgeon and hospital volume and the management of colorectal cancer patients in Australia. | The evidence for a relationship between patient outcomes and clinician and hospital volume is increasing. The National Colorectal Cancer Care Survey was undertaken to determine the management patterns | Results: Of 2,383 surgical questionnaires generated, 2,015 (85%) were completed. The majority (58%) of surgeons treated one or two patients with colorectal cancer over the 3 months of the survey. There was variation across surgeon cohorts for preoperative measures including the use of deep vein |

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| ANZ J Surg 2005; 75:901–10. | in Australia for individuals newly diagnosed with colorectal cancer in a 3 month period in the year 2000. | thrombosis prophylaxis. Patients seen by low volume surgeons were most likely to be given a permanent stoma (P < 0.0001). Patients with rectal cancer who were operated on by high volume surgeons were significantly more likely to receive a colonic pouch (P < 0.0001).<br>CONCLUSION: This nationwide population-based survey of the treatment of colorectal cancer patients suggests that the delivery of care by surgeons (the majority) who treat patients with rectal cancer infrequently should be evaluated. |
| Sacerdote et al. 2012<br>Colorectal cancer<br>Italy<br>Hospital factors and patient characteristics in the treatment of colorectal cancer: a population based study.<br>BMC Public health 12(1)775. | The study focused on non-clinical factors that can lead to disparities in the management and outcome of care.<br>The study used routinely available administrative data. | In our study, a hospital's annual caseload was a predictor of the type of surgery performed among rectal cancer patients but not of in-hospital mortality.<br>Patients were more likely to receive RT if the hospital where the surgery was performed had a RT service (preoperative radiotherapy).<br>The probability of receiving AP resection increased with age and in less-educated patients and in hospitals with a low volume. |
| Pulliam et al. (2016)<br>Hysterectomy, pelvic organ prolapse<br>US<br>Differences in Patterns of Preoperative Assessment Between High, Intermediate, and Low Volume Surgeons When Performing Hysterectomy for Uterovaginal Prolapse.<br>Female Pelvic Medicine & Reconstructive Surgery, 22(1), 7–10. | Objective The aim of the study was to determine whether surgeon case volume is associated with preoperative evaluation of pelvic organ prolapse before a hysterectomy for uterovaginal prolapse including a complete objective evaluation of prolapse (Baden-Walker or Pelvic Organ Prolapse Quantification), an offer of nonsurgical options for therapy (pessary), and a preoperative assessment of urinary incontinence. | Methods We performed a multicenter retrospective review of hysterectomies done for uterovaginal prolapse at 4 hospital systems between January 1, 2008 and December 31, 2011. The number of hysterectomies per surgeon for 4 years was evaluated to establish low-volume (≤10 cases), intermediate-volume (11–49 cases), and high-volume (≥50 cases) groups. Rates of preoperative standardized prolapse evaluations, offer of pessary, and evaluation of stress urinary incontinence were determined by chart review of 15% of the hysterectomy cases. Adjustment was made in a logistic regression model for age, race, insurance status, and prolapse size.<br>Results Three hundred one surgeons performed 4238 hysterectomies for prolapse during the study period. Rates of preoperative assessment by standardized pelvic examination differed between high-, intermediate-, and low-volume surgeons (91.2% vs 61.3% vs 48.8%, respectively), as did offer of a pessary (86.5% vs 71.9% vs 69.9%, respectively) and preoperative stress test for urinary incontinence (93.5% vs 72.8% vs 63.5%, respectively). Regression analysis revealed that high-volume surgeons were more likely than intermediate- or low-volume surgeons to perform a standardized pelvic examination, offer a pessary, or perform preoperative evaluation for urinary incontinence.<br>Conclusions High-volume surgeons were more likely than low-volume surgeons to perform a standardized preoperative pelvic examination, offer a pessary, and evaluate stress urinary incontinence. |

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| Kontos, Wang, Chaudhry et al. (2013).<br>Primary percutaneous coronary intervention<br>Lower hospital volume is associated with higher in-hospital mortality in patients undergoing primary percutaneous coronary intervention for ST-segment-elevation myocardial infarction: A report from the NCDR.<br>*Circulation.Cardiovascular Quality and Outcomes, 6*(6), 659-667. | BACKGROUND: Current guidelines recommend >36 primary percutaneous coronary interventions (PCIs) per hospital per year. Whether these standards remain valid when routine coronary stenting and newer pharmacological agents are used is unclear. | METHODS AND RESULTS: We analyzed patients who underwent primary PCI from July 2006 through June 2009 included in the CathPCI Registry. Hospitals were separated into 3 groups: low (36-60 primary PCIs/y), and high volume (>60 primary PCIs/y). In-hospital mortality and door-to-balloon time were examined for each group. A total of 87 324 patient visits for 86 044 patients from 738 hospitals were included. There were 278 low- (38%), 236 (32%) intermediate-, and 224 (30%) high-volume hospitals.<br>The majority of patients with primary PCI (54%) were treated at high-volume hospitals, with 15% at low-volume hospitals. Unadjusted mortality was significantly higher in low-volume hospitals compared with high-volume hospitals (5.6% versus 4.8%; P<0.001), which was maintained after multivariate adjustment (1.20; 95% confidence interval, 1.08-1.33; P=0.001). In contrast, mortality was not significantly different between intermediate-volume and high-volume hospitals (4.8% versus 4.8%; adjusted odds ratio, 1.02; 95% confidence interval, 0.94-1.11; P=0.61). Door-to-balloon times were significantly shorter in high-volume hospitals compared with low-volume hospitals (median, 72 minutes; interquartile range, [53-91] versus 77 [57-100] minutes; P<0.0001).<br>CONCLUSIONS: Higher annual hospital volume of primary PCI continues to be associated with lower mortality, with higher mortality in hospitals performing </=36 primary PCIs/y. |
| Shahian, O'Brien et al. (2010).<br>Coronary artery bypass<br>US<br>Association of hospital coronary artery bypass volume with processes of care, mortality, morbidity, and the society of thoracic surgeons composite quality score.<br>The Journal of Thoracic and Cardiovascular Surgery, 139(2), 273-282. | OBJECTIVE: This study examines the association of hospital coronary artery bypass procedural volume with mortality, morbidity, evidence-based care processes, and Society of Thoracic Surgeons composite score. | METHODS: The study population consisted of 144,526 patients from 733 hospitals that submitted data to the Society of Thoracic Surgeons Adult Cardiac Database in 2007. End points included use of National Quality Forum-endorsed process measures (internal thoracic artery graft; preoperative beta-blockade; and discharge beta-blockade, antiplatelet agents, and lipid drugs), operative mortality (in-hospital or 30-day), major morbidity (stroke, renal failure, reoperation, sternal infection, and prolonged ventilation), and Society of Thoracic Surgeons composite score. Procedural volume was analyzed as a continuous variable and by volume strata (or = 450). Analyses were performed with logistic and multivariate hierarchical regression modeling.<br>RESULTS: Unadjusted mortality decreased across volume categories from 2.6% (450 cases, P < .0001), and these differences persisted after risk factor adjustment (odds ratio for lowest- vs highest-volume group, 1.49). Care processes and morbidity end points were not associated with hospital procedural volume except for a trend (P = .0237) |

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| | | toward greater internal thoracic artery use in high-volume hospitals. The average composite score for the lowest volume (< 100 cases) group was significantly lower than that of the 2 highest-volume groups, but only 1% of composite score variation was explained by volume.<br>CONCLUSION: A volume-performance association exists for coronary artery bypass grafting but is weaker than that of other major complex procedures. There is considerable outcomes variability not explained by hospital volume, and low volume does not preclude excellent performance. Except for internal thoracic artery use, care processes and morbidity rates were not associated with volume. |
| Willison et al. (2000).<br>Acute myocardial infarction<br>US<br>Association of physician and hospital volume with use of aspirin and reperfusion therapy in acute myocardial infarction.<br>Medical Care, 38(11), 1092-1102. | To examine the association of hospital and physician volume with use of aspirin and reperfusion therapy in the management of acute myocardial infarction (AMI) in eligible patients. | METHODS: We reviewed charts of 2,215 patients treated at 35 Minnesota hospitals for AMI between October 1, 1992, and July 31, 1993, comparing use of aspirin and reperfusion therapy in eligible patients across different physician and hospital volume categories through multiple logistic regression.<br>RESULTS: Aspirin use did not vary significantly with physician volume. Use of reperfusion therapy was reduced among the lowest-volume physicians only.<br>Compared with the highest volume hospitals, aspirin use among very low volume hospitals was lower. These same hospitals had increased odds of using thrombolytics. This may be a "desperation reaction" with a perceived lack of other alternatives, such as cardiac catheterization labs and cardiologists. |
| Vrijens, Stordeur, Beirens et al. (2012).<br>Breast cancer<br>Belgium<br>Effect of hospital volume on processes of care and 5-year survival after breast cancer: A population-based study on 25000 women.<br>*Breast (Edinburgh, Scotland), 21*(3), 261-266. | To compare processes of care and survival for breast cancer by hospital volume in Belgium, based on 11 validated process quality indicators. | Six of eleven process indicators showed higher rates in high-volume hospitals: multidisciplinary team meeting, cytological and/or histological assessment before surgery, use of neoadjuvant chemotherapy, breast-conserving surgery rate, adjuvant radiotherapy after breast-conserving surgery, and follow-up mammography. Higher volume was also associated with improved survival. The 5-year observed survival rates were 74.9%, 78.8%, 79.8% and 83.9% for patients treated in very-low-, low-, medium- and high-volume hospitals respectively.<br>Limitations:… our analysis does not account for the effect of surgeon volume, a variable which has been shown to be a prognostic factor for survival from breast cancer.<br>CONCLUSION: Survival benefits reported in high-volume hospitals suggest a better application of recommended processes of care, justifying the centralization of breast cancer care in such hospitals. |

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| Lovrics, Cornacchi et al. (2010).<br>Breast cancer<br>Canada<br>Technical factors, surgeon case volume and positive margin rates after breast conservation surgery for early-stage breast cancer.<br>*Canadian Journal of Surgery.Journal Canadien De Chirurgie, 53*(5), 305-312. | For patients with breast cancer, a negative surgical margin at first breast-conserving surgery (BCS) minimizes the need for reoperation and likely reduces postoperative anxiety. We assessed technical factors, surgeon and hospital case volume and margin status after BCS in early-stage breast cancer. | We performed a retrospective cohort study using a regional cancer centre database of patients who underwent BCS for breast cancer from 2000 to 2002.<br>RESULTS: We reviewed 489 cases. There were no differences in patient or tumour characteristics among the low-, medium- and high-volume surgeon groups. High-volume surgeons were significantly more likely than other surgeons to operate with a confirmed preoperative diagnosis and to resect a larger volume of tissue. In our univariate analysis and at first operation, the rates of positive margins were 16.4%, 32.9% and 29.1% for high-, medium- and low-volume surgeons, respectively (p = 0.002). In the multivariate analysis, tumour factors (palpability, size, histology), presence of a confirmed preoperative diagnosis and size of resection specimen significantly predicted negative margins. However, when we controlled for these and other factors, high surgeon volume was not a predictor of negative margins at first surgery (odds ratio 1.8, 95% confidence interval 0.9-3.8, p = 0.09). Increased hospital volume was not associated with a lower rate of positive margins at first surgery.<br>CONCLUSION: Various tumour and technical factors were associated with negative margins at first BCS, whereas surgeon and hospital volume status were not. Technical steps that are under the control of the operating surgeon are likely effective targets for quality initiatives in breast cancer surgery. |
| Hermans et al. (2016).<br>Netherland<br>Bladder cancer<br>Nationwide population-based study<br>Variations in pelvic lymph node dissection in invasive bladder cancer: A Dutch nationwide population-based study during centralization of care.<br>Urologic Oncology: Seminars and Original Investigations, 34(12), 532.e7-532.e12. | To assess temporal trends in radical cystectomy (RC) and pelvic lymph node dissection (PLND) and the effect of centralization of care in the Netherlands between 2006 and 2012. | Patients and methods: This nationwide population-based study included 3524 patients from the Netherlands Cancer Registry who underwent RC as the primary treatment for cT1-4a, N0 or Nx, M0 urothelial carcinoma.<br>Results: In total, 3,191 (91%) patients had PLND during RC and the use increased from 84% in 2006 to 96% in 2012 (P20 RC per year) in 2011 and 2012. PLND use was highest in males, younger patients and in academic, teaching, and high-volume hospitals (>20 RC per year). In 2012, PLND application rates were comparable for academic, teaching, and nonteaching hospitals (P = 0.344). Median LNC increased from 7 in 2006 to 13 in 2012 (P10 (63% in 2012). Furthermore, lymph node count (LNC)>10 was associated with cT3-4a and, pN+disease, R0 and treatment in academic, teaching, or high-volume hospitals (>20 RC per year). Rate of pN+disease increased from 18% to 24% between 2006 and 2012 (P = 0.014). This trend was significantly associated with increased LNC on a continuous scale (odds ratio = 1.03).<br>Conclusions: After centralization of care, PLND during RC for cT1-4a, N0 or Nx, M0 urothelial carcinoma has become |

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| | | standard in all types of Dutch hospitals. The increase in LNC between 2006 and 2012 was associated with a higher incidence of pN+disease and suggests more adequate template extension and adherence to contemporary guidelines in recent years. |
| Ananthakrishnan et al. (2009a).<br>Acute nonvariceal upper-GI hemorrhage<br>US<br>Higher hospital volume is associated with lower mortality in acute nonvariceal upper-GI hemorrhage.<br>Gastrointestinal Endoscopy, 70(3), 422-432. | BACKGROUND: Acute nonvariceal upper-GI hemorrhage (NVUGIH) is associated with significant morbidity and mortality.<br>OBJECTIVE: To examine the relationship between hospital volume and outcomes of NVUGIH. DESIGN: A cross-sectional study. | SETTING: Participating hospitals from the Nationwide Inpatient Sample 2004. PATIENTS: All discharged patients with a primary discharge diagnosis of NVUGIH based on the International Classification of Diseases, Clinical Modification, ninth edition codes. INTERVENTIONS: Patients were divided into 3 groups based on discharge from hospitals with annual discharge volumes of 1 to 125 (low), 126 to 250 (medium), and >250 (high). MAIN OUTCOME MEASUREMENTS: In-hospital mortality, length of stay, and hospitalization charges.<br>RESULTS: The study included a total of 135,366, 132,746, and 123,007 discharges with NVUGIH occurred from low-volume, medium-volume, and high-volume hospitals, respectively. On multivariate analysis, when adjusting for age, comorbidity, and the presence of complications, patients at high-volume hospitals had significantly lower in-hospital mortality (odds ratio [OR] 0.85 [95% CI, 0.74-0.98]) than patients at low-volume hospitals. Patients at high-volume hospitals were also more likely to undergo upper-GI endoscopy (OR 1.52 [95% CI, 1.36-1.69]) or early endoscopy within 1 day of hospitalization compared with low-volume hospitals (60.5% vs 53.8%, adjusted OR 1.28 [95% CI, 1.02-1.61]). Undergoing endoscopy within day 1 was associated with shorter hospital stays (-1.08 days [95% CI, -1.24 to -0.92 days]) and lower hospitalization charges (-$1958 [95% CI, -$3227 to -$688]). LIMITATIONS: The study was based on an administrative data set.<br>CONCLUSIONS: Higher hospital volume is associated with lower mortality and with higher rates of endoscopy and endoscopic intervention in patients with NVUGIH. |
| Ananthakrishnan et al. (2009b).<br>Acute variceal hemorrhage<br>US<br>Higher hospital volume predicts endoscopy but not the in-hospital mortality rate in patients with acute variceal hemorrhage.<br>Gastrointestinal Endoscopy, 69(2), 221-229. | BACKGROUND: Acute variceal hemorrhage (AVH) is an important complication of cirrhosis that carries a high mortality rate. Management of AVH requires early initiation of specialized care that may be more readily available at centers that deal with a high volume of AVH.<br>OBJECTIVE: Our purpose was to examine the relationship between the annual hospitalization volume and the in-hospital mortality rate for AVH. | DESIGN: Cross-sectional study from a national representative sample. SETTING: A 20% sample of all nonfederal short-term hospitals from 37 states participating in the Nationwide Inpatient Sample 2004. PATIENTS: A total of 28,817 discharges with AVH identified through appropriate International Classification of Diseases, 9th Revision, Clinical Modification codes for bleeding esophageal varices. Hospitals were divided into low-, medium-, and high-volume hospitals if they had 1 to 15, 16 to 35, and 36 or more annual discharges related to AVH. MAIN OUTCOME |

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| | | MEASUREMENT: In-hospital mortality rate.<br>RESULTS: On multivariate analysis, there was no significant difference in the mortality rate either for medium- (odds ratio [OR] 0.84; 95% CI, 0.67-1.05) or high-volume hospitals (OR 1.06; 95% CI, 0.82-1.37). However, patients both at medium- (OR 1.27; 95% CI, 1.02-1.58) and high-volume hospitals (OR 1.40; 95% CI, 1.07-1.84) were more likely to undergo endoscopy for AVH. Endoscopic intervention for control of variceal hemorrhage was significantly more common in medium- (OR 1.20) and high- (OR 1.33) volume hospitals. Patients at medium- (OR 3.10; 95% CI, 2.09-4.60) and high-volume hospitals (OR 4.12; 95% CI, 2.52-6.75) were also more likely to undergo transjugular intrahepatic portosystemic shunt (TIPS).<br>CONCLUSION: Higher hospital volume is associated with greater rates of endoscopy, endoscopic intervention, and higher utilization of TIPS in the management of AVH. |
| Bachmann, Alderson et al. (2002)<br>Oesophageal and gastric cancers.<br>UK<br>Cohort study in south and west england of the influence of specialization on the management and outcome of patients with oesophageal and gastric cancers.<br>The British Journal of Surgery, 89(7), 914-922. | BACKGROUND: To evaluate specialization in National Health Service (NHS) cancer care, volume-outcome relationships were examined. | METHODS: This was a cohort study of 1512 patients with oesophageal or gastric cancer in 23 acute NHS hospitals. Outcomes were survival time and operative (30 day) mortality. Multiple regression analysis was performed, adjusted for diagnoses, prognoses and treatments.<br>RESULTS: For oesophageal cancer, the operative mortality rate decreased by 40 per cent (odds ratio 0.60 (95 per cent confidence interval (c.i.) 0.36 to 0.99 per cent); P = 0.047) for each increase of ten patients in doctors' annual surgical caseloads, and the risk of death decreased by 8 per cent (hazard ratio 0.92 (95 per cent c.i. 0.85 to 0.99); P = 0.021) for each increase of ten patients in doctors' annual caseloads. For gastric cancer, the operative mortality rate decreased by 41 per cent (odds ratio 0.59 (95 per cent c.i. 0.32 to 1.07)) for each increase of ten patients in doctors' annual surgical caseloads, and the risk of death decreased by 7 per cent (hazard ratio 0.93 (95 per cent c.i. 0.89 to 0.98); P = 0.009) for each increase of ten patients in hospitals' annual caseloads. Patients of higher-volume doctors were more likely to receive most investigations and treatments, independently of presenting features.<br>It also suggests, however, that patients of non-specialist doctors and hositals are less likely to receive effective investiagions and treatments, regardless of their clinical presentation.<br>CONCLUSION: The study supports concentration of services for oesophageal and gastric cancers. Specialization of doctors and their teams is at least as important as specialization of hospitals. |

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| Smith et al. (2013)<br>Bariatric Surgery<br>US<br>Can technical factors explain the volume-outcome relationship in gastric bypass surgery?<br>Surgery for Obesity and Related Diseases: Official Journal of the American Society for Bariatric Surgery, 9(5), 623-629. | The purpose of the present study is to understand possible explanations for the volume-outcome relationship in the Longitudinal Assessment of Bariatric Surgery (LABS) study.<br>Despite multiple studies demonstrating volume-outcome relationships, fewer studies investigate the causes of this relationship.<br>LABS includes a 10-center, prospective study examining 30-day outcomes after bariatric surgery. | METHODS: LABS includes a 10-center, prospective study examining 30-day outcomes after bariatric surgery. The relationship between surgeon annual RYGB volume and incidence of a composite endpoint (CE) has been published previously. Technical aspects of RYGB surgery were compared between high and low volume surgeons. The previously published model was adjusted for select technical factors.<br>RESULTS: High-volume surgeons (>100 RYGBs/yr) were more likely to perform a linear stapled gastrojejunostomy, use fibrin sealant, and place a drain at the gastrojejunostomy compared with low-volume surgeons (<25 RYGBs/yr), and less likely to perform an intraoperative leak test. After adjusting for the newly identified technical factors, the relative risk of CE was .93 per 10 RYGB/yr increase in volume, compared with .90 for clinical risk adjustment alone.<br>CONCLUSION: High-volume surgeons exhibited certain differences in technique compared with low-volume surgeons. After adjusting for these differences, the strength of the volume-outcome relationship previously found was reduced only slightly, suggesting that other factors are also involved. |
| Loperfido et al. (1998)<br>ERCP<br>Italy<br>Major early complications from diagnostic and therapeutic ERCP: a prospective multicenter study.<br>Gastrointest Endosc 1998, 48(1), 1-10. | To evaluate the risks of complications and deaths of diagnostic and therapeutic endoscopic retrograde cholangiopancreatography (ERCP). | Large centers > 200 cases, small centers < 200 cases.<br>Major ERCP complications and related deaths occurred in inverse proportion to the activity rate of the endoscopy center. The variable of small center increased the overall complication risk of therapeutic ERCPs and specifically the risk of pancreatitis, cholangitis, and bleeding.<br>The better outcome in high volume centres may be associated with less frequently use of precut a technique that increases the risk of complications. |
| Kalaitzakis & Toth (2015)<br>ERCP for benign disease<br>Sweden<br>Hospital volume status is related to technical failure and all-cause mortality following ERCP for benign disease.<br>Digestive Diseases and Sciences, 60(6), 1793-1800. | BACKGROUND: Population-based data on hospital procedure volume and outcome of endoscopic retrograde cholangiopancreatography (ERCP) are limited.<br>AIMS: To investigate procedural failure, early re-admission, and all-cause mortality following ERCP performed due to benign disease and to examine their relation to hospital procedure volume. | METHODS: All patients with a first ERCP in 2005-2008 in Sweden were identified from the Swedish Hospital Discharge Registry. Data on indication, admission method, length of stay (LOS), and comorbid illness were extracted. Patients were linked to the Swedish Death and Cancer Registries. Factors associated with failed index ERCP, early re-admission, and all-cause mortality were identified by multiple logistic analyses.<br>RESULTS: Overall, 12,695 first ERCPs for benign disease were analyzed. The 30-day re-admission rate was 13 % and all-cause 30-day mortality 2.2 %. Failed index ERCP was more common in low-volume than high-volume institutions ($p = 0.007$). In logistic regression analysis, low hospital procedure volume was an independent predictor of failed index ERCP (odds ratio (OR) 2.72 vs. high), but not 30-day re-admission ($p > 0.05$). |

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| | | LOS was longer in cases of procedural failure (p < 0.001). All-cause 30-day mortality was independently related to low hospital ERCP volume (OR 1.41 vs. high) and failed ERCP (OR 5.65 vs. successful).<br>CONCLUSION: In this population-based cohort of first ERCPs due to benign disease, lower hospital ERCP volume was related to failed ERCP, which, in turn, was associated with longer LOS. Failed ERCP and lower hospital procedure volume were associated with poor survival, but not with early re-admission following index ERCP. These findings may have implications for service development |
| Onete et al. (2015).<br>Pancreatoduodenectomy<br>Netherlands<br>Impact of centralization of pancreatoduodenectomy on reported radical resections rates in a nationwide pathology database.<br>Hpb, 17(8), 736-742. | Background Centralization of a pancreatoduodenectomy (PD) leads to a lower post-operative mortality, but is unclear whether it also leads to improved radical (R0) or overall resection rates.<br>The aim of the present work was to analyse the impact of centralization of PD in the period 2004–2009 in the Netherlands on resection rates and reported R0 resections of pancreatic and peri-ampullary neoplasms and the quality of pathology reports. | Methods: Between 2004 and 2009, pathology reports of 1736 PDs for pancreatic and peri-ampullary neoplasms from a nationwide pathology database were analysed. Pre-malignant lesions were excluded. High-volume hospitals were defined as performing > 20 PDs annually. The relationship between R0 resections, PD-volume trends, quality of pathology reports and hospital volume was analysed.<br>Results: During the study period, the number of hospitals performing PDs decreased from 39 to 23. High-volume hospitals reported more R0 resections in the pancreatic head and distal bile duct tumours than low-volume hospitals (60% versus 54%, P = 0.035) although they operated on more advanced (T3/T4) tumours (72% versus 58%, P < 0.001). The number of PDs increased from 258 in 2004 to 394 in 2009 which was partly explained by increased overall resection rates of pancreatic head and distal bile duct tumours (11.2% in 2004 versus 17.5% in 2009, P < 0.001). The overall reported R0 resection rate of pancreatic head and distal bile duct tumours increased (6% in 2004 versus 11% in 2009, P < 0.001). Pathology reports of low-volume hospitals lacked more data including tumour stage (25% versus 15%, P < 0.001).<br>Conclusions: Centralization of PD was associated with both higher resection rates and more reported R0 resections. The impact of this finding on overall survival should be further assessed. |
| Wright et al. (2012)<br>Radical hysterectomy<br>US<br>Comparative effectiveness of minimally invasive and abdominal radical hysterectomy for cervical cancer<br>Gynecologic Oncology 127(1), 11–17. | Objective: We analyzed the uptake, morbidity, and cost of laparoscopic and robotic radical hysterectomies for cervical cancer. | Methods: We identified women recorded in the Perspective database with cervical cancer who underwent radical hysterectomy (abdominal, laparoscopic, robotic) from 2006 to 2010. The associations between patient, surgeon, and hospital characteristic and use of minimally invasive hysterectomy as well as complications and cost were estimated using multivariable logistic regression models.<br>Results: We identified 1894 patients including 1610 (85.0%) who underwent abdominal, 217 (11.5%) who underwent |

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| | | laparoscopic, and 67 (3.5%) who underwent robotic radical hysterectomy were analyzed. In 2006, 98% of the procedures were abdominal and 2% laparoscopic; by 2010 abdominal radical hysterectomy decreased to 67%, while laparoscopic increased to 23% and robotic radical hysterectomy was performed in 10% of women (p<0.0001). Patients treated at large hospitals (>600 beds) were more likely to undergo a minimally invasive procedure (OR=4.80; 95% CI, 1.28–18.01) while those with more medical comorbidities (OR=0.60; 95% CI, 0.41–0.87) were less likely to undergo a minimally invasive surgery. Perioperative complications were noted in 15.8% of patients who underwent abdominal surgery, 9.2% who underwent laparoscopy, and 13.4% who had a robotic procedure (p=0.04). Both laparoscopic and robotic radical hysterectomies were associated with lower transfusion requirements and shorter hospital stays than abdominal hysterectomy (p<0.05). Median costs were $9618 for abdominal, $11,774 for laparoscopic, and $10,176 for robotic radical hysterectomy (p<0.0001).<br>Conclusion: Uptake of minimally invasive radical hysterectomy for cervical cancer has been slow. Both laparoscopic and robotic radical hysterectomies are associated with favorable morbidity profiles.<br>Compared to an open procedure, minimally invasive operations often take longer and are reimbursed at the same rate. |
| Schurman et al. (1999)<br>Pediatric renal transplantation<br>US<br>Cohort study<br>Center Volume effects in pediatric renal transplantation. A report of the North American Pediatric Renal Transplant Cooperative Study.<br>Pediatric Nephrology 1999, 13(5), 373-378. | The goal of this report is to analyze center volume effects using the experience reported to North American Pedeatric Renal Transplant Cooperative Study (NAPRTCS) | Given the distinctiveness of pediatric renal transplantation and the large variation in center volume, investigation for relationships between center volume and graft outcome was pursued using the North American Pediatric Transplant Cooperative Study databse. Center volume groups were based on the total number of pediatric transplants reported fram 1987 to 1995. Centers reporting > 100, 51-100, og ≤50 transplants were grouped as high- (n=11), moderate- (n=28), or low-volume (n=65), respectively. Difference between groups included increasing, rates of cadaver donor graft thrombosis (2.4%, 4.3% and 5.7%, P<0.01) and acte tubular necrosis (ATN) (10.2%, 11.5% and 14.0%, p<0.01) with decreasing center volume. Threatment differences included a higher rate of induction with an anti-T-cell antibody preparation in the larger-volume groups, 60.2%, 51.8%, and 39.2% (P<0.001). |
| Rogers, Ayanian et al. (2009)<br>Colorectal cancer<br>US | BACKGROUND: Few studies have assessed associations of surgeons' practice volume with processes of care that lead to better outcomes. | SUBJECTS AND METHODS: Surgeons caring for patients with colorectal cancer in multiple regions and health-care organizations were surveyed to assess their volume of colorectal cancer resections and participation in decisions |

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| Surgeons' volume of colorectal cancer procedures and collaborative decision-making about adjuvant therapies.<br>Annals of Surgery, 250(6), 895-900. | OBJECTIVE: We surveyed surgeons treating colorectal cancer to determine whether high-volume surgeons were more likely to collaborate with other physicians in decisions about adjuvant therapies. | about adjuvant chemotherapy and radiation therapy. We used logistic regression to assess physician and practice characteristics associated with surgical volume and the relation of surgical volume and these other characteristics to collaborative decision-making regarding adjuvant therapies.<br>RESULTS: Of 635 responding surgeons, those who identified themselves as surgical oncologists or colorectal surgeons were more likely than others to report high volume of colorectal cancer resections (P < 0.001), as were those who practiced at a comprehensive cancer center (P = 0.06) and attended tumor board meetings weekly (vs. quarterly or less, P = 0.09). Most surgeons reported a collaborative role in decisions about chemotherapy and radiation therapy. However, in adjusted analyses, higher-volume surgeons more often reported a collaborative role with other physicians in decisions about chemotherapy (P < 0.001) and radiation therapy (P < 0.001).<br>CONCLUSIONS: Higher-volume surgeons are more likely to report collaborating with other physicians in decisions about adjuvant therapies for patients following colorectal cancer surgery. This collaborative decision-making of higher-volume surgeons may contribute to outcome differences by surgeon volume. |
| Rogers, Wolf et al. (2006)<br>Colorectal cancer surgery<br>US<br>Relation of surgeon and hospital volume to processes and outcomes of colorectal cancer surgery.<br>Annals of Surgery, 244(6), 1003-1011. | BACKGROUND: Greater hospital volume has been associated with lower mortality after colorectal cancer surgery. The contribution of surgeon volume to processes and outcomes of care is less well understood. We assessed the relation of surgeon and hospital volume to postoperative and overall mortality, colostomy rates, and use of adjuvant radiation therapy. | METHODS: From the California Cancer Registry, we studied 28,644 patients who underwent surgical resection of stage I to III colorectal cancer during 1996 to 1999 and were followed up to 6 years after surgery to assess 30-day postoperative mortality, overall long-term mortality, permanent colostomy, and use of adjuvant radiation therapy.<br>RESULTS: Across decreasing quartiles of hospital and surgeon volume, 30-day postoperative mortality ranged from 2.7% to 4.2% (P < 0.001). Adjusting for age, stage, comorbidity, and median income among patients with colorectal cancer who survived at least 30 days, patients in the lowest quartile of surgeon volume had a higher adjusted overall mortality rate than those in the highest quartile (hazard ratio, 1.16; 95% confidence interval, 1.09-1.24), as did patients in the lowest quartile of hospital volume relative to those treated in the highest quartile (hazard ratio, 1.11; 95% confidence interval, 1.05-1.19). For rectal cancer, adjusted colostomy rates were significantly higher for low-volume surgeons, and the use of adjuvant radiation therapy was significantly lower for low-volume hospitals.<br>CONCLUSIONS: Greater surgeon and hospital volumes were associated with improved outcomes for patients undergoing surgery for colorectal cancer. Further study of processes that led to these |

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| | | differences may improve the quality of colorectal cancer care. |
| Siemens et al. (2014)<br>Cystectomy – bladder cancer<br>Canada<br>Processes of care and the impact of surgical volumes on cancer-specific survival: A population-based study in bladder cancer.<br>Urology, 84(5),1049–1057 | To describe the relationships between procedure volume and late survival after cystectomy for muscle-invasive bladder cancer (MIBC) and explore variables explaining any effect. | The cohort included 2802 MIBC patients treated with cystectomy. High-volume hospitals were more likely to have used adjuvant chemotherapy (25% vs 18%; P <.001), more likely to have performed an LND (83% vs 53%; P <.001), and associated with a lower 90-day mortality (6% vs 10%; P = .032). Low-volume hospitals had a lower 5-year CSS rate of 32% (28%-36%) compared with those of high-volume centers at 38% (33%-42%).<br>Individual surgeon volume was similarly associated with both early- and long-term outcomes. In multivariate analysis, both surgeon and hospital volumes were associated with CSS and overall survival. The surgeon volume effect on long-term outcomes was modestly modified by indicators of the quality of the LND, with little effect of the other explanatory variables.<br>CONCLUSION: Higher provider volume is associated with higher CSS in patients with MIBC in the general population. The volume effect was modestly mediated by the quality of LND. |
| Auerbach, Hilton et al. (2010a)<br>Coronary artery bypass surgery<br>US<br>Case volume, quality of care, and care efficiency in coronary artery bypass surgery.<br>Archives of Internal Medicine, 170(14), 1202-1208.<br>*Inkluderet I Mesman et al 2015* | To examine the relationship between surgeon and hospital volume, and costs and length of stay. | METHODS: We conducted an observational study of patients 18 years or older who underwent coronary artery bypass grafting surgery in a network of US hospitals. Case volumes were estimated using our data set. Quality was assessed by whether recommended medications and services were not received in ideal patients, as well as the overall number of measures missed. We used multivariable hierarchical models to estimate the effects of case volume and quality on hospital cost and LOS.<br>RESULTS: The majority of hospitals (51%) and physicians (78%) were lowest-volume providers, and only 18% of patients received all quality of care measures. Median LOS was 7 days (interquartile range [IQR], 6-11 days), and median costs were $25 140 (IQR, $19 677-$33 121). In analyses adjusted for patient and site characteristics, lowest-volume hospitals had 19.8% higher costs (95% CI, 3.9%-38.0% higher); adjusting for care quality did not eliminate differences in costs. Low surgeon volume was also associated with higher costs, though less strongly (3.1% higher costs [95% CI, 0.6%-5.6% higher]). Individual quality measures had inconsistent associations with costs or LOS, but patients who had no quality measures missed had much shorter LOS and lower costs than those who missed even one.<br>CONCLUSION: Avoiding lowest-volume hospitals and maximizing quality are separate approaches to improving health care efficiency through reducing costs of coronary bypass surgery. |

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| | | Quality measures (use of antimicrobials, compression devises, aspirin etc.) |
| Auerbach, Maselli et al. (2010b)<br>Complex cancer surgery<br>US<br>The relationship between case volume, care quality, and outcomes of complex cancer surgery.<br>Journal of the American College of Surgeons, 211(5), 601-608.<br>*Inkluderet i Mesman et al 2015* | How case volume and quality of care relate to each other and to results of complex cancer surgery is not well-understood. | STUDY DESIGN: Observational cohort of 14,170 patients 18 years or older who underwent pneumonectomy, esophagectomy, pancreatectomy, or pelvic surgery for cancer between October 1, 2003 and September 1, 2005 at a US hospital participating in a large benchmarking database. Case volumes were estimated within our dataset. Quality was measured by determining whether ideal patients did not receive appropriate perioperative medications (such as antibiotics to prevent surgical site infections), both as individual "missed"measures and as overall number missed. We used hierarchical models to estimate effects of volume and quality on 30-day readmission, in-hospital mortality, length of stay, and costs.<br>RESULTS: After adjustment, we noted no consistent associations between higher hospital or surgeon volume and mortality, readmission, length of stay, or costs. Adherence to individual measures was not consistently associated with improvement in readmission, mortality, or other outcomes. For example, continuing antimicrobials past 24 hours was associated with longer length of stay (21.5% higher, 95% CI, 19.5-23.6%) and higher costs (17% higher, 95% CI, 16-19%). In contrast, overall adherence, although not associated with differences in mortality or readmission, was consistently associated with longer length of stay (7.4% longer with 1 missed measure and 16.4% longer with >/=2) and higher costs (5% higher with 1 missed measure, and 11% higher with >/=2).<br>CONCLUSIONS: Although hospital and surgeon volume were not associated with outcomes, lower overall adherence to quality measures is associated with higher costs, but not improved outcomes. This finding might provide a rationale for improving care systems by maximizing care consistency, even if outcomes are not affected. |
| Kong, Pezzin & Nattinger (2015)<br>Breast cancer<br>US<br>Identifying patterns of breast cancer care provided at high-volume hospitals: A classification and regression tree analysis.<br>Breast Cancer Research and Treatment, 153(3), 689-698. | There is a growing body of literature linking hospital volume to outcomes in breast cancer. However, the mechanism through which volume influences outcome is poorly understood.<br>The purpose of this study was to examine the relationship between hospital volume of breast cancer cases and patterns of processes of care in a population-based cohort of Medicare patients. | Hospital volume was divided into tertiles. A Classification and Regression Tree (CART) model was performed to look for statistically significant relationships between patterns of processes of care and hospital volume. Using CART analysis, eight patterns of care were identified that differentiated breast cancer care at high- versus low-volume hospitals. Sentinel lymph node dissection (SLND) was the single process of care that demonstrated the greatest differentiation across hospitals with differing volumes. Four patterns of care significantly predicted that a patient was less likely to be treated at a high-volume hospital. Our study demonstrates differences in patterns of processes of care |

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| | | between low- and high-volume hospitals. Hospital volume was associated with several patterns of care that reflect the most current standards of care, particularly SLND. Greater adoption of these patterns by low-volume hospitals could improve the overall quality of care for breast cancer. |
| Fjösne, Søreide, Kåresen et al. (2011).<br>Breast cancer<br>Norway<br>Hospital volume and prognosis among norwegian breast cancer patients enrolled in adjuvant trials.<br>Acta Oncologica, 50(7), 1068-1074. | Background. Several studies have reported an association between breast cancer unit volume and prognosis. We hypothesize that this may be due to inappropriate coping with the recommended guidelines for adjuvant therapy rather than improper breast cancer surgery provided at smaller units. | Methods. A cohort of 1131 patients with operable breast cancer (pT1-2 and positive axillary lymph nodes, stage II) enrolled between 1984 and 1994 were analyzed. The women had participated in one of three prospective trials on adjuvant endocrine treatment and were enrolled from 50 centers in Norway. The hospitals were categorized into four groups according to the annual number of surgically treated breast cancer patients reported to the national discharge database in 1990. The hospitals were also stratified according to whether they are university or non-university hospitals. To assess the effect of unit size on patient outcome, local recurrence rates and overall survival were compared in women treated at units with different patient volumes.<br>Results. The median time from study enrolment to the end of the study was 10.5 years. Relapse-free survival and overall survival did not differ significantly between the hospital groups based on the surgical workload or between university and non-university hospitals.<br>Conclusions. Patient volume or teaching status of a hospital did not have any impact on the prognosis of pre- or postmenopausal stage II breast cancer patients included in the adjuvant endocrine trials. Our data support the hypothesis that differences in survival related to patient volume at the treatment units may be explained by inappropriate adjuvant systemic treatment. |
| Hollenbeck et al. 2007b<br>Cystectomy<br>(bladder cancer)<br>U.S.<br>Volume, process of care, and operative mortality for cystectomy for bladder cancer.<br>Urology, 69(5), 871-875.<br>*Inkluderet i Mesman et al 2015* | To identify the processes that underlie the volume-outcome relationship for cystectomy. | METHODS: Within the Surveillance, Epidemiology, and End Results (SEER)-Medicare data set, we used International Classification of Diseases (ICD)-9 procedure codes to identify 4465 patients who underwent cystectomy for bladder cancer between 1992 and 1999. The preoperative and perioperative processes of care were abstracted from the inpatient, outpatient, and physician files using the procedure and diagnosis codes available through 2002. Logistic models were used to assess the relationship between the process and hospital volume, adjusting for differences in patient characteristics.<br>RESULTS: Substantial variation was found in the use of specific processes of care across the hospital volume strata. High-volume hospitals had greater rates of preoperative cardiac testing (odds ratio [OR] 1.57, 95% confidence interval [CI] 1.24 to 1.98), intraoperative arterial |

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| | | monitoring (OR 3.73, 95% CI 3.11 to 4.46), and the use of a continent diversion (OR 4.01, 95% CI 3.03 to 5.30), among many others. Patients treated at low-volume hospitals were 48% more likely to die in the postoperative period (4.9% versus 3.5%, adjusted OR 1.48, 95% CI 1.03 to 2.13). Differences in the use of processes of care explained 23% of this volume-mortality effect.<br>CONCLUSIONS: High-volume and low-volume hospitals differ with regard to many processes of care before, during, and after radical cystectomy. Although these practices have partly explained the volume-outcome relationships for cystectomy, the primary mechanisms underlying this effect remain unclear. |
| Patschan et al. (2015)<br>Bladder cancer<br>Sweden<br>Use of bacillus calmette-guerin in stage T1 bladder cancer: Long-term observation of a population-based cohort.<br>Scandinavian Journal of Urology, 49(2), 127-132. | To analyse the rate of use of bacillus Calmette-Guerin (BCG) at a population-based level, and the overall mortality and bladder cancer mortality due to stage T1 bladder cancer in a national, population-based register. | MATERIALS AND METHODS: In total, 3758 patients with primary stage T1 bladder cancer, registered in the Swedish Bladder Cancer Register between 1997 and 2006, were included. Age, gender, tumour grade and primary treatment in the first 3-6 months were registered. High-volume hospitals registered 10 or more T1 tumours per year. Date and cause of death were obtained from the National Board of Health and Welfare Cause of Death Register.<br>RESULTS: BCG was given to 896 patients (24%). The use of BCG increased from 18% between 1997 and 2000, to 24% between 2001 and 2003, and to 31% between 2004 and 2006. BCG was given more often to patients with G3 tumours, patients younger than 75 years and patients attending high-volume hospitals. BCG treatment, grade 2 tumours and patient age younger than 75 years were associated with lower mortality due to bladder cancer. Hospital volume, gender and year of diagnosis were not related to bladder cancer mortality. However, selection factors might have affected the results since comorbidity, number of tumours and tumour size were unknown.<br>CONCLUSIONS: Intravesical BCG is underused at a population-based level in stage T1 bladder cancer in Sweden, particularly in patients 75 years or older, and in those treated at low-volume hospitals. BCG should be offered more frequently to patients with stage T1 bladder cancer in Sweden. |
| McKiernan et al. (2000)<br>UK and Ireland<br>Biliary atresia<br>The frequency and outcome of biliary atresia in the UK and Ireland<br>*Lancet 2000; 355: 25-29* | The aim of this study was to establish the current frequency of biliary atresia in the UK and Ireland, to examine current referral patterns, and to find the factors that influence the success of poroenterostomy. | Centers were gouped according to caseload; group A had more than 5 cases/year and group B fewer than 5 cases/year. Only two centres treated more than five cases per year.<br>Time between referral to the surgical centre and undergoing surgery was significantly shorter in group-A centres compared with group-B centres, 10 days (2 -55) compared with 14 days (1-94), p<0.05. Early success was higher in group A centres, odds raio2.02 (95% |

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| | | CI0.86-4.73), but this did not reach statistical significance. |
| Birkmeyer et al. (2006).<br>High-risk cancer surgery<br>US<br>Volume and process of care in high-risk cancer surgery.<br>Cancer, 106(11), 2476-2481.<br>*Inkluderet i Mesman et al 2015* | The study was conducted to examine relations between hospital volume, process of care, and operative mortality in cancer surgery. | METHODS: Using the Medicare claims database (2000-2002), we identified all patients undergoing major resections for lung, esophageal, gastric, liver, or pancreatic cancer (n=71,558). Preoperative, intraoperative, and postoperative processes of care potentially related to operative mortality were identified from inpatient, outpatient, and physician claims files using appropriate International Classification of Diseases--Clinical Modification (ICD-9) and Current Procedural Terminology (CPT) codes. We then assessed variation in the use of each process according to hospital volume, adjusting for patient characteristics and procedure type. Study Participants were US Medicare patients. The main outcome measure was specific processes of care.<br>RESULTS: Relative to those at low-volume centers (lowest 20th by volume), patients at high-volume hospitals (highest 20th) were significantly more likely to undergo stress tests (odds ratio [OR]: 1.51, 95% confidence interval [CI]: 1.21-1.87), but not other preoperative imaging tests. They were more likely to see medical or radiation oncologists (OR: 1.37, 95% CI: 1.16-1.62), but not other specialists, preoperatively. Although blood transfusions and use of epidural pain management did not vary significantly by volume, patients at high-volume hospitals had significantly longer operations and were more likely to receive perioperative invasive monitoring (OR: 2.56, 95% CI: 1.82-3.60). Differences in measurable processes of care did not explain volume-related differences in operative mortality to any significant degree.<br>CONCLUSIONS: Although high-volume and low-volume hospitals differ with regard to many aspects of perioperative care, mechanisms underlying volume-outcome relations in high-risk cancer surgery remain to be identified. |
| Gammie, O'Brien et al. (2007).<br>Mitral regurgitation<br>US<br>Influence of hospital procedural volume on care process and mortality for patients undergoing elective surgery for mitral regurgitation.<br>Circulation, 115(7), 881-887. | BACKGROUND: Few studies have examined the procedural volume-outcome relationship for heart valve surgery. None have examined process of care factors that may be mediators of this association. | METHODS AND RESULTS: This was a retrospective review of outcomes for 13,614 patients having elective surgery for mitral regurgitation between 2000 and 2003 in 575 North American centers participating in the Society of Thoracic Surgeons National Cardiac Database.<br>Hospital annual mitral valve volume varied widely from 22 cases per year in the lowest-volume quartile to 394 in the highest. Unadjusted mortality rates decreased from 3.08% in the lowest-volume category to 1.11% in the highest-volume category. The risk-adjusted odds ratio for mortality in the highest-volume category compared with the lowest was 0.48 (95% confidence interval 0.28 to 0.82). The rates of mitral valve |

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| | | repair increased from 47.7% in the lowest-volume quartile to 77.4% in high-volume hospitals (P65 years rose from 59% in the lowest-volume quartile to 75% in the highest-volume quartile (P=0.0002). The association between volume and mortality was still significant but attenuated when the risk adjustment was modified to adjust for mitral valve repair versus replacement.<br>CONCLUSIONS: Hospital procedural volume was associated with higher frequency of valve repair, higher frequency of prosthetic valve usage in elderly patients, and lower adjusted operative mortality. Differences in care process may contribute to improved outcomes in higher-volume centers. |
| Kurlansky et al. (2012).<br>Coronary artery bypass surgery<br>US<br>Quality, not volume, determines outcome of coronary artery bypass surgery in a university-based community hospital network.<br>The Journal of Thoratic and Cardiovascular Surgery, 143(2), 287-293.<br>*Inkluderet i Mesman et al 2015* | To examine the relationship between hospital and surgeon coronary artery bypass grafting procedural volume, mortality, morbidity, and National Quality Forum care processes in a university-based community hospital quality improvement program. | METHODS: The study population consisted of 2218 consecutive patients undergoing isolated coronary artery bypass grafting from 2007 to 2009 in a university-based quality improvement program that emphasizes involvement of all surgeons in the academic quality endeavor. The endpoints included operative mortality, major morbidity, and National Quality Forum-endorsed process measures as defined by the Society of Thoracic Surgeons. The procedural volume was analyzed as a categorical and continuous variable using general estimating equations, which accounted for clustering effects and which were adjusted for Society of Thoracic Surgeons risk scores and the propensity for operation in a low- versus high-volume program.<br>RESULTS: The annual program volume ranged from 67 to 292 (median, 136; interquartile range, 88-224) and surgeon volume from 1 to 124 (median, 58; interquartile range, 30-89). The mortality rate among the hospitals was 0.47% to 2.23% (0.8% overall), and the observed/expected mortality ranged from 0 to 1.20 (0.41 overall). When comparing low-volume (<200 cases/year) and high-volume centers, no difference was found in the mortality (odds ratio [OR], 1.08; 95% confidence interval [CI], 0.46-2.54, P = .85), morbidity (OR, 1.34; 95% CI, 0.73-2.43), or any of the medication process measures. No difference was found in mortality (OR, 1.59; 95% CI, 0.81-3.13; P = .18), morbidity (OR, 1.20; 95% CI, 0.86-1.66; P = .28), or medication failure (OR, 0.57, 95% CI, 0.3-1.10; P = .10) between the high- and low-volume surgeons (<87). After adjustment for both the Society of Thoracic Surgeons risk score and the propensity score, no association was found for either hospital or surgeon volume with mortality or morbidity. However, a lack of compliance with National Quality Forum measures was highly predictive of morbidity (OR, 1.51; 95% CI, 1.18-1.93; |

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| | | P = .001), regardless of volume, even after adjustment for predicted risk.<br>CONCLUSION: In the setting of a university-based community hospital quality improvement program, excellent surgical results can consistently be obtained even in relatively low-volume programs. The surgical outcomes were not associated with program or surgeon volume, but were directly correlated with the focus on quality as manifested by compliance with evidence-based quality standards. Meaningful university affiliation might represent a new quality paradigm for cardiac surgery in the community hospital setting. |
| Soohoo, Tang, Krenek et al. (2011).<br>Total knee replacement<br>US<br>Variations in the quality of care delivered to patients undergoing total knee replacement at 3 affiliated hospitals. Orthopedics, 34(5), 356-20110317-08 | While excellent clinical results have been seen with total knee replacement (TKR), extensive documentation exists in variations in outcomes due to factors such as hospital and surgeon volume.<br>The hypothesis of this study was that statistically significant variation exists in the processes of care delivered to patients undergoing TKR at 3 affiliated hospitals. | Retrospective chart review was used to compare the quality of care delivered to a sample of patients from an academic medical center, public county hospital, and private community hospital. Two hundred twenty-four patients undergoing primary TKR were included. Quality of care was measured by determining adherence to a set of 31 evidence-based quality indicators created using the RAND/UCLA modified Delphi expert panel methodology.<br>The overall rate of adherence to the quality indicators was 53% (95% confidence interval [CI], 52%-55%) for the 224 patients. There was a statistically significant difference between sites, with patients treated at the high-volume academic center demonstrating a 58% rate of adherence (95% CI, 56%-61%) compared with 50% (95% CI, 48-51%; P =.008) at the lower-volume public hospital and 52% (95% CI, 51%-54%; P =.03) at the lower-volume private hospital.Further study is warranted to determine the extent of variation in the delivery of care and its relationship to variation in outcomes of care for patients undergoing TKR. |
| Bozic et al. (2010).<br>Total joint replacement surgery<br>US<br>The influence of procedure volumes and standardization of care on quality and efficiency in total joint replacement surgery.<br>The Journal of Bone and Joint Surgery. American Volume, 92(16), 2643-2652.<br>*Inkluderet i Mesman et al 2015* | The purpose of this study was to evaluate the independent contributions of surgeon procedure volume, hospital procedure volume, and standardization of care on short-term postoperative outcomes and resource utilization in lower-extremity total joint arthroplasty. | METHODS: An analysis of 182,146 consecutive patients who underwent primary total joint arthroplasty was performed with use of data entered into the Perspective database by 3421 physicians from 312 hospitals over a two-year period. Adherence to evidence-based processes of care was defined by administration of appropriate perioperative antibiotic prophylaxis, beta-blockade, and venous thromboembolism prophylaxis. Patient outcomes included mortality, length of hospital stay, discharge disposition, surgical complications, readmissions, and reoperations within the first thirty days after discharge. Hierarchical models were used to estimate the effects of hospital and surgeon procedure volume and process standardization on individual and combined surgical outcomes and length of stay.<br>RESULTS: After adjustment in multivariate models, higher surgeon volume was |

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| | | associated with lower risk of complications, lower rates of readmission and reoperation, shorter length of hospital stay, and higher likelihood of being discharged home. Higher hospital volume was associated with lower risk of mortality, lower risk of readmission, and higher likelihood of being discharged home. The impact of process standardization was substantial; maximizing adherence to evidence-based processes of care resulted in improved clinical outcomes and shorter length of hospital stay, independent of hospital or surgeon procedure volume.<br>CONCLUSIONS: Although surgeon and hospital procedure volumes are unquestionably correlated with patient outcomes in total joint arthroplasty, process standardization is also strongly associated with improved quality and efficiency of care. The exact relationship between individual processes of care and patient outcomes has not been established; however, our findings suggest that process standardization could help providers optimize quality and efficiency in total joint arthroplasty, independent of hospital or surgeon volume. |
| Bristow, Puri, et al. (2009).<br>Ovarian cancer<br>US<br>Analysis of contemporary trends in access to high-volume ovarian cancer surgical care.<br>Annals of Surgical Oncology, 16(12), 3422-3430. | BACKGROUND: Positive volume-outcome relationships exist for cancers treated with technically complex surgery, including ovarian cancer. However, contemporary patterns of primary surgical care for ovarian cancer according to hospital and surgeon case volume remain poorly defined. | METHODS: The Maryland Health Service Cost Review Commission database was accessed for annual hospital and surgeon primary ovarian cancer surgical case volume for 2001-2008 and evaluated for statistically significant trends in access to high-volume surgical care compared with the earlier period for 1990-2000. chi(2) and logistic regression analyses were used to evaluate for significant trends in case volume distribution over time as well as factors associated with access to high-volume care.<br>RESULTS: Overall, 2,475 primary ovarian cancer operations were performed by 472 surgeons at 43 hospitals. There was a statistically significant increase in the proportion of cases performed at high-volume centers from 22.8% in 1990-2000 to 61.1% in 2001-2008 (odds ratio = 5.30, 95% confidence interval = 4.68-6.00, P < .0001), while low-volume hospital case distribution decreased from 49.6 to 31.3%. Access to high-volume surgeons increased from 34.5% in 1990-2000 to 64.5% in 2001-2008 (odds ratio = 3.44, 95% confidence interval = 3.06-3.87, P < .0001), while the proportion of cases performed by low-volume surgeons decreased from 56.3 to 28.9%. After controlling for other variables, high-volume surgeons were significantly more likely to perform ovarian cancer surgery that included hysterectomy and staging/cytoreductive surgical procedures.<br>CONCLUSIONS: The proportions of ovarian cancer patients undergoing primary surgery at high volume centers and by high-volume surgeons increased |

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| | | statistically significantly from 1990-2000 to 2001-2008. Further investigation is necessary to determine factors contributing to this favorable trend. |
| Capecci, Jeremitsky, Smith & Philp (2015)<br>blunt splenic injury<br>US<br>Trauma centers with higher rates of angiography have a lesser incidence of splenectomy in the management of blunt splenic injury.<br>Surgery, 158(4), 1020-6; discussion 1024-6. | BACKGROUND: Nonoperative management (NOM) for blunt splenic injury (BSI) is well-established. Angiography (ANGIO) has been shown to improve success rates with NOM. Protocols for NOM are not standardized and vary widely between centers.<br>We hypothesized that trauma centers that performed ANGIO at a greater rate would demonstrate decreased rates of splenectomy compared with trauma centers that used ANGIO less frequently. | METHODS: A large, multicenter, statewide database (Pennsylvania Trauma Systems Foundation) from 2007 to 2011 was used to generate the study cohort of patients with BSI (age >/= 13). The cohort was divided into 2 populations based on admission to centers with high (>/=13%) or low (<13%) rates of ANGIO. Patient demographics, grade of BSI, Injury Severity Score, level of trauma center designation, and patient volume were analyzed. Splenectomy rates were then compared between the 2 groups, and multivariable logistic regression for predictors of splenectomy (failed NOM) were also performed.<br>RESULTS: The overall rate of splenectomy in the entire cohort was 21.0% (1,120 of 5,333 BSI patients). The high ANGIO group had a lesser rate of splenectoy compared with the low ANGIO group (19% vs 24%; P < .001). Treatment at high ANGIO centers was negatively associated with splenectomy compared with low ANGIO centers (odds ratio, 0.68; 95% CI 0.58-0.80; P < .001); this association was independent of the number of BSI admissions or level of trauma center designation.<br>CONCLUSION: Treatment of BSI at trauma centers that performed ANGIO more frequently resulted in lesser splenectomy rates compared with centers with lesser rate of ANGIO. Inclusion of angiographic protocols for NOM of BSI should be considered strongly. |
| Kristensen, Thillemann et al. (2014)<br>Hip fracture<br>Denmark<br>Is bigger always better? A nationwide study of hip fracture unit volume, 30-day mortality, quality of in-hospital care, and length of hospital stay.<br>*Medical Care, 52*(12), 1023-1029. | BACKGROUND: Higher patient volume has been linked with better clinical outcomes for a range of surgical procedures; however, little is known about the impact of volume on quality of care and clinical outcome among patients with hip fracture.<br>OBJECTIVES: To examine the association between hip fracture patient volume and 30-day mortality, quality of in-hospital care, time to surgery, and length of hospital stay, respectively. | DESIGN: Population-based follow-up study. SUBJECTS: Using prospectively collected data from the Danish Multidisciplinary Hip Fracture Registry, we identified 12,065 patients 65 years and older who were admitted with a hip fracture between March 1, 2010 and November 30, 2011.<br>MEASURES: Patient volume was divided into 3 groups; /= 351 admissions per year based on the distribution of the hospitals and to ensure a reasonable proportion of hospitals in each category. Data were analyzed using regression techniques while controlling for potential confounders.<br>RESULTS: Admission to high-volume units was associated with higher 30-day mortality [adjusted odds ratio (OR)=1.37 (95% confidence interval (CI), 1.14-1.64)] and a longer length of hospital stay (adjusted relative time=1.25 (95% CI, 1.02-1.52)]. Furthermore, patients had lower odds for being mobilized within 24 hours postoperatively and for receiving basic mobility assessment and a postdischarge rehabilitation program. |

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| | | Time to surgery was nonsignificantly increased [adjusted relative time=1.25 (95% CI, 0.99-1.58)].<br>CONCLUSIONS: Patients admitted to high-volume hip fracture units had higher mortality rates, received a lower quality of in-hospital care, and had longer length of hospital stay. |
| Welch, Brinjikji et al. (2015)<br>Percutaneous image-guided renal thermal ablation<br>US<br>Evaluation of the charges, safety, and mortality of percutaneous renal thermal ablation using the nationwide inpatient sample.<br>*Journal of Vascular and Interventional Radiology: JVIR, 26*(3), 342-347. | PURPOSE: To perform a national analysis of safety, charges, complications, and mortality of percutaneous image-guided renal thermal ablation and compare outcomes by hospital volume. | MATERIALS AND METHODS: Using the Nationwide Inpatient Sample, trends in the proportion of inpatient percutaneous renal thermal ablation procedures performed at high-volume centers in the United States from 2007-2011 were evaluated. In-hospital mortality, discharge to long-term care facility, length of stay, hospitalization charges, and postoperative complications were compared between high-volume and low-volume ablation centers. High volume was set at the 90th percentile for renal thermal ablation volume, which equated to seven or more patients per year. A multivariate logistic regression analysis adjusting for hospital volume, age, sex, Charlson Comorbidity Index, obesity, race, and insurance status was performed to analyze the influence of hospital volume on the above-listed outcomes.<br>RESULTS: This study included 874 patients. The number of hospitals ranged from 59-77 depending on year. Overall, 328 patients (37.5%) were treated at high-volume ablation centers. The proportion of patients treated at high-volume centers decreased from 42.0% in 2007-2009 to 28.5% in 2010-2011. High-volume hospitals also performed significantly more partial nephrectomies than low-volume hospitals. On multivariate logistic regression analysis, increasing hospital volume was associated with lower odds of in-hospital mortality (odds ratio [OR] = 0.31, 95% confidence interval [CI] = 0.02-0.95) and lower odds of discharge to a long-term care facility (OR = 0.00, 95% CI = 0.00-0.66). Increasing hospital volume was also associated with lower odds of blood transfusion (OR = 0.84, 95% CI = 0.72-0.94). Length of stay decreased with increasing hospital volume (P = .03).<br>CONCLUSIONS: Patient safety may be maximized when renal ablation is performed at high-volume centers as a result of both greater procedural experience and potentially multidisciplinary triage and periprocedural management. |
| Ayanian et al. (2003)<br>Adjuvant chemotherapy and radiation therapy for colorectal cancer<br>US<br>Use of adjuvant chemotherapy and radiation therapy for colorectal cancer in a population-based cohort. | Randomized trials have demonstrated that adjuvant chemotherapy improves survival for patients with stage III colon cancer and that chemotherapy combined with radiation therapy improves survival for patients with stage II or III rectal cancer. This population-based study was designed to assess use | RESULTS: Chemotherapy rates varied widely by age from 88% (age or= 85 years), and radiation therapy varied similarly. Adjusting for demographic, clinical, and hospital characteristics, chemotherapy was used less often among older and unmarried patients, and radiation therapy was used less often among older patients, black patients, and those |

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| Journal of Clinical Oncology: Official Journal of the American Society of Clinical Oncology, 21(7) 11293-1300. | of these treatments in clinical practice. | initially treated in low-volume hospitals. Adjusted rates of chemotherapy varied significantly (P <.01) among individual hospitals: 79% and 51%, respectively, at one SD above and below average (67%). Physicians' reasons for not providing adjuvant therapy included patient refusal (30% for chemotherapy, 22% for radiation therapy), comorbid illness (22% and 14%, respectively), or lack of clinical indication (22% and 45%, respectively).<br>CONCLUSION: Use of adjuvant therapy for colorectal cancer varies substantially by age, race, marital status, hospital volume, and individual hospital, indicating opportunities to improve care. With enhanced data on adjuvant therapies, population-based registries could become a valuable resource for monitoring the quality of cancer care. |
| Huesch (2011)<br>Cardiac surgery<br>US<br>Provider-hospital "fit" and patient outcomes: Evidence from Massachusetts cardiac surgeons, 2002-2004.<br>*Health Services Research, 46*(1 Pt 1), 1-26. | OBJECTIVE: To examine whether the "fit" of a surgeon with hospital resources impacts cardiac surgery outcomes, separately from hospital or surgeon effects.<br>DATA SOURCES: Retrospective secondary data from the Massachusetts Department of Public Health's Data Analysis Center, on all 12,983 adult isolated coronary artery bypass surgical admissions in state-regulated hospitals from 2002 through 2004. Clinically audited chart data was collected using Society of Thoracic Surgeons National Cardiac Surgery Database tools and cross-referenced with administrative discharge data in the Division of Health Care Finance and Policy. Mortality was followed up through 2007 via the state vital statistics registry. | STUDY DESIGN: Analysis was at the patient level for those receiving isolated coronary artery bypass surgery (CABG). Sixteen outcomes included 30-day mortality, major morbidity, indicators of perioperative, and pre-discharge processes of care. Hierarchical crossed mixed models were used to estimate fixed covariate and random effects at hospital, surgeon, and hospital x surgeon level.<br>PRINCIPAL FINDINGS: Hospital volume was associated with significantly reduced intraoperative durations and significantly increased probability of aspirin, beta-blocker, and lipid-lowering discharge medication use. The proportion of outcome variability due to unobserved hospital x surgeon interaction effects was small but meaningful for intraoperative practices, discharge destination, and medication use. For readmissions and mortality within 30 days or 1 year, unobserved patient and hospital factors drove almost all variability in outcomes.<br>CONCLUSIONS: Among Massachusetts patients receiving isolated CABG, consistent evidence was found that the hospital x surgeon combination independently impacted patient outcomes, beyond hospital or surgeon effects. Such distinct local interactions between a surgeon and hospital resources may play an important part in moderating quality improvement efforts, although residual patient-level factors generally contributed the most to outcome variability. |
| Miller, Woosley, Martin & Sandler (2004)<br>Lymph node detection<br>US<br>Hospital-to-hospital variation in lymph node detection after colorectal resection. | Better recovery of lymph nodes from colorectal carcinoma resection specimens has been shown to be associated with higher survival rates for patients with TNM Stage II and Stage III tumors. It is possible that inadequate lymph node recovery and/or assessment could contribute to disparities in survival, with | METHODS: Data from a population-based study that involved 33 counties in North Carolina and was conducted between April 1997 and April 2000 were available for the examination of variations in lymph node recovery and detection of positive lymph nodes according to self-reported demographic characteristics and hospital volume. The study |

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| *Cancer, 101*(5), 1065-1071. | particular variation according to hospital volume. | comprised 324 patients with T2-T3N0-N1M0 colon adenocarcinoma. Logistic regression was used to determine odds ratios (ORs) associated with the recovery of fewer than seven lymph nodes and ORs associated with the detection of a positive lymph node according to hospital volume and patient characteristics.<br>RESULTS: Low-volume hospitals were more likely to recover < 7 lymph nodes compared with high- and medium-volume hospitals (low-volume vs. high-volume: adjusted OR, 1.9; 95% confidence interval [CI], 0.8-4.6; low-volume vs. medium-volume: adjusted OR, 1.7; 95% CI, 0.7-4.5) and less likely to detect positive lymph nodes. After controlling for tumor characteristics, low-volume hospitals were less than one-half as likely to detect a positive lymph node (low-volume vs. high-volume: adjusted OR, 0.3; 95% CI, 0.1-0.8; low-volume vs. medium-volume: adjusted OR, 0.4; 95% CI, 0.1-1.2).<br>CONCLUSIONS: The current study suggests that patients at low-volume hospitals may have their tumors pathologically understaged more frequently compared with patients at high- and medium-volume hospitals. |
| Lombardi, Raffaelli et al. (2012).<br>Adrenocortical carcinoma<br>Adrenocortical carcinoma: Effect of hospital volume on patient outcome.<br>*Langenbeck's Archives of Surgery, 397*(2), 201-207. | PURPOSE: Optimal management of adrenocortical carcinoma (ACC) involves a detailed diagnostic workup, radical surgery, and appropriate adjuvant therapy. However, due to the rarity of this disease, adequate expertise is necessary to ensure optimal patient care.<br>We evaluated if the experience of a treating center influences the outcome of ACC. | METHODS: Two hundred sixty-three patients who underwent adrenalectomy for ACC were included in a multi-institutional surgical survey and divided into 2 groups: "high-volume center" (HVC) (>/=10 adrenalectomies for ACC) and "low-volume center" (LVC) (<10 adrenalectomies for ACC). A comparative analysis was performed.<br>RESULTS: One hundred seventy-two patients underwent adrenalectomy at HVC and 91 at LVC. The two groups were homogeneous for age, sex, clinical presentation, and stage. The mean lesions size of ACC was higher in HVC than in LVC (104.1 +/- 54.6 vs 82.8 +/- 41.3 mm; P < 0.001). A significantly higher rate of lymph node dissection (P < 0.01) and of multiorgan resection (P < 0.01) was accomplished in HVC. The number of patients who underwent adjuvant therapy was significantly higher in HVC (P < 0.001). Local recurrence rate was lower in patients treated at HVC (6% vs 18.5%; P = NS). Mean time to recurrence was significantly longer in HVC than in LVC (25.2 +/- 28.1 vs 10.1 +/- 7.5; P < 0.01).<br>CONCLUSION: The expertise of dedicated centers had a positive impact on the outcome of patients with ACC, resulting in a lower recurrence rate and improved mean time to recurrence. The improved patient outcome could be related not only to the appropriateness of the surgical procedure, but also to a |

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| | | more adequate multidisciplinary approach. |
| Auerbach, Hilton et al. (2009)<br>Coronary artery bypass surgery<br>US<br>Observational cohort.<br>Follow the crowd or shop for the best?: Volume, quality, and outcomes of coronary artery bypass surgery.<br>Annals of internal medicine, 19, Vol. 150(10), pp.696-704.<br><br>*Inkluderet i Mesman et al 2015* | Care from high-volume centers or surgeons has been associated with lower mortality rates in coronary artery bypass surgery, but how volume and quality of care relate to each other is not well understood. To determine how volume and differences in quality of care influence outcomes after coronary artery bypass surgery. | 164 hospitals in the United States. 81,289 patients 18 years or older who had coronary artery bypass grafting from 1 October 2003 to 1 September 2005. Hospital and surgeon case volumes were estimated by using a data set. Quality measures were defined by whether patients received specific medications and by counting the number of measures missed. Hierarchical models were used to estimate effects of volume and quality on death and readmission up to 30 days. After adjustment for clinical factors, lowest surgeon volume and highest hospital volume were associated with higher mortality rates and lower readmission risk, respectively. Patients who did not receive aspirin (odds ratio, 1.89 [95% CI, 1.65 to 2.16) or beta-blockers (odds ratio, 1.29 [CI, 1.12 to 1.49]) had higher odds for death, after adjustment for clinical risk factors and case volume. Adjustment for individual quality measures did not alter associations between volume and readmission or death. However, if no quality measures were missed, mortality rates at the lowest-volume centers (adjusted mortality rate, 1.05% [CI, 0.81% to 1.29%]) and highest-volume centers (adjusted mortality rate, 0.98% [CI, 0.72% to 1.25%]) were similar. Because administrative data were used, the quality measures may not replicate measures collected through chart abstraction. Maximizing adherence to quality measures is associated with improved mortality rates, independent of hospital or surgeon volume. |
| Gonzalez, Dimick et al. (2014)<br>Aortic valve replacement<br>US<br>Understanding the Volume-Outcome Effect in Cardiovascular Surgery. The Role of Failure to Rescue.<br>JAMA Surg. 149(2):119-123. | Objective: To determine whether increased mortality at low-volume hospitals performing cardiovascular surgery is a function of higher post-operative complication rates or of less successful rescue from complications.<br>Importance: To effectively guide interventions aimed at reducing mortality in low-volume hospitals, the underlying mechanisms of the volume-outcome relationship must be further explored. Reducing mortality after major post-operative complications may represent one point along the continuum of patient care that could significantly impact overall hospital mortality. | Design: We utilized patient-level data on Medicare beneficiaries undergoing coronary artery bypass grafting, aortic valve repair, or abdominal aortic aneurysm repair. For each operation, we first divided hospitals into quintiles of procedural volume. We then assessed hospital risk-adjusted rates of mortality, major complications, and “failure to rescue” (i.e., case fatality among patients with complications) within each volume quintile. Setting: Medicare fee-for-service beneficiaries age 65 to 99. Participants: A total of 119,434 Medicare beneficiaries undergoing one of three major cardiovascular operations between 2005 and 2006. Exposure: Hospital procedural volume. Main Outcome Measure: Hospital rates of risk-adjusted mortality, major complications, and failure to rescue.<br>Results: For each operation, hospital volume was more strongly related to failure to rescue rates than to complication rates. For example, patients undergoing aortic valve replacement at very low-volume hospitals (lowest quintile) were 12% more likely to have a major complication than those at very high-volume |

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| | | hospitals (highest quintile), but 57% more likely to die if a complication occurs.<br>Conclusion and Relevance: High-volume and low-volume hospitals performing cardiovascular surgery have similar complication rates but disparate failure to rescue rates. While preventing complications is important, hospitals should also consider interventions aimed at quickly recognizing and managing complications once they occur. |
| Ghaferi, Birkmeyer & Dimick (2011)<br>High-risk surgery<br>US<br>Hospital volume and failure to rescue with high-risk surgery. *Medical Care, 49*(12), 1076-1081. | INTRODUCTION: Although the relationship between surgical volume and mortality is well established, the mechanisms underlying these associations remain uncertain.<br>We sought to determine whether increased mortality at low-volume centers was due to higher complication rates or less success in rescuing patients from complications. | METHODS: Using 2005 to 2007 Medicare data, we identified patients undergoing 3 high-risk cancer operations: gastrectomy, pancreatectomy, and esophagectomy. We first ranked hospitals according to their procedural volume for these operations and divided them into 5 equal groups (quintiles) based on procedure volume cutoffs that most closely resulted in an equal distribution of patients through the quintiles. We then compared the incidence of major complications and "failure to rescue" (ie, case fatality among patients with complications) across hospital quintiles. We performed this analysis for all operations combined and for each operation individually.<br>RESULTS: With all 3 operations combined, failure to rescue had a much stronger relationship to hospital volume than postoperative complications. Very low-volume (lowest quintile) hospitals had only slightly higher complications rates (42.7% vs. 38.9%; odds ratio 1.17, 95% confidence interval, 1.02-1.33), but markedly higher failure-to-rescue rates (30.3% vs. 13.1%; odds ratio 2.89, 95% confidence interval, 2.40-3.48) compared with very high-volume hospitals (highest quintile). These relationships also held true for individual operations. For example, patients undergoing pancreatectomy at very low-volume hospitals were 1.7 times more likely to have a major complication than those at very high-volume hospitals (38.3% vs. 27.7%, P<0.05), but 3.2 times more likely to die once those complications had occurred (26.0% vs. 9.9%, P<0.05).<br>CONCLUSIONS: Differences in mortality between high and low-volume hospitals are not associated with large differences in complication rates. Instead, these differences seem to be associated with the ability of a hospital to effectively rescue patients from complications. Strategies focusing on the timely recognition and management of complications once they occur may be essential to improving outcomes at low-volume hospitals. |
| Sukumar, Roghmann et al. (2013).<br>National trends in hospital-acquired preventable adverse events after major cancer surgery in the USA. | Objectives: While multiple studies have demonstrated variations in the quality of cancer care in the USA, payers are increasingly assessing | Design: Retrospective, cross-sectional analysis of a weighted-national estimate from the Nationwide Inpatient Sample |

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| *BMJ Open, 3*(6) (pagination). | structure-level and process-level measures to promote quality improvement. Hospital-acquired adverse events are one such measure and we examine their national trends after major cancer surgery. | (NIS) undergoing major oncological procedures (colectomy, cystectomy, oesophagectomy, gastrectomy, hysterectomy, lung resection, pancreatectomy and prostatectomy). The Agency for Healthcare Research and Quality Patient Safety Indicators (PSIs) were utilised to identify trends in hospital-acquired adverse events. Setting: Secondary and tertiary care, US hospitals in NIS Participants: A weighted-national estimate of 2 508 917 patients (>18 years, 1999-2009) from NIS. Primary outcome measures: Hospital-acquired adverse events.<br><br>Results: 324 852 patients experienced >1-PSI event (12.9%). Patients with >1-PSI experienced higher rates of in-hospital mortality (OR 19.38, 95% CI 18.44 to 20.37), prolonged length of stay (OR 4.43, 95% CI 4.31 to 4.54) and excessive hospital-charges (OR 5.21, 95% CI 5.10 to 5.32). Patients treated at lower volume hospitals experienced both higher PSI events and failure-to-rescue rates. While a steady increase in the frequency of PSI events after major cancer surgery has occurred over the last 10 years (estimated annual % change (EAPC): 3.5%, p<0.001), a concomitant decrease in failure-to-rescue rates (EAPC -3.01%) and overall mortality (EAPC -2.30%) was noted (all p<0.001).<br><br>In the overall analysis of patients undergoing any of the eight procedures, very high-volume hospitals (4th quartile) had both a lower PSI event rate *and* lower failure-to-rescue rates. However, this relationship was procedure-specific: for colectomy, oesophagectomy, lung resection, pancreatectomy and prostatectomy, very high-volume hospitals had both lower PSI event rates *and* lower failure-to-rescue rates. For gastrectomy, very high-volume hospitals did not have lower PSI event rates but they did have lower failure-to-rescue rates; for hysterectomy, very high-volume hospitals had *higher* PSI event rates, but had lower failure-to-rescue rates; for cystectomy, very high volume-hospitals had lower PSI event rates and a trend towards lower failure-to-rescue rates.<br><br>Conclusions: Over the past decade, there has been a substantial increase in the national frequency of potentially avoidable adverse events after major cancer surgery, with a detrimental effect on numerous outcome-level measures. However, there was a concomitant reduction in failure-to-rescue rates and overall mortality rates. Policy changes to improve the increasing burden of specific adverse events, such as postoperative sepsis, pressure ulcers and respiratory failure, are required. |
| Kansy, Ebels, Schreiber et al. (2014).<br>Congenital heart surgery | BACKGROUND: The relation between surgical volumes and outcome in congenital heart surgery | METHODS: We have used only the verified data of the European Association for Cardio-Thoracic Surgery Congenital |

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| European data<br>Association of center volume with outcomes: Analysis of verified data of European association for cardio-thoracic surgery congenital database.<br>The Annals of Thoracic Surgery, 98(6), 2159-2164. | (CHS) was investigated with no clear conclusions. We sought to quantify the relationship between surgical volume and surgical performance defined as the relation between outcome and Society of Thoracic Surgeons-European Association for Cardio-Thoracic Surgery Congenital Heart Surgery (STAT) Mortality Score and The Society of Thoracic Surgeons (STS) Morbidity Score. | Database. The verified dataset consists of 17,861 procedures performed in 23 congenital heart surgery centers between 2003 and 2011. The centers were divided into 4 volume-related groups with annual caseload of below 150, 150 to 250, 250 to 350, and over 350. Stepwise logistic regression was used to calculate the ratio between volume and mortality, as well as between volume and onset of complications. The relations between volume and STAT Mortality Score, and STS Morbidity Score were evaluated using the analysis of variance test. The performance was calculated as the following: 100 - observed mortality/STAT Mortality Score; and 100 - observed complications/STS Morbidity Score.<br>RESULTS: The study showed no relation between volume and raw mortality ($p = 0.94$) and between volume and complications ($p = 0.6$). The STAT Mortality Score and STS Morbidity Score were higher in larger volume centers ($p < 0.001$). Surgical performances measured as related to mortality and morbidity were higher at high-volume centers ($R(2) = 0.95$ and $R(2) = 0.92$).<br>CONCLUSIONS: Our analysis suggests that after adjustment for case mix higher programmatic volume is associated with lower rates of mortality and morbidity. The small- and medium-volume centers have higher rates of major complications. When complications occurred the chance of rescue is higher in large-volume centers. |
| Kilic, George, Beaty, et al. (2012).<br>Lung transplantation<br>US<br>The effect of center volume on the incidence of postoperative complications and their impact on survival after lung transplantation.<br>*The Journal of Thoracic and Cardiovascular Surgery, 144*(6), 1502-8. | OBJECTIVE: The aim of this study was to evaluate the effect of center volume on the incidence of postoperative complications and their impact on survival after lung transplantation (LTx). | METHODS: United Network for Organ Sharing data were used to identify adult patients undergoing LTx between 1999 and 2009. Center volume was modeled as both a continuous and a categorical variable. Postoperative complications included infection, rejection, stroke, reoperation, and renal failure requiring dialysis. Multivariable Cox regression and Kaplan-Meier analyses were conducted after stratification on the basis of center volume and type of complication.<br>RESULTS: A total of 12,565 LTx recipients were included in the study. Overall rates of postoperative complications were 5.4% for renal failure requiring dialysis, 1.9% for stroke, 19.9% for reoperation, 42.8% for infection, and 10.0% for rejection. High volume centers did not have significantly reduced rates of postoperative complications. Risk-adjusted multivariable Cox analysis demonstrated that in patients with a complication, low volume center was a significant risk factor for increased 90-day, 1-year, and 5-year mortality. Kaplan-Meier analyses similarly demonstrated reduced posttransplant survival in lower volume centers, a finding that |

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| | | persisted after stratification based on individual complication type except for stroke.<br>CONCLUSIONS: Although high volume centers do not have significantly lower incidences of individual postoperative complications after LTx, they are best able to minimize the adverse effects of these complications on short- and long-term survival. These data suggest that identifying and implementing the institutional practices that lead to better management of postoperative complications after LTx in high volume centers may be prudent to improving outcomes in lower volume hospitals. |
| *Ikke-kirurgi (ikke-interventionsbehandling)* | | |
| **Hospitalsinfrastruktur** | | |
| Chung et al. (2011)<br>Very low birth weight infants<br>US<br>Examining the effect of hospital-level factors on mortality of very low birth weight infants using multilevel modeling.<br>Journal of Perinatology 2001; 31(12): 770-5<br>*Inkluderet I Mesman et al. 2015* | To examine the effect of hospital-level factors on mortality of very low birth weight infants using multilevel modeling. | Increasing hospital volume of very low birth weight deliveries was associated with lower odds of very low birth weight mortality. Characteristics of a particular hospital's obstetrical and neonatal services (the presence of residency and fellowship training programs and the availability of perinatal and neonatal services) had no independent effect. |
| **Specialisering** | | |
| Chung, Phibbs, Boscardin et al. (2010)<br>Very low birth weight infants<br>US<br>The Effect of Neonatal Intensive Care Level and Hospital Volume on Mortality of Very Low Birth Weight Infants<br>Medical Care, 2010, Vol.48(7), p.635-644<br>*Inkluderet i Mesman et al 2015* | OBJECTIVE: To determine the adjusted effect of hospital level of care and volume on mortality of very low birth weight (VLBW) infants in the state of California, where deregionalization of perinatal care has occurred. | RESEARCH DESIGN: Secondary data analysis of California maternal-infant hospital discharge data from 1997 to 2002 was performed. Logistic regression was used to evaluate the odds of mortality among VLBW infants by hospital level of neonatal intensive care and volume of VLBW deliveries, in the context of differences in antenatal and delivery factors by hospital site of delivery.<br>RESULTS: Both maternal and fetal antenatal risk profiles and delivery characteristics vary by hospital site of delivery. After risk adjustment, lower-level, lower-volume units were associated with a higher odds of mortality. The highest odds of mortality occurred in level-1 units with ≤10 VLBW deliveries per year (odds ratio, 1.69; 95% confidence interval, 1.43–1.99). In isolation, hospital volume, rather than level of care, had the greater effect.<br>CONCLUSIONS: Although deregionalization of perinatal services may increase access to care for high-risk mothers and newborns, its impact on hospital volume may outweigh its potential benefit. |
| Joynt, Orav & Jha (2013)<br>Heart failure<br>US | BACKGROUND: There is an urgent need to improve outcomes and reduce costs for patients with heart failure (HF). Physician volume is associated with better outcomes for patients undergoing procedures, | METHODS AND RESULTS: We used Medicare inpatient data in 2009 to examine all HF admissions to acute care hospitals in the United States. We divided physicians into quintiles according to their volume of patients with HF. We |

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| Physician volume, specialty, and outcomes of care for patients with heart failure.<br>Circ Heart Fail. 1;6(5):890-7.<br>*Inkluderet i Mesman et al 2015* | but its association with outcomes for medically managed diseases, such as HF, is not well understood. | used patient-level regression to compare 30-day risk-adjusted mortality, readmissions, and costs across volume groups, controlling for patient, physician, and hospital characteristics. We examined physician volume within strata of hospital volume and physician specialty. Patients cared for by the high-volume physicians had lower mortality than those by the low-volume physicians (8.9% versus 9.7%; P<0.001); this relationship was strongest in low-volume hospitals. In contrast, patients cared for by high-volume physicians had higher readmission rates (25.8% versus 21.5%; P<0001); this relationship was similar across hospital volume groups. Finally, costs were higher for the high-volume physicians ($8982 versus $8731; P=0.002, a difference that was consistent across hospital volume groups). The relationship between physician volume and mortality was strongest for internists (9.2% versus 10.6%; P<0.001) and weakest for cardiologists (6.4% versus 6.7%; P=0.485).<br>CONCLUSIONS: Physician volume is associated with lower mortality for HF, particularly in low-volume institutions and among noncardiologist physicians. Our findings suggest that clinician expertise may play an important role in HF care. |
| **Proces** | | |
| Sharma, Schwartz & Mendez (2013)<br>Advanced head and neck cancer<br>US<br>Hospital volume is associated with survival but not multimodality therapy in medicare patients with advanced head and neck cancer.<br>Cancer, 119(10), 1845-1852. | Given the complexity of management of advanced head and neck squamous cell carcinoma (HNSCC), this study hypothesized that high hospital volume would be associated with receiving National Comprehensive Cancer Network (NCCN) guideline therapy and improved survival in patients with advanced HNSCC. | METHODS: The Surveillance, Epidemiology, and End Results (SEER)-Medicare database was used to identify patients with advanced HNSCC. Treatment modalities and survival were determined using Medicare data. Hospital volume was determined by the number of patients with HNSCC treated at each hospital.<br>RESULTS: There were 1195 patients with advanced HNSCC who met inclusion criteria. In multivariable analyses, high hospital volume was not associated with receiving multimodality therapy per NCCN guidelines (odds ratio = 1.02, 95% confidence interval = 0.66-1.60), but showed a nearly significant inverse association with survival in a model adjusted for National Cancer Institute-designated cancer center status, age, sex, race, socioeconomic status, marital status, comorbidity, year of diagnosis, tumor site, and tumor stage (hazard ratio = 0.85, 95% confidence interval = 0.69-1.04).<br>CONCLUSIONS: Medicare patients with advanced HNSCC treated at high-volume hospitals were not more likely to receive NCCN guideline therapy, but had nearly statistically significant better survival, when compared with patients treated at low-volume hospitals. These results suggest that features of high-volume hospitals other than delivery of |

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| | | NCCN guideline therapy influence survival. Cancer 2013. (c) 2013 American Cancer Society. |
| Lindenauer et al. (2006)<br>Pneumonia<br>US<br>Volume, quality of care, and outcome in pneumonia.<br>Annals of Internal Medicine, 144(4), 262-269. | BACKGROUND: The establishment of minimum volume thresholds has been proposed as a means of improving outcomes for patients with various medical and surgical conditions.<br>OBJECTIVE: To determine whether volume is associated with either quality of care or outcome in the treatment of pneumonia. | DESIGN: Retrospective cohort study. SETTING: 3243 hospitals participating in the National Pneumonia Quality Improvement Project in 1998 and 1999. PATIENTS: 13,480 patients with pneumonia cared for by 9741 physicians. MEASUREMENTS: The association between the annual pneumonia caseload of physicians and hospitals and adherence to quality-of-care measures and severity-adjusted in-hospital and 30-day mortality rates.<br>RESULTS: Physician volume was unrelated to the timeliness of administration of antibiotics and the obtainment of blood cultures; however, physicians in the highest-volume quartile had lower rates of screening for and administration of influenza (21%, 19%, 20%, and 12% for quartiles 1 through 4, respectively; P < 0.01) and pneumococcal (16%, 13%, 13%, and 9% for quartiles 1 through 4, respectively; P < 0.01) vaccines. Among hospitals, the percentage of patients who received antibiotics within 4 hours of hospital arrival was inversely related to pneumonia volume (72%, 64%, 60%, and 56% for quartiles 1 through 4, respectively; P < 0.01), while selection of antibiotic, obtainment of blood cultures, and rates of immunization were similar. Physician volume was not associated with in-hospital or 30-day mortality rates. Odds ratios for in-hospital mortality rates rose with increasing hospital volume (1.14 95% CI, 0.87 to 1.49], 1.34 CI, 1.03 to 1.75], and 1.32 CI, 0.97 to 1.80] for quartiles 2 to 4, respectively); however, odds ratios for 30-day mortality rates were similar. LIMITATIONS: This study was limited to Medicare beneficiaries 65 years of age and older. Ascertainment of some measures of the quality of care and severity of illness depended on the documentation practices of the physician.<br>CONCLUSION: Among both physicians and hospitals, higher pneumonia volume is associated with reduced adherence to selected guideline recommendations and no measurable improvement in patient outcomes. |
| Groot, Nederkoorn et al. (2015)<br>Acute ischemic stroke<br>Netherlands<br>Association between I.V. thrombolysis volume and door-to-needle times in acute ischemic stroke.<br>International Journal of Stroke, 10, 126. | Background: Concentration of intravenous thrombolysis (IVT) for acute ischemic stroke (AIS) in high-volume centers is often believed to result in shorter door-to-needle times (DNTs), but evidence for this assumption is limited. Our aim was to examine the relation between IVT volume and DNTs in the Netherlands. | Methods: All hospitals in the province of North-Holland that perform IVT were invited to participate. We retrospectively identified consecutive patients treated with IVT between January 2009 and January 2013. Based on annualized IVT volumes, hospitals were categorized as low-volume (50). We compared median DNTs and onset-to-needle times (ONTs) between centers.<br>Results: 11/13 hospitals agreed to participate in the study. 1822 of 1962 patients treated with IVT were included |

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| | | (mean age 70.1 years). Reasons for exclusion were in-hospital stroke (n = 54) or missing DNT (n = 86). Overall, 80,5% of patients had a DNT<60 minutes. There were 2 low volume (101 patients), 5 medium-volume (747 patients) and 4 highvolume hospitals (974 patients). The DNT was significantly shorter in high-volume centers (median DNT 30 minutes) compared to mediumvolume (42 min, p < 0.001) and low-volume hospitals (38 min, p < 0.001). High-volume hospitals also more often achieved a DNT<30 minutes compared to the other two groups (43,8% vs. 17,4% and 26,7%, p < 0.001). High-volume centers had shorter ONTs than medium-volume (median 113 vs. 120 min, p = 0.03), but not than low-volume hospitals (113 vs. 98 min, p = 0.04).<br>Conclusion: In this Dutch province with overall short DNTs, hospitals with the largest annual IVT volumes achieved the shortest DNTs. |
| Tsai, Rowe, Cydulka et. al (2009).<br>Emergency department<br>USA and Canada<br>Cohort study<br>ED visit volume and quality of care in acute exacerbations of chronic obstructive pulmonary disease.<br>*The American Journal of Emergency Medicine, 27*(9), 1040-1049. | The purpose of this study is to determine whether emergency department (ED) visit volume is associated with ED quality of care in patients with acute exacerbations of chronic obstructive pulmonary disease (COPD). | METHODS: We performed a prospective multicenter cohort study involving 29 EDs in the United States and Canada. Using a standard protocol, we interviewed consecutive ED patients with COPD exacerbation, reviewed their charts, and completed a 2-week telephone follow-up. The associations between ED visit volume and quality of care (process and outcome measures) were examined at both the ED and patient levels.<br>RESULTS: After adjustment for patient mix in the multivariable analyses, chest radiography was less frequent among patients with COPD exacerbations in the low-volume (odds ratio [OR], 0.2; 95% confidence interval [CI], 0.1-0.4) and high-volume EDs (OR, 0.1; 95% CI, 0.05-0.5), with medium-volume EDs as the reference. Arterial blood gas testing was less frequent in the low-volume EDs (OR, 0.1; 95% CI, 0.02-0.8). Medication use was similar across volume tertiles. With respect to outcome measures, patients in high-volume EDs were more likely to be discharged (OR, 4.2; 95% CI, 2.2-7.7) and to report ongoing exacerbation at a 2-week follow-up (OR, 1.9; 95% CI, 1.02-3.5).<br>CONCLUSIONS: Traditional positive volume-quality relationships did not apply to emergency care of COPD exacerbation. High-volume EDs used less guideline-recommended diagnostic procedures, had a higher admission threshold, and had a worse short-term patient-centered outcome. |
| Bray, Campbell et al. (2013)<br>tPA administration in acute stroke<br>England | Background: Short door-to-needle times of thrombolytic (tPA) therapy in acute stroke is central to its effectiveness. Experience from other conditions suggests that high volume hospitals may achieve better | Methods: Data were extracted from the Stroke Improvement National Audit Programme (SINAP) of patients with acute ischaemic stroke admitted to a participating hospital in England from Jan 2011- Aug 2012. Data were linked with |

| Author(s) & clinical area | Objectives & studied organizational factors | Results and comments |
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| Door-to-needle times of tPA administration in acute stroke: The relationship with hospital volume of thrombolysis activity.<br>Cerebrovascular Diseases, 35, 470. | outcomes. We aimed to identify if there was a relationship between the number of patients treated with tPA by hospitals and the door-to-needle times achieved in patients with acute stroke. | the national admissions dataset for England (Hospital Episode Statistics) and only patients from hospitals with >80% case ascertainment in SINAP were included in the analysis. Hospitals were categorised by the annualised number of patients treated with tPA: 100 per annum. Median door-to-needle times were compared using Kruskall-Wallis tests.<br>Results: Of 44 942 patients admitted with acute stroke to 83 hospitals, 4478 (9.1%) received tPA. Median door-to-needle times were significantly shorter in patients admitted to hospitals treating> 100 patients per year (41 mins IQR 30-60) compared to those admitted to hospitals treating 50-99 patients (72 mins IQR 51-98) or <50 (73 mins IQR 53-102); time difference 32 minutes , p=0.0001. A similar result was found after categorising hospitals into quintiles of thrombolysis volume, with hospitals in the top quintile of thrombolysis activity achieving a median door-to-needle time of 40 mins (IQR 29-58) compared to 78 mins in the lowest quintile (IQR 60-103); time difference 38 mins, p<0.0001.<br>Conclusions: Hospitals treating high volumes of patients with tPA achieved clinically and statistically significant shorter door-to-needle times in this large observational dataset. These findings may have important implications for the planning of stroke services. |
| Svendsen et al. (2012)<br>Stroke<br>Denmark<br>Higher stroke unit volume associated with improved quality of early stroke care and reduced length of stay.<br>Stroke, 43(11), 3041-3045. | Specialized stroke unit care improves outcome among patients with stroke, but it is unclear whether there are any scale advantages in costs and clinical outcome from treating a larger number of patients.<br>We examined whether the case volume in stroke units was associated with quality of early stroke care, mortality, and hospital bed-day use.<br>Nationwide population-based cohort study. | METHODS: In a nationwide population-based cohort study, we identified 63 995 patients admitted to stroke units in Denmark between 2003 and 2009. Data on exposure, outcome, and covariates were collected prospectively. Comparisons were clustered within stroke units and adjusted for patient and hospital characteristics.<br>RESULTS: Patients in high-volume stroke units overall had a better prognostic profile than patients in low-volume stroke units. Patients in high-volume stroke units also received more processes of care (antiplatelet therapy, CT/MRT scan, occupational therapy assessment, and nutritional assessment), in the early phase of stroke compared with patients in low-volume stroke units (unadjusted difference, 9.84 percentage points; 95% CI, 3.98-15.70). High stroke unit volume was associated with shorter length of the initial hospital stay (adjusted ratio, 0.49; 95% CI, 0.41-0.59) and reduced bed-day use in the first year after stroke (adjusted ratio, 0.79; 95% CI, 0.70-0.87). No association between volume and mortality was found.<br>CONCLUSIONS: Patients admitted to high-volume stroke units received a higher quality of early stroke care and spent fewer days in the hospital compared with patients in low-volume units. |

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| | | We observed no association between volume and mortality. |

# Bilag 2 “Surgeon volume”

Bilag 2 præsenterer fund vedrørende arbejdstilrettelæggelse relateret til betydningen af at samle indgreb eller behandlinger på færre hænder.

Systematic reviews and Observational studies.

**Bilagstabel 2.1** Betydningen af surgeon volume

| Author(s) & clinical area | Objectives & studied factors | Results and comments |
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| Morche et al. (2016)<br>Systematic review of systematic reviews<br>Relationship between surgeon volume and outcomes: a systematic review of systematic reviews.<br>Systematic Reviews 5(1). | To summarize systematic reviews in order to present current evidence. | Thirty-two reviews reporting on 15 surgical procedures/conditions were included.<br>Most reviews tend to support the presence of a surgeon volume-outcome relationship. This is most clear-cut in colorectal cancer, bariatric surgery, and breast cancer where reviews of high quality show large effects. |
| Burgers et al. (2007)<br>Review<br>Relationship between volume and quality of care for surgical interventions: results of a literature review.<br>Nederlands tijdschrift voor geneeskunde, 22 September 2007, Vol.151(38), pp.2105-10 | Objective. To examine the relationship between the number of procedures performed per hospital or per surgeon and health care outcomes. | Results. 5 systematic reviews were found, which described the results of a total of 41 relevant articles. 8 original articles of sufficient quality published since 2000 were also identified. Most of these articles were also included in the reviews. Relationships between volume per hospital and per surgeon and case fatality (or survival) and morbidity were found for a number of surgical procedures. The strongest associations between volume and case fatality were found for pancreatic and oesophageal resection and, to a lesser degree, elective repair of abdominal aortic aneurysm. For other procedures the relationship was relatively weak, absent, or not studied.<br>Conclusion. Volume appears to be related to quality for some surgical procedures. The magnitude of the relationship differs depending on the procedure. For technically less complex procedures, organisation within the hospital appears to have a greater influence on the differences between hospitals than the performing surgeon. |
| Strom et al. (2014)<br>Systematic review and meta-analysis<br>Percutaneous coronary intervention<br>Association between operator procedure volume and patient outcomes in percutaneous coronary intervention: A systematic review and meta-analysis.<br>*Circulation: Cardiovascular Quality and Outcomes,* 7(4), 560-566. | The growth of centers capable of performing percutaneous coronary intervention (PCI) has outpaced population growth despite declining incidence of myocardial infarction and prevalence of coronary artery disease, potentially increasing the proportion of operators falling below minimal yearly volume standards set by professional societies. | In total, the studies evaluated 15 907 operators performing 205 214 PCIs on 1 109 103 patients at 2456 centers with a mean follow-up of 2.8 years. Eleven (48%) were considered higher quality. Studies with higher methodological quality and large sample sizes more often showed a relationship between operator volume and outcomes in PCI. Higher volume was associated with improved major adverse cardiac events at every threshold, regardless of the threshold evaluated.<br>Mortality and major adverse cardiac events increase as operator volumes decrease in PCI. Among studies showing a relationship, high-volume operators were defined variably, with annual PCIs ranging from >11 to >270, with no clear evidence of a threshold effect within the ranges studied. |
| Goossens-Laan et al. (2011)<br>Systematic review and meta-analysis<br>Radical cystectomy<br>The Netherlands<br>A systematic review and meta-analysis of the relationship between hospital/surgeon volume | To conduct a systematic review of the literature on the volume-outcome relationship for RC for bladder cancer (BCa) with consideration for the methodologic quality of the available evidence and to perform a meta-analysis on | Ten studies of good methodologic quality were included for meta-analysis. Eight studies were based on administrative data, two studies on clinical data. The results showed a significant association between high-volume hospitals and low mortality.<br>One study showed a positive effect of hospital volume on survival (hazard ratio [HR]: 0.89; p=0.06). Two studies showed a beneficial effect of surgeon volume on mortality (OR: 0.55; OR: 0.64). Only one study on the impact of surgeon volume on survival |

| Author(s) & clinical area | Objectives & studied factors | Results and comments |
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| and outcome for radical cystectomy: An update for the ongoing debate.<br>European Urology, 59(5), 775-783. | the studies meeting predefined quality criteria.<br>There is an ongoing debate about centralisation of radical cystectomy (RC) procedures. | was found; it showed no significant positive effect for higher volume (HR: 0.83; p=0.26).<br>Postoperative mortality after cystectomy is significantly inversely associated with high-volume providers. However, additional quality criteria, such as infrastructure and level of specialisation, should be formulated to direct centralisation initiatives. |
| Archampong et al. (2010).<br>Systematic review and meta analysis<br>Rectal cancer surgery<br>Impact of surgeon volume on outcomes of rectal cancer surgery: A systematic review and meta-analysis.<br>The Surgeon: Journal of the Royal Colleges of Surgeons of Edinburgh and Ireland, 8(6), 341-352. | To clarify the relationship between surgeon caseload and patient outcomes for patients undergoing rectal cancer surgery in order to inform debate about organisation of services. | METHODS: We searched Medline and Embase for articles published up to March 2010, and included studies examining surgeon caseload and outcomes in rectal cancer patients treated after 1990. Outcomes considered were 30-day mortality, overall survival, anastomotic leak, local recurrence, permanent stoma and abdominoperineal excision rates. We assessed the risk of bias in included studies and performed random effects meta-analyses based on both unadjusted and casemix adjusted data.<br>RESULTS: Eleven included studies enrolled 18,301 rectal cancer patients undergoing resective surgery. Unadjusted meta-analysis showed a statistically significant benefit in favour of high volume surgeons for 30-day postoperative mortality (OR = 0.57, 95% CI: 0.43-0.77; based on three studies, 4809 patients) and overall survival (HR = 0.76, 95% CI 0.63-0.90; based on two studies, 1376 patients), although the former relationship was attenuated and non-significant when based on two studies (9685 patients) that adjusted for casemix (OR = 0.79, 95% CI: 0.59-1.06). Pooling of three studies (2202 patients) showed no significant relationship between surgeon volume and anastomotic leak rate. Permanent stoma formation was less likely for high volume surgeons (adjusted OR = 0.75, 95% CI: 0.64 to 0.88; based on two studies, 9685 patients) and APER rates were lower for high volume surgeons (unadjusted OR = 0.58, 95% CI: 0.45 to 0.76); based on six studies, 3921 participants.<br>CONCLUSIONS: This review gives evidence that higher surgeon volume is associated with better overall survival, lower permanent stoma and APER rates. |
| Gruen, Pitt, green et al. (2009)<br>Systematic review and meta-analysis<br>Cancer mortality<br>The effect of provider case volume on cancer mortality. Systematic review and meta-analysis.<br>CA Cancer J Clin 2009; 59:192–211. | The authors systematically reviewed the association between provider case volume and mortality in 101 publications involving greater than 1 million patients with esophageal, gastric, hepatic, pancreatic, colon, or rectal cancer, of whom more than 70,000 died. | The majority of studies addressed the relation between hospital surgical case volume and short-term perioperative mortality. Few studies addressed surgeon case volume or evaluated long-term survival outcomes. Common methodologic limitations were failure to control for potential confounders, post hoc categorization of provider volume, and unit of analysis errors. A significant volume effect was evident for the majority of gastrointestinal cancers; with each doubling of hospital case volume, the odds of perioperative death decreased by 0.1 to 0.23. The authors calculated that between 10 and 50 patients per year, depending on cancer type, needed to be moved from a “low-volume” hospital to a “high-volume” hospital to prevent 1 additional volume-associated perioperative death. Despite this, approximately one-third of all analyses did not find a significant volume effect on mortality.<br>The heterogeneity of results from individual studies calls into question the validity of case volume as a proxy for care quality, and leads the authors to conclude that more direct quality measures and the validity of their use to inform policy should also be explored. |
| Gooiker et al. (2011)<br>Systematic review and meta analysis | Many studies have shown lower mortality and higher survival rates after pancre- | Fourteen studies were included in the meta-analysis. The results showed a significant association between hospital volume and postoperative mortality, and be- |

| Author(s) & clinical area | Objectives & studied factors | Results and comments |
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| Pancreatic surgery<br>The Netherlands<br>Systematic review and meta-analysis of the volume-outcome relationship in pancreatic surgery.<br>The British Journal of Surgery, 98(4), 485-494. | atic surgery with high-volume providers, suggesting that centralization of pancreatic surgery can improve outcomes. The methodological quality of these studies is open to question.<br>This study involves a systematic review of the volume-outcome relationship for pancreatic surgery with a meta-analysis of studies considered to be of good quality. | tween hospital volume and survival. The effect of surgeon volume on postoperative mortality was not significant.<br>There was a consistent association between high hospital volume and lower postoperative mortality rates with improved long-term survival. |
| Chowdhury et al. (2007)<br>Systematic review<br>A systematic review of the impact of volume of surgery and specialization on patient outcome.<br>Br J Surg.,94(2):145-61. | Volume of surgery and specialization may affect patient outcome. Articles examining the effects of one or more of three variables (hospital volume of surgery, surgeon volume and specialization) on outcome (measured by length of hospital stay, mortality and complication rate) were analysed. | The search identified 55,391 articles published between 1957 and 2002; 1075 were relevant to the study, of which 163 fulfilled the entry criteria.<br>High-volume hospitals had significantly better outcomes in 74.2 per cent of studies, but this effect was limited in prospective studies (40 per cent). Surgeon volume was reported in 58 studies; high-volume surgeons had significantly better outcomes in 74 per cent of studies. Specialization was reported in 22 studies; specialist surgeons had significantly better outcomes than general surgeons in 91 per cent of studies. The benefit of high surgeon volume and specialization varied in magnitude between specialities.<br>High surgeon volume and specialization are associated with improved patient outcome, while high hospital volume is of limited benefit. |
| Archampong et al. (2012)<br>Systematic review<br>Colorectal cancer, colon cancer and rectal cancer surgery<br>Workload and surgeon's specialty for outcome after colorectal cancer surgery.<br>The Cochrane Database of Systematic Reviews, (3):CD005391. | BACKGROUND: A large body of research has focused on investigating the effects of healthcare provider volume and specialization on patient outcomes including outcomes of colorectal cancer surgery. However there is conflicting evidence about the role of such healthcare provider characteristics in the management of colorectal cancer.<br>OBJECTIVES: To examine the available literature for the effects of hospital volume, surgeon caseload and specialization on the outcomes of colorectal, colon and rectal cancer surgery. | SEARCH METHODS: We searched Cochrane Central Register of Controlled Trials (CENTRAL), and LILACS using free text search words (as well as MESH-terms). We also searched Medline (January 1990-September 2011), Embase (January 1990-September 2011) and registers of clinical trials, abstracts of scientific meetings, reference lists of included studies and contacted experts in the field. SELECTION CRITERIA: Non-randomised and observational studies that compared outcomes for colorectal cancer, colon cancer and rectal cancer surgery (overall 5-year survival, five year disease specific survival, operative mortality, 5-year local recurrence rate, anastomotic leak rate, permanent stoma rate and abdominoperineal excision of the rectum rate) between high volume/specialist hospitals and surgeons and low volume/specialist hospitals and surgeons. DATA COLLECTION AND ANALYSIS: Two review authors independently abstracted data and assessed risk of bias in included studies. Results were pooled using the random effects model in unadjusted and case-mix adjusted meta-analyses.<br>MAIN RESULTS: Overall five year survival was significantly improved for patients with colorectal cancer treated in high-volume hospitals (HR=0.90, 95% CI 0.85 to 0.96), by high-volume surgeons (HR=0.88, 95% CI 0.83 to 0.93) and colorectal specialists (HR=0.81, 95% CI 0.71 to 0.94). Operative mortality was significantly better for high-volume surgeons (OR=0.77, 95% CI 0.66 to 0.91) and specialists (OR=0.74, 95% CI 0.60 to 0.91), but there was no significant association with higher hospital caseload (OR=0.93, 95% CI 0.84 to 1.04) when only case-mix adjusted studies were included. There were differences in the effects of caseload depending on the level of case-mix adjustment and also whether the studies originated in the US or in other countries. For |

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| | | rectal cancer, there was a significant association between high-volume hospitals and improved 5-year survival (HR=0.85, 95% CI 0.77 to 0.93), but not with operative mortality (OR=0.97, 95% CI 0.70 to 1.33); surgeon caseload had no significant association with either 5-year survival (HR=0.99, 95% CI 0.86 to 1.14) or operative mortality (OR=0.86, 95% CI 0.62 to 1.19) when case-mix adjusted studies were reviewed. Higher hospital volume was associated with significantly lower rates of permanent stomas (OR=0.64, 95% CI 0.45 to 0.90) and APER (OR=0.55, 95% CI 0.42 to 0.72). High-volume surgeons and specialists also achieved lower rates of permanent stoma formation (0.75, 95% CI 0.64 to 0.88) and (0.70, 95% CI 0.53 to 0.94, respectively).<br>AUTHORS' CONCLUSIONS: The results confirm clearly the presence of a volume-outcome relationship in colorectal cancer surgery, based on hospital and surgeon caseload, and specialisation. The volume-outcome relationship appears somewhat stronger for the individual surgeon than for the hospital; particularly for overall 5-year survival and operative mortality, there were differences between US and non-US data, suggesting provider variability at hospital level between different countries, making it imperative that every country or healthcare system must establish audit systems to guide changes in the service provision based on local data, and facilitate centralisation of services as required. Overall quality of the evidence was low as all included studies were observational by design. In addition there were discrepancies in the definitions of caseload and colorectal specialist. However ethical challenges associated with the conception of randomised controlled trials addressing the volume outcome relationship makes this the best available evidence. |
| Mahar et al. (2012)<br>Systematic review<br>Gastric cancer<br>A Systematic Review of the Effect of Institution and Surgeon Factors on Surgical Outcomes for Gastric Cancer<br>Journal of the American College of Surgeons, 215(1), 165-168. | A potential relationship between institution volume and surgical outcomes has been explored for many complex surgical procedures performed for a variety of benign and malignant medical conditions.<br>Institution volume and surgeon experience are potentially modifiable factors; where an association of increased institution volume and improved outcomes has been observed, arguments have been brought forth to centralize services and for the requirement of minimum case-load requirements for certain procedures, affecting the provision of health care at both the system and physician level.<br>Unfortunately, increasing volume alone may not improve outcomes, as institution volume might represent a proxy measure for the technology, amenities, and increased infrastructure available to physicians | 8 articles explored the impact of surgeon training or volume.<br>The effect of surgeon volume or experience on short-term outcomes was assessed in 6 studies; comparing procedurerelated morbidity rates in 3 and procedure-related mortality rates in all 6. Lower rates of procedure-related morbidity were significantly associated with increased surgeon volume in the only study that investigated this relationship, and these rates were associated with surgeon training in 1 of 2 studies that defined experience as years of training. Lower rates of procedure-related mortality were significantly associated with higher surgeon volume and increased surgeon training in 2 and 1 study, respectively, but these results were not uniform across all studies.<br>Five studies investigated the relationship of surgeon volume, training, or age with survival. Increased surgeon experience, defined as training, age, or volume, was associated with improved 5-year survival in one study each. Differences in the number of operations performed per surgeon to define the volume categories make interpretation of the results difficult. The low-volume category cutoff point was ≤13 operations/year in the study that found an association between high surgeon volume and better 5-year survival, and overlapped with the cutoff point for the high-volume categories of the studies that did not report the same statistically significant association. L.ee and colleagues investigated the learning curve for adequate performance of D2 lymphadenectomy and measured adequacy as retrieving more than 25 lymph nodes during gastrectomy for gastric cancer. |

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| | treating patients at higher-volume hospitals.<br>Surgeon volume, subspecialty training, and age are also believed to be factors that affect a surgeons' ability to perform a procedure to the best advantage of the patient.<br>In surgical oncology, this has been an especially relevant topic for cancers of the gastrointestinal tract. Many of the surgical procedures required to treat tumors in the esophagus, lung, kidney, liver, pancreas, and stomach are technically intricate to perform, and are performed infrequently by individual physicians due to the low prevalence of these diseases. These facts encourage the questions of whether volume plays a role in outcomes for these operations and, if so, how to best allocate resources to optimize both quality of life and survival for the patient. | The learning curve was defined as achieving adequate lymphadenectomy 92% of the time. The performance of 2 junior surgeons was tracked and a learning curve of 35 and 23 gastrectomies during the study period were identified before adequate lymphadenectomy could be performed.<br>This systematic review identified 28 articles reporting the relationship between hospital and surgeon factors with procedure-related morbidity, procedure-related mortality, or 5-year survival for gastric cancer surgery. Results of the meta-analysis conclude that high hospital volume is associated with lower, unadjusted procedure-related mortality. Surgeon volume, level of training, hospital volume, and specialization were also implicated in procedure-related morbidity, procedure-related mortality, and 5-year survival; however, the association is not consistent across all studies.<br>Conclusions: Some evidence exists to suggest that hospital and surgeon factors influence surgical outcomes for gastric cancer surgery; however, the mechanism of action is not clear. Patient case-mix differs among levels of hospital volume and can complicate our understanding of the volume–outcomes relationship. Specialized and/or high-volume centers for oncologic surgery can improve outcomes for gastric cancer patients as the result of increased surgeon knowledge, experience, and training, as well as structural hospital processes. |
| Meyer (2005).<br>Gastric cancer<br>Literature review<br>The influence of case load and the extent of resection on the quality of treatment outcome in gastric cancer.<br>*European Journal of Surgical Oncology: The Journal of the European Society of Surgical Oncology and the British Association of Surgical Oncology, 31*(6), 595-604. | AIMS: The background was to analyse the influence of hospital- and surgeon volume and of the extent of resective procedures on the quality of early and late treatment results in gastric cancer. | METHODS: The literature was reviewed by searching the databases of Medline, Cancerlit, Pubmed and the Cochran register.<br>RESULTS: The levels of evidence showed wide variations. The influence of hospital volume was more important for the outcome than the case load of the individual surgeon. The extent of surgical resection should be adapted to histology--or stage. The value of systematic lymph node dissection is still under discussion.<br>CONCLUSIONS: We have found that the best treatment results were seen in high volume hospitals with experienced surgeons, even taking into account extended surgical procedures. Further studies are needed to define the optimal number of operations necessary to be carried out each year. |
| Trinh et al. (2013).<br>Systematic review<br>Radical prostatectomy<br>A systematic review of the volume-outcome relationship for radical prostatectomy.<br>European Urology 64, 786 – 798. | To review systematically the association between hospital and surgeon volume and perioperative, oncologic, and functional outcomes after RP. | Evidence acquisition: A systematic review of the literature was performed, searching PubMed, Embase, and Scopus databases for original and review articles between January 1, 1995, and December 31, 2011. Inclusion and exclusion criteria comprised RP, hospital and/or surgeon volume reported as a predictor variable, a measurable end point, and a description of multiple hospitals or surgeons.<br>Evidence synthesis: 45 publications fulfilled the inclusion criteria, where most data originated from retrospective institutional or population-based cohorts. Studies generally focused on hospital or surgeon volume separately. Although most of these analyses corroborated the impact of increasing volume with better outcomes, some failed to find any significant effect. Studies also differed with respect to the proposed volume cut-off for improved outcomes, as well as the statistical means of evaluating the volume-outcome relationship. Five studies simultaneously compared hospital and surgeon volume, where results |

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| | | suggest that the importance of either hospital or surgeon volume largely depends on the end point of interest.<br>Considerable evidence indicates that increasing volume improves surgical outcomes, and the most plausible hypothesis is that the relation is a causal one. There is also considerable evidence that outcomes vary, even between surgeons with similar volume.<br>Conclusions: Undeniable evidence suggests that increasing volume improves outcomes. Although it would seem reasonable to refer RP patients to high-volume centers, such regionalization may not be entirely practical. As such, the implications of such a shift in practice have yet to be fully determined and warrant further exploration. |
| Wilson, Marlow et al. (2010).<br>Systematic review<br>Radical prostatectomy<br>Radical prostatectomy: A systematic review of the impact of hospital and surgeon volume on patient outcome.<br>ANZ Journal of Surgery, 80(1-2), 24-29. | BACKGROUND: To assess the impact of hospital and surgeon volume on mortality, morbidity, length of hospital stay and costs of radical prostatectomy (RP). | METHODS: This systematic review identified relevant studies published between 1997 and June 2007. Inclusion of papers was established through application of a predetermined protocol, independent assessment by two reviewers, and a final consensus decision.<br>RESULTS: Compared with low volume hospitals, the included studies showed high volume hospitals demonstrated lower rates of mortality, postoperative complications and readmissions, and lower overall hospital costs. High volume surgeons similarly showed lower rates of postoperative complications and shorter length of stay compared with low volume surgeons, but no difference in mortality.<br>CONCLUSIONS: From the literature obtained, patients undergoing RP performed by high volume providers may have better outcomes compared to low volume providers; however, any move to centralize RP must be further evaluated. |
| Wilt et al. 2008<br>Systematic review<br>Radical prostatectomy<br>Association between hospital and surgeon radical prostatectomy volume and patient outcomes: a systematic review. | Purpose: We examined the association between hospital and surgeon volume, and patient outcomes after radical prostatectomy. | Materials and Methods: Databases were searched from 1980 to November 2007 to identify controlled studies published in English. Information on study design, hospital and surgeon annual radical prostatectomy volume, hospital status and patient outcome rates were abstracted using a standardized protocol. Data were pooled with random effects models.<br>Results: A total of 17 original investigations reported patient outcomes in categories of hospital and/or surgeon annual number of radical prostatectomies, and met inclusion criteria. Hospitals with volumes above the mean (43 radical prostatectomies per year) had lower surgery related mortality (rate of difference 0.62, 95% CI 0.47–0.81) and morbidity (rate difference −9.7%, 95% CI −15.8, −3.6). Teaching hospitals had an 18% (95% CI −26, −9) lower rate of surgery related complications. Surgeon volume was not significantly associated with surgery related mortality or positive surgical margins. However, the rate of late urinary complications was 2.4% lower (95% CI −5, −0.1) and the rate of long-term incontinence was 1.2% lower (95% CI −2.5, −0.1) for each 10 additional radical prostatectomies performed by the surgeon annually. Length of stay was lower, corresponding to surgeon volume.<br>Conclusions: Higher provider volumes are associated with better outcomes after radical prostatectomy. Greater understanding of factors leading to this volume-outcome relationship, and the potential benefits and harms of increased regionalization is needed. |
| Barocas et al. (2010)<br>Review article | To identify and summarize the seminal studies to date | With regard to surgeon volume it is evident there is a learning curve: higher surgeon volume is associated |

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| Radical prostatectomy<br>Impact of surgeon and hospital volume on outcomes of radical prostatectomy.<br>Urologic Oncology: Seminars and Original Investigations. Volume 28, Issue 3, 243-250. | that investigate the impact of RP volume on patient outcomes. | with better results in perioperative outcomes, long-term, and cancer control.<br>We advocate careful studies to identify successful surgical techniques of high volume surgeons and efforts to disseminate these techniques. |
| Mayer, Purkayastha et al. (2009).<br>Literature review<br>Uro-oncology<br>Assessing the quality of the volume-outcome relationship in uro-oncology.<br>BJU International, 103(3), 341-349. | OBJECTIVE: To assess systematically the quality of evidence for the volume-outcome relationship in uro-oncology, and thus facilitate the formulating of health policy within this speciality, as 'Implementation of Improving Outcome Guidance' has led to centralization of uro-oncology based on published studies that have supported a 'higher volume-better outcome' relationship, but improved awareness of methodological drawbacks in health service research has questioned the strength of this proposed volume-outcome relationship. | METHODS: We systematically searched previous relevant reports and extracted all articles from 1980 onwards assessing the volume-outcome relationship for cystectomy, prostatectomy and nephrectomy at the institution and/or surgeon level. Studies were assessed for their methodological quality using a previously validated rating system. Where possible, meta-analytical methods were used to calculate overall differences in outcome measures between low and high volume healthcare providers.<br>RESULTS: In all, 22 studies were included in the final analysis; 19 of these were published in the last 5 years. Only four studies appropriately explored the effect of both the institution and surgeon volume on outcome measures. Mortality and length of stay were the most frequently measured outcomes. The median total quality scores within each of the operation types were 8.5, 9 and 8 for cystectomy, prostatectomy and nephrectomy, respectively (possible maximum score 18). Random-effects modelling showed a higher risk of mortality in low-volume institutions than in higher-volume institutions for both cystectomy and nephrectomy (odds ratio 1.88, 95% confidence interval 1.54-2.29, and 1.28, 1.10-1.49, respectively).<br>CONCLUSION: The methodological quality of volume-outcome research as applied to cystectomy, prostatectomy and nephrectomy is only modest at best. Accepting several limitations, pooled analysis confirms a higher-volume, lower-mortality relationship for cystectomy and nephrectomy. Future research should focus on the development of a quality framework with a validated scoring system for the benchmarking of data to improve validity and facilitate rational policy-making within the speciality of uro-oncology. |
| Hillner, Smith & Desch (2000)<br>Review<br>Cancer treatment<br>Hospital and physician volume or specialization and outcomes in cancer treatment: importance in quality of cancer care.<br>Journal of Clinical Oncology 18(11):2327-40. | PURPOSE: To conduct a comprehensive review of the health services literature to search for evidence that hospital or physician volume or specialty affects the outcome of cancer care. | METHODS: We reviewed the 1988 to 1999 MEDLINE literature that considered the hypothesis that higher volume or specialization equals better outcome in processes or outcomes of cancer treatments.<br>RESULTS: An extensive, consistent literature that supported a volume-outcome relationship was found for cancers treated with technologically complex surgical procedures, eg, most intra-abdominal and lung cancers. These studies predominantly measured in-hospital or 30-day mortality and used the hospital as the unit of analysis. For cancer primarily treated with low-risk surgery, there were fewer studies. An association with hospital and surgeon volume in colon cancer varied with the volume threshold. For breast cancer, British studies found that physician specialty and volume were associated with improved long-term outcomes, and the single American report showed an association between hospital volume of initial surgery and better 5-year survival. Studies of nonsurgical cancers, principally lymphomas and testicular cancer, were few but consistently showed better long-term outcomes associated with larger hospital volume or specialty focus. Studies in recurrent or metastatic cancer were absent. Across studies, the absolute |

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| | | benefit from care at high-volume centers exceeds the benefit from break-through treatments.<br>CONCLUSION: Although these reports are all retrospective, rely on registries with dated data, rarely have predefined hypotheses, and may have publication and self-interest biases, most support a positive volume-outcome relationship in initial cancer treatment. Given the public fear of cancer, its well-defined first identification, and the tumor-node-metastasis taxonomy, actual cancer care should and can be prospectively measured, assessed, and benchmarked. The literature suggests that, for all forms of cancer, efforts to concentrate its initial care would be appropriate. |
| Killeen, O'Sullivan et al. (2005).<br>Review<br>(Pancreatic resection, oesophagectomy, colorectal resection, gastric, lung, breast and miscellaneous cancers)<br>Provider volume and outcomes for oncological procedures. *The British Journal of Surgery, 92*(4), 389-402. | BACKGROUND: Oncological procedures may have better outcomes if performed by high-volume providers. | METHODS: A review of the English language literature incorporating searches of the Medline, Embase and Cochrane collaboration databases was performed.<br>From the discussion: The question of whether the hospital or the doctor is a stronger influence is difficult to answer. Given the large sample-size requirements encompassing many surgeons and hospitals, and the difficulty in obtaining surgeon-specific volume estimates, few studies have simultaneously assessed the effect of surgeon volume and hospital volume. Only six studies analysed both variables simultaneously, often with conflicting results. It seems that the impacts of surgeon and hospital volumes differ from procedure to procedure, with surgeon volume more important in technically demanding operations such as pancreatectomy, oesphagectomy, gastrectomy and rectal cancer procedures (compared with colonic resections). In contrast, patients having lung resection rarely die because of technical complications; rather they die from cardiac events and pneumonia. Hospital-based services such as intensive care, physiotherapy and pain management, are often vital and so it is not surprising that hospital volume has a major role in the outcome of operations requiring such services.<br>The underlying mechanism of this relationship remains elusive. In complex procedures the surgeon's ability and experience may be enhanced with familiarity, i.e. there is a direct causal relationship. Furthermore, 'inverse causality' may result from better outcomes leading to increased referrals. Whatever the mechanism, better outcomes would be achieved by referral to high-volume units. The issue is further clouded by clustering of good or bad outcomes within a particular provider. It is important to determine whether low-volume providers generally achieve worse outcomes or whether a few high-volume providers with exceptionally good outcomes make low-volume providers look bad. A high volume–better outcome relationship found among many high-volume providers supports a regionalization policy, but if only a few providers exhibit this relationship, strategies to identify the features of their practice that make them successful seem more rational.<br>A note of caution is advisable before advocating policy changes based solely on currently available evidence. Many studies have assessed a single measure of provider volume, namely either hospital or surgeon volume, and there is no consensus definition of low- or high-provider volume. Most have used restrictive databases (such as Medicare which is confined to patients aged 65 years of age or older) which |

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| | | make assessment of cancer stage, adjuvant treatment and time to intervention impossible.<br>CONCLUSION: High-volume providers have a significantly better outcome for complex cancer surgery, specifically for pancreatectomy, oesphagectomy, gastrectomy and rectal resection. |
| Kidher, Sepehripour et al. (2010)<br>Review<br>Aortic or mitral valve surgery<br>Do bigger hospitals or busier surgeons do better adult aortic or mitral valve operations?<br>Interactive Cardiovascular and Thoracic Surgery, 10(4), 605-610. | A best evidence topic in cardiac surgery was written according to a structured protocol. The question addressed was whether there is a relationship between hospital or surgeon volume (SV) and postoperative outcome in adult aortic or mitral valve surgery. | One hundred and sixty papers were found using the specified search strategy, of which seven papers represented the best evidence to answer this question. The author, journal, date and country of publication, patient group studied, study type, relevant outcomes, methodology scores, study weaknesses and results are tabulated. Outcomes assessed by these studies were variable; four papers used mortality, one paper used morbidity, one paper used care processes and one paper examined all the above-mentioned outcomes. Six papers investigated the effect of hospital volume (HV) on outcome whilst only one paper assessed the effect of both HV and SV on outcome. The type of valve operated on was also mixed; two papers studied aortic valve only, one paper studied mitral valve only and four papers studied both valves. The methodological quality and validity of each study was assessed by a predefined scoring system. The median total quality score was modest and not strong enough to support the conclusions reported by these studies. In addition, volume-outcome relationship can be affected by several factors related to patient, surgeon and hospital. These factors have not been considered in depth by the mentioned papers. However, there may be a positive relationship between hospital procedural volume and mortality which is more likely to be mediated by SV, and there is also a potential relationship with the rate of mitral valve repair and the use of bio-prosthetic valves in elderly patients.<br>We conclude that regionalisation of adult aortic or mitral valve surgery based on such a limited number of modest quality studies would be an indefensible policy. The implementation of such a scheme can have many clinical, practical, economical and political consequences which have not been examined prospectively until today. Furthermore, the relationship between volume and other outcomes rather than mortality needs further assessment. |
| Sepehripour & Athanasiou (2013).<br>Review<br>Is there a surgeon or hospital volume-outcome relationship in off-pump coronary artery bypass surgery?<br>Interactive Cardiovascular and Thoracic Surgery, 16(2), 202-207. | A best evidence topic was written according to a structured protocol.<br>The question addressed was whether there is a surgeon or hospital volume-outcome relationship in patients undergoing off-pump coronary artery bypass surgery. | A total of 281 papers were found using the reported searches, of which six represented the best evidence to answer the clinical question. The authors, date, journal, study type, population, main outcome measures and results are tabulated. The studies found analysed the outcomes of off-pump coronary artery bypass surgery in relation to surgeon or hospital volume and evaluated the presence of a volume-outcome relationship. Reported measures included mortality and major adverse cardiovascular and cerebrovascular events. The methodological quality and strength of each study for exploring volume-outcome relationships were quantitatively assessed using a predefined scoring system. Three studies analysed surgeon volume and three studies analysed hospital volume. The two largest and most recent studies presented a significant volume-outcome relationship in mortality and postoperative complications. Perhaps owing to the smaller sample size, this significant relationship in mortality was not observed in the four smaller studies; however, one of these studies demonstrated a significantly positive relationship for postoperative complications and another study demonstrated a similar significant relationship for the number of grafts and the degree of completeness of |

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| | | revascularization. While the volume-outcome relationship in coronary artery bypass graft surgery is very well-documented, the technically challenging nature of off-pump surgery, the length of the learning curve associated with the operation and the higher risk profile of patients undergoing off-pump surgery in comparison with routine on-pump surgery render these results difficult to interpret.<br>Although our review does support the idea of a volume-outcome relationship in off-pump coronary artery bypass surgery, this relationship may not be so clearly defined and requires further analysis by higher-quality studies. |
| Caputo, Salottolo et al. (2014).<br>Systematic review<br>Trauma centers<br>US<br>The relationship between patient volume and mortality in american trauma centres: A systematic review of the evidence.<br>Injury, 45(3), 478-486. | OBJECTIVE: To synthesise published and unpublished findings examining the relationship between institutional trauma centre volume or trauma patient volume per surgeon and mortality.<br>BACKGROUND: Evidence on the relationship between patient volume and survival in trauma patients is inconclusive in the literature and remains controversial. | METHODS: A literature search was performed to identify studies published between 1976 and 2013 via MEDLINE (Pubmed) and the Cumulative Index to Nursing and Allied Health Literature (EbscoHost) as well as footnote chasing. Abstracts from appropriate conferences and ProQuest Dissertations and Theses were also searched. Inclusion criteria required studies to be original research published in English that examined the relationship between mortality and either institutional or per surgeon volume in American trauma centres. We employed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) Statement checklist and flowchart. The Grading of Recommendations Assessment, Development, and Evaluation (GRADE) approach was employed to rate the quality of the evidence.<br>RESULTS: Of 1392 studies reviewed, 19 studies met defined inclusion criteria; all studies were retrospective. The definition of volume was heterogeneous across the studies. Patient population and analysis methods also varied across the studies. Sixteen studies (84%) examined the relationship between institutional trauma centre volume and mortality. Of the 16 studies, 12 examined the volume of severely injured patients and eight examined overall trauma patient volume. High institutional volume was associated with at least somewhat improved mortality in ten of 16 studies (63%); however, nearly half of these studies found only some subpopulations experienced benefits. In the remaining six studies, volume was not associated with any benefits. Four studies (25%) analysed the impact of surgeon volume on mortality. High volume per surgeon was associated with improved mortality in only one of four studies (25%).<br>CONCLUSIONS: The studies were extremely heterogeneous, thus definitive conclusions cannot be drawn regarding optimal volume before a clear advantage in survival is observed. A prospective study defining volume as a continuous variable is warranted to support current admission criteria for American trauma patients. |
| Shervin, Rubash & Katz (2007).<br>Systematic literature review<br>Orthopaedic procedure volume and patient outcomes: A systematic literature review.<br>Clinical Orthopaedics and Related Research, 457, 35-41. | The association between greater hospital procedure volumes and improved patient outcomes has been well established with respect to a variety of procedures and treatments. However, this association in orthopaedics has not been summarized systematically. | We reviewed existing literature on associations between hospital and surgeon procedure volume and patient outcomes in orthopaedic surgery. The patient outcomes examined were mortality, hip dislocation, infection, revision, complications, functional outcome, and satisfaction.<br>Of the 26 articles reviewed, most examined outcomes after primary joint arthroplasties (predominantly hip arthroplasties) with a relatively limited number of studies examining revision arthroplasties, hip fractures, spine, or general orthopaedics. No studies evaluated any other subspecialties. We found an association between higher hospital volumes and lower rates of mortality and hip dislocation. We also found |

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| | | an association between higher surgeon volume and lower rates of hip dislocation. All other associations were negative or inconclusive. In addition, surgeon volume had a greater effect on patients than hospital volume for primary and revision joint arthroplasties, whereas hospital volume was more strongly related to outcome than surgeon volume for the other procedures examined. Our findings suggest the need for additional studies in the various subspecialties to establish more definitive conclusions. |
| Lau et al. (2012)<br>Systematic review<br>Total knee arthroplasty<br>The role of surgeon volume on patient outcome in total knee arthroplasty: a systematic review of the literature.<br>*BMC Musculoskeletal Disorders, 13 (1)*, 250. | To investigate the association between surgeon volume and primary total knee arthroplasty outcomes.<br>A number of factors have been identified as influencing total knee arthroplasty outcomes, including patient factors such as gender and medical comorbidity, technical factors such as alignment of the prosthesis, and provider factors such as hospital and surgeon procedure volumes.<br>Recently, strategies aimed at optimizing provider factors have been proposed, including regionalization of total joint arthroplasty to higher volume centers, and adoption of volume standards. | METHODS: We performed a systematic review examining the association between surgeon volume and primary knee arthroplasty outcomes. To be included in the review, the study population had to include patients undergoing primary total knee arthroplasty. Studies had to report on the association between surgeon volume and primary total knee arthroplasty outcomes, including perioperative mortality and morbidity, patient-reported outcomes, or total knee arthroplasty implant survivorship. There were no restrictions placed on study design or language.<br>RESULTS: Studies were variable in defining surgeon volume ('low': 5 to >70 total knee arthroplasty per year).<br>Mortality rate, survivorship and thromboembolic events were not found to be associated with surgeon volume. We found a significant association between low surgeon volume and higher rate of infection, procedure time (165 min versus 135 min), longer length of stay (0.4 - 2.13 days longer), transfusion rate (13% versus 4%), and worse patient reported outcomes.<br>Findings suggest a trend towards better outcomes for higher volume surgeons, but results must be interpreted with caution. |
| Marlow et al. (2010).<br>Review<br>Knee arthroplasty<br>Centralization and the relationship between volume and outcome in knee arthroplasty procedures.<br>ANZ Journal of Surgery, 80(4), 234-241. | This review assessed the efficacy of centralization for knee arthroplasty by examining the relationship between hospital and surgeon volume and patient outcomes. | DATA SOURCES AND REVIEW METHODS: The systematic review identified studies using multiple databases, including Medline and Embase. Two independent researchers ensured studies met the inclusion criteria. Morbidity, mortality, length of stay, financial outcomes and statistical rigour were examined. Correlations between volume and outcome were reported.<br>RESULTS: Twelve primary knee arthroplasty studies examined hospital volume, which was significantly associated with decreased morbidity (five of seven studies), mortality (two of five studies) and length of stay (two of three studies). Three primary knee arthroplasty studies examined surgeon volume, which was significantly associated with decreased morbidity (two of three studies), mortality (zero of two studies) and length of stay (one of one study). Two revision knee arthroplasty studies examined hospital volume. One study examined but did not test for significance between hospital volume and patient morbidity; both studies examined volume and patient mortality reporting inconclusive results; and one study reported no significant association between volume and length of stay. None of the revision knee arthroplasty studies examined surgeon volume.<br>CONCLUSIONS: Significant associations between increased hospital and surgeon volume and improved patient outcomes were reported. However, when these results were separated by arthroplasty type, the association appeared tenuous. Judgements regarding centralization of knee arthroplasty should be made with caution until further evidence is published. |

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| Battaglia, Mulhall et al. (2006)<br>Review<br>Hip arthroplasty<br>Increased surgical volume is associated with lower THA dislocation rates.<br>Clinical Orthopaedics and Related Research, 447, 28-33. | The presumed correlation between an increasing volume of health care procedures and an improvement in outcomes is sometimes referred to as the practice-makes-perfect effect. Growing interest in outcomes-based research has led to numerous papers examining this relationship for various surgical procedures, including total hip arthroplasty. The results of these studies have important implications for consumers, providers, and healthcare financers.<br>Accordingly, we review the literature to date examining surgeon and hospital volume effects on hip arthroplasty outcomes, with a specific focus on the effects of volume on dislocation. | A systemic review of the literature demonstrates a substantial positive association between surgical volumes and improvement in most THA outcomes, including dislocation; that is, increasing surgical volume is associated with lower dislocation rates. This correlation appears to be stronger and is more clearly established for surgeon volumes than it is for hospital volumes. |
| SBU (2014).<br>Cancerkirurgi (tjocktarm/ändtarm, urinblåsa, huvud/hals, matstrupe, prostata, lunga och bukspottskörtel) och fetma-, barn-, lever-, hjärt- eller knäkirurgi<br>*Volym och resultat i sjukvården.*<br>Stockholm: SBU, Statens beredning för medicinsk och social utvärdering. | Upplysningstjänsten har identifierat 19 systematiska översikter av det vetenskapliga underlaget för sambandet mellan sjukhus- och/eller kirurgvolym (antal ingrepp per enskild kirurg) och resultat. | I majoriteten av dessa översikter behandlas olika typer av kirurgi: nio om cancerkirurgi (tjocktarm/ändtarm, urinblåsa, huvud/hals, matstrupe, prostata, lunga och bukspottskörtel) och sju om fetma-, barn-, lever-, hjärt- eller knäkirurgi.<br>I resterande tre översikter berörs HIV, hjärnblödning (subarachnoidal-blödning) och intensivvård.<br><br>I alla översikter rapporteras om dödlighet och/eller överlevnad som primära utfallsmått. I några översikter rapporterar man även om sekundära utfallsmått såsom komplikationer och längd av sjukhusvistelse.<br><br>I de systematiska översikterna behandlas skilda specialområden men samtliga författare drar slutsatsen att högre sjukhusvolymer och/eller kirurgvolymer är förenade med lägre dödlighet (på sjukhus eller inom 30 dagar) och/eller bättre överlevnad (vanligtvis fem år). Det är dock stora variationer i definitionen av hög respektive låg volym mellan de ingående studierna i översikterna. Det är därför svårt att dra några slutsatser om tröskelvärden.<br><br>Ingen översikt rapporterade några negativa hälsoeffekter av hög volym. Inga studier avser konsekvenser av interventioner där volymen förändras. |
| AlSahaf & Lim (2015).<br>Lung resection<br>US and UK<br>The association between surgical volume, survival and quality of care.<br>Journal of Thoracic Disease, 7, S152-S155. | Increasing hospital volume is associated with better survival although the categorisation of procedure volume is arbitrary. | For individual surgeon volume, reports are not consistent. However, studies suggest that surgeon subspecialty is an important consideration. The results of general thoracic surgeons and cardiac surgeons are reported to be better than general surgeons for lung resection surgery, and the effects of specialty training was also associated with an increase in the number of patients undergoing lung resection. |
| ASERNIPS (2014).<br>Rapid systematic review<br>Bariatric surgery | To explore the potential effects of centralising bariatric surgery services in Victoria by systematically | Evidence suggested that high-volume hospitals and surgeons were associated with improved patient outcomes in terms of in-hospital mortality and morbidity, |

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| Australia<br>Centralisation of bariatric surgery: Policy implications. Rapid review.<br>Melbourne: Australian Safety & Efficacy Register of New Interventional Procedures – Surgical. The Royal Australasian College of Surgeons. | reviewing the association between the volume of bariatric surgeries performed and patient outcomes, and determining the relationship between surgical volume and cost, workforce sustainability and patient access. | but data were equivocal regarding length of hospital stay.<br>It should be noted that it was not possible to define a minimum annual case volume due to the heterogeneity of methods, lengths of follow-up and risk adjustment strategies used in the studies. |
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| Ho & Aloia (2008).<br>6 cancer resections<br>US<br>Hospital volume, surgeon volume, and patient costs for cancer surgery.<br>*Medical Care, 46*(7), 718-725. | BACKGROUND: Several cancer surgery studies document an association between higher provider volume and lower mortality rates. Less is known about the relative influence of hospital and surgeon volume on patient costs. We evaluate associations between hospital and surgeon volume and inpatient costs for 6 cancer resections | METHODS: We analyzed administrative discharge data on patients receiving 1 of 6 cancer resections in Florida, New Jersey, and New York between 1989 and 2000. After dividing hospital and surgeon volumes into tertiles, we examined the relations between the total cost of an inpatient stay and surgeon and hospital volume, adjusting for patient and hospital characteristics. We tested for differences in adjusted volume-cost relationships that persisted throughout the sample period, versus those that lasted for shorter periods.<br>RESULTS: For the entire sample period, relative to low-volume surgeons, high-volume surgeons were 5.5% less costly for pneumonectomy (P = 0.005) and 10.6% less costly for esophagectomy (P < 0.001). For the 4 other procedures, high-volume surgeons were less costly than low-volume surgeons for the periods 1993-1996 and 1997-2000 (all P values < 0.001). The lowest differential was for colectomy (4.4% in 1993-1996, P < 0.001), and the highest differential was for pancreaticoduodenectomy (25.6% in 1993-1996, P < 0.001). High hospital volume was associated with lower costs only for colectomy (P = 0.02).<br>CONCLUSIONS: High surgeon volume, rather than high hospital volume is associated with lower inpatient cancer surgery costs, and the relationship has become significant in recent years for each cancer procedures examined. These data suggest that cost savings are best achieved through a surgeon-specific referral program. |
| Birkmeyer et al. 2003a<br>Eight cardiovascular procedures or cancer resections.<br>US<br>Surgeon volume and operative mortality in the United States.<br>N Eng J Med., 349:2117–27 | Although the relation between hospital volume and surgical mortality is well established, for most procedures, the relative importance of the experience of the operating surgeon is uncertain. | Surgeon volume was inversely related to operative mortality for all eight procedures.<br>Surgeon volume accounted for a large proportion of the apparent effect of the hospital volume, to an extent that varied according to the procedure: it accounted for 100 percent of the effect for aortic-valve replacement, 57 percent for elective repair of an abdominal aortic aneurysm, 55 percent for pancreatic resection, 49 percent for coronary-artery bypass grafting, 46 percent for esophagectomy, 39 percent for cystectomy, and 24 percent for lung resection.<br>For most procedures, the mortality rate was higher among patients of low-volume surgeons than among those of high-volume surgeons, regardless of the surgical volume of the hospital in which they practiced. |
| Hannen et al. (2002)<br>Cancer diagnosis who underwent colectomy, lobectomy of the lung, or gastrectomy<br>The influence of hospital and surgeon volume on in-hospital mortality for colectomy, gastrectomy, and lung lobectomy in patients with cancer. | This study explores the volume-mortality relationship for 3 groups of cancer procedures to determine whether higher-volume hospitals, higher-volume surgeons, or both are associated with lower in-hospital mortality. | RESULTS: For hospital volume for gastrectomy, the highest-volume quartile had an absolute risk-adjusted mortality rate that was 7.1% lower (P <.0001) than the lowest-volume quartile, although the overall mortality rate for the procedure was only 6.2%. For surgeon volume for colectomy, the highest- and lowest-volume quartiles differed by 1.9% (P <.0001), although the procedure mortality rate was only 3.5%. For hospital volume for lung lobectomy, the absolute difference in mortality was 1.7%. Patients undergoing |

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| Surgery. 131(1):6-15. | | operations performed by high-volume surgeons in high-volume hospitals usually had significantly lower risk-adjusted mortality rates than did patients who had low-volume surgeons or who were in low-volume hospitals, or both.<br>CONCLUSIONS: For all 3 procedure groups, the risk-adjusted in-hospital mortality is significantly lower when the procedures are performed by high-volume providers. |
| Kalkanis, Eskandar et al. (2003)<br>Microvascular decompression surgery<br>US<br>Microvascular decompression surgery in the united states, 1996 to 2000: Mortality rates, morbidity rates, and the effects of hospital and surgeon volumes.<br>Neurosurgery, 52(6), 1251-61; discussion 1261-2. | OBJECTIVE: Microvascular decompression (MVD) is associated with low mortality and morbidity rates at specialized centers, but many MVD procedures are performed outside such centers.<br>We studied short-term end points after MVD in a national hospital discharge database sample. | METHODS: A retrospective cohort study was performed by using the Nationwide Inpatient Sample, 1996 to 2000.<br>RESULTS: The sample included 1326 MVD procedures for treatment of trigeminal neuralgia, 237 for treatment of hemifacial spasm, and 27 for treatment of glossopharyngeal neuralgia, performed at 305 hospitals by 277 identified surgeons. The mortality rate was 0.3%, and the rate of discharge other than to home was 3.8%. Neurological complications were coded in 1.7% of cases, hematomas in 0.5%, and facial palsies in 0.6%, with 0.4% of patients requiring ventriculostomies and 0.7% postoperative ventilation. Trigeminal nerve section was also coded for 3.4% of patients with trigeminal neuralgia, more commonly among older patients (P = 0.08), among female patients (P = 0.03), and at teaching hospitals (P = 0.02). The median annual caseloads were 5 cases per hospital (range, 1-195 cases) and 3 cases per surgeon (range, 1-107 cases). With adjustment for age, sex, race, primary insurance, diagnosis (trigeminal neuralgia versus hemifacial spasm versus glossopharyngeal neuralgia), geographic region, admission type and source, and medical comorbidities, outcomes at discharge were superior at higher-volume hospitals (P = 0.006) and with higher-volume surgeons (P = 0.02). Complications were less frequent after surgery performed at high-volume hospitals (P = 0.04) or by high-volume surgeons (P = 0.01). The rate of discharge other than to home was 5.1% for the lowest-volume-quartile hospitals, compared with 1.6% for the highest-volume-quartile hospitals. Volume and mortality rate were not significantly related, but three of the four deaths in the series followed procedures performed by surgeons who had performed only one MVD procedure that year. Length of stay (median, 3 d) and hospital volume were not significantly related. Hospital charges were slightly higher at higher-volume hospitals (P = 0.007).<br>CONCLUSION: Although most MVD procedures in the United States are performed at low-volume centers, mortality rates remain low. Morbidity rates are significantly lower at high-volume hospitals and with high-volume surgeons. |
| Cowan, Dimick, et al. (2003a)<br>Intracranial tumor resection.<br>The impact of provider volume on mortality after intracranial tumor resection.<br>Neurosurgery, 52(1), 48-53; discussion 53-4. | OBJECTIVE: Policies of regionalization and selective referral for a number of "high-risk" surgical procedures are being explored and implemented as a result of significant variation in postoperative mortality between high- and low-volume providers. The effect of provider volume on outcomes after intracranial tumor resection is unknown and warrants investigation. | METHODS: By use of the Nationwide Inpatient Sample for 1996 and 1997, patients (older than 19 yr) who had a diagnosis of a malignant central nervous system neoplasm and underwent craniotomy or craniectomy were included. Hospital volume and surgeon volume were categorized by quartiles (very low, low, high, or very high volume). Unadjusted and case mix-adjusted analyses were performed with regard to postoperative in-hospital mortality.<br>RESULTS: The crude in-hospital mortality was 2.8% for a total of 7547 patients. The mean patient age was 55.8 years (66.5% /=65). Mortality for very low- to very high-volume hospitals was as follows: 3.8, 3.2, 2.4, and 1.8% (P < 0.001). Mortality for very low- to very high-volume surgeons was as follows: 4.1, |

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| | | 3.9, 3.1, and 1.4% (P = 0.003). Predictors of mortality in a logistic regression model were emergent admission (odds ratio [OR], 2.97; 95% confidence interval [CI], 2.02-4.38; P < 0.001), and age 65 years or greater (OR, 1.63; 95% CI, 1.16-2.30; P = 0.005). The risk of mortality was reduced for very high-volume hospitals (OR, 0.58; 95% CI, 0.35-0.97; P = 0.038) and very high-volume surgeons (OR, 0.42; 95% CI, 0.22-0.84; P = 0.012).<br>CONCLUSION: Higher-volume providers have superior outcomes after surgical resection of malignant intracranial tumors. This reduction was maintained despite adjustment for case mix. As the regionalization of high-risk surgery moves forward, it is important for neurosurgeons to maintain leadership roles in the development of specialty-specific data collection and health policy initiatives that improve and reduce variation in outcomes. |
| Smith, Butler & Barker (2004).<br>Craniotomy<br>US<br>Craniotomy for resection of pediatric brain tumors in the united states, 1988 to 2000: Effects of provider caseloads and progressive centralization and specialization of care. Neurosurgery, 54(3), 553-63; discussion 563-5. | OBJECTIVE: Large provider caseloads are associated with better patient outcomes after many complex surgical procedures. Mortality rates for pediatric brain tumor surgery in various practice settings have not been described.<br>We used a national hospital discharge database to study the volume-outcome relationship for craniotomy performed for pediatric brain tumor resection, as well as trends toward centralization and specialization. | METHODS: We conducted a cross sectional and longitudinal cohort study using Nationwide Inpatient Sample data for 1988 to 2000 (Agency for Healthcare Research and Quality, Rockville, MD). Multivariate analyses adjusted for age, sex, geographic region, admission type (emergency, urgent, or elective), tumor location, and malignancy.<br><br>RESULTS: We analyzed 4712 admissions (329 hospitals, 480 identified surgeons) for pediatric brain tumor craniotomy. The in-hospital mortality rate was 1.6% and decreased from 2.7% (in 1988-1990) to 1.2% (in 1997-2000) during the study period. On a per-patient basis, median annual caseloads were 11 for hospitals (range, 1-59 cases) and 6 for surgeons (range, 1-32 cases). In multivariate analyses, the mortality rate was significantly lower at high-volume hospitals than at low-volume hospitals (odds ratio, 0.52 for 10-fold larger caseload; 95% confidence interval, 0.28-0.94; P = 0.03). The mortality rate was 2.3% at the lowest-volume-quartile hospitals (4 or fewer admissions annually), compared with 1.4% at the highest-volume-quartile hospitals (more than 20 admissions annually). There was a trend toward lower mortality rates after surgery performed by high-volume surgeons (P = 0.16). Adverse hospital discharge disposition was less likely to be associated with high-volume hospitals (P < 0.001) and high-volume surgeons (P = 0.004). Length of stay and hospital charges were minimally related to hospital caseloads. Approximately 5% of United States hospitals performed pediatric brain tumor craniotomy during this period. The burden of care shifted toward large-caseload hospitals, teaching hospitals, and surgeons whose practices included predominantly pediatric patients, indicating progressive centralization and specialization.<br>CONCLUSION: Mortality and adverse discharge disposition rates for pediatric brain tumor craniotomy were lower when the procedure was performed at high-volume hospitals and by high-volume surgeons in the United States, from 1988 to 2000. There were trends toward lower mortality rates, greater centralization of surgery, and more specialization among surgeons during this period. |
| Barker et al. (2003).<br>Unruptured intracranial aneurysms<br>US | OBJECTIVE: We sought to determine the risk of adverse outcome after contemporary surgical treat- | METHODS: We performed a retrospective cohort study with the Nationwide Inpatient Sample, 1996 to 2000. Multivariate logistic and ordinal regression analyses were performed with endpoints of mortality, |

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| In-hospital mortality and morbidity after surgical treatment of unruptured intracranial aneurysms in the united states, 1996-2000: The effect of hospital and surgeon volume.<br>Neurosurgery, 52(5), 995-1007; discussion 1007-9. | ment of patients with unruptured intracranial aneurysms in the United States.<br>Patient, surgeon, and hospital characteristics were tested as potential outcome predictors, with particular attention to the surgeon's and hospital's volume of care. | discharge other than to home, length of stay, and total hospital charges. RESULTS: We identified 3498 patients who were treated at 463 hospitals, and we identified 585 surgeons in the database. Of all patients, 2.1% died, 3.3% were discharged to skilled-nursing facilities, and 12.8% were discharged to other facilities. The analysis adjusted for age, sex, race, primary payer, four variables measuring acuity of treatment and medical comorbidity, and five variables indicating symptoms and signs. The statistics for median annual number of unruptured aneurysms treated were eight per hospital and three per surgeon.<br>High-volume hospitals had fewer adverse outcomes than hospitals that handled comparatively fewer unruptured aneurysms: discharge other than to home occurred after 15.6% of operations at high-volume hospitals (20 or more cases/yr) compared with 23.8% at low-volume hospitals (fewer than 4 cases/yr) (P = 0.002). High surgeon volume had a similar effect (15.3 versus 20.6%, P = 0.004). Mortality was lower at high-volume hospitals (1.6 versus 2.2%) than at hospitals that handled comparatively fewer unruptured aneurysms, but not significantly so. Patients treated by high-volume surgeons had fewer postoperative neurological complications (P = 0.04). Length of stay was not related to hospital volume. Charges were slightly higher at high-volume hospitals, partly because arteriography was performed more frequently than at hospitals that handled comparatively fewer unruptured aneurysms.<br>CONCLUSION: For patients with unruptured aneurysms who were treated in the United States between 1996 and 2000, surgery performed at high-volume institutions or by high-volume surgeons was associated with significantly lower morbidity and modestly lower mortality. |
| Davies & Lawton (2016)<br>Cerebrovascular malformations<br>US<br>Improved outcomes for patients with cerebrovascular malformations at high-volume centers: The impact of surgeon and hospital volume in the united states, 2000-2009.<br>Journal of Neurosurgery, 1-12. | OBJECTIVE Treatment of cerebrovascular malformations has grown in complexity with the development of multimodal approaches, including microsurgery, endovascular treatments, and radiosurgery. In spite of this changing standard of care, the provision of care continues across a variety of settings.<br>The authors sought to determine the risk of adverse outcome after treatment of patients with vascular malformations in the US. Patient, surgeon, and hospital characteristics, including volume, were tested as potential outcome predictors. | METHODS The authors examined data collected between 2000 and 2009 in the Nationwide Inpatient Sample (NIS) database, assessing safety, quality, and cost-effectiveness. They performed multivariate analyses of trends in microsurgical, radiosurgical, and endovascular treatment by hospital and surgeon volume, using death, routine discharge percentage, length of stay (LOS), complications, and hospital charges as end points. They further computed the value of care, which was defined as the ratio of the functional outcome (routine discharge percentage) to cost of care to the payer (hospital charges).<br>RESULTS The authors identified 8227 patients with vascular malformations who were treated at US hospitals. Hospitals and surgeons were classified by yearly case volume. Compared with low-volume hospitals (2 or fewer cases/year), high-volume hospitals (16 or more cases/year) had shorter LOS (3 vs 2 days, p = 0.005), higher total charges ($37,374 vs $19,986, p = 0.003), more frequent discharge to home (p < 0.001), and lower mortality rates (0.7% vs 1.16%, p = 0.010). High-volume surgeons (7 or more cases/year) likewise had superior outcomes compared with low-volume surgeons (1 or fewer cases/year), with shorter LOS (2 vs 3 days, p = 0.03), more frequent discharge to home (p < 0.001), and lower mortality rates (0.7% vs 1.10%, p = 0.005). Underlying these outcomes, the rates of intervention for surgery, angiography, embolization, and radiosurgery were likewise significantly different in high- versus low-volume practices. Based on these results the authors modeled how outcomes might change if care |

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| | | were consolidated at designated centers of excellence (COEs), and found that on an annual basis, care at high-volume hospital COEs would result in 18.5 fewer deaths, 1252.1 fewer hospital days, 182.7 more discharges home without additional services, 48.5 fewer medical complications, and 117.4 fewer perioperative complications. Surgeon-level rates for high-volume COEs demonstrated an even larger benefit over current standards, with 27.4 fewer deaths, 10,713.7 fewer hospital days, a $51.6-million reduction in charges, 370.9 additional routine discharges, and reduced complications in all categories (27.8 fewer surgical, 198.0 fewer medical, and 32.1 fewer perioperative) compared with care at non-COEs.<br>CONCLUSIONS For patients with vascular malformations who were treated in the US between 2000 and 2009, treatment performed at high-volume centers was associated with significantly lower morbidity and, for high-volume surgeons, with lower mortality rates. These data suggest that treatment by high-volume institutions and surgeons will yield superior outcomes and superior value. The authors therefore advocate the creation of care paradigms that triage patients to high-volume institutions and surgeons, which can serve as cerebrovascular COEs. |
| Williams et al. (2016).<br>Brain tumour surgery<br>England<br>Surgeon volume and 30 day mortality for brain tumours in England.<br>British Journal of Cancer, 115(11), 1379-1382. | There is evidence that surgeons who perform more operations have better outcomes. However, in patients with brain tumours, all of the evidence comes from the USA. | BACKGROUND: There is evidence that surgeons who perform more operations have better outcomes. However, in patients with brain tumours, all of the evidence comes from the USA. METHODS: We examined all English patients with an intracranial neoplasm who had an intracranial resection in 2008-2010. We included surgeons who performed at least six operations over 3 years, and at least one operation in the first and last 6 months of the period.<br>RESULTS: The analysis data set comprised 9194 operations, 163 consultant neurosurgeons and 30 centres. Individual surgeon volumes varied widely (7-272; median=46). 72% of operations were on the brain, and 30 day mortality was 3%. A doubling of surgeon load was associated with a 20% relative reduction in mortality. Thirty day mortality varied between centres (0.95-8.62%) but was not related to centre workload.<br>CONCLUSION: Individual surgeon volumes correlated with patient 30 day mortality. Centres and surgeons in England are busier than surgeons and centres in the USA. There is no relationship between centre volume and 30 day mortality in England. Services in the UK appear to be adequately arranged at a centre level, but would benefit from further surgeon sub-specialisation. |
| Curry, McDermott et al. (2005).<br>Craniotomy for meningioma<br>US<br>Craniotomy for meningioma in the united states between 1988 and 2000: Decreasing rate of mortality and the effect of provider caseload.<br>Journal of Neurosurgery, 102(6), 977-986. | OBJECT: The goal of this study was to determine the risk of adverse outcomes after contemporary surgical treatment of meningiomas in the US and trends in patient outcomes and patterns of care. | METHODS: The authors performed a retrospective cohort study by using the Nationwide Inpatient Sample covering the period of 1988 to 2000. Multivariate regression models with disposition end points of death and hospital discharge were used to test patient, surgeon, and hospital characteristics, including volume of care, as outcome predictors.<br>Multivariate analyses revealed that larger-volume centers had lower mortality rates for patients who underwent craniotomy for meningioma (odds ratio [OR] 0.74, 95% confidence interval [CI] 0.59-0.93, p = 0.01). Adverse discharge disposition was also less likely at high-volume hospitals (OR 0.71, 95% CI 0.62-0.80, p < 0.001). With respect to the surgeon caseload, there was a trend toward a lower rate of mortality after surgery when higher-caseload providers were involved, and a significantly less frequent |

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| | | adverse discharge disposition (OR 0.71, 95% CI 0.62-0.80, p < 0.001). The annual meningioma caseload in the US increased 83% between 1988 and 2000, from 3900 patients/year to 7200 patients/year. In-hospital mortality rates decreased 61%, from 4.5% in 1988 to 1.8% in 2000. Reductions in the mortality rates were largest at high-volume centers (a 72% reduction in the relative mortality rate at largest-volume-quintile centers, compared with a 6% increase in the relative mortality rate at lowest-volume-quintile centers). The number of US hospitals where craniotomies were performed for meningiomas increased slightly. Fewer centers hosted one meningioma resection annually, whereas the largest centers had disproportionate increases in their caseloads, indicating a modest centralization of meningioma surgery in the US during this interval.<br>CONCLUSIONS: The mortality and adverse hospital discharge disposition rates were lower when meningioma surgery was performed by high-volume providers. |
| Smith, Butler, Barker et al. (2004)<br>Pediatric shunt procedures<br>US<br>In-hospital mortality rates after ventriculoperitoneal shunt procedures in the united states, 1998 to 2000: Relation to hospital and surgeon volume of care.<br>Journal of Neurosurgery, 100(2 Suppl Pediatrics), 90-97. | OBJECT: Death after ventriculoperitoneal (VP) shunt surgery is uncommon, and therefore it has been difficult to study.<br>The authors used a population-based national hospital discharge database to examine the relationship between annual hospital and surgeon volume of VP shunt surgery in pediatric patients and in-hospital mortality rates. | METHODS: All children in the Nationwide Inpatient Sample (1998-2000, age 90 days-18 years) who underwent VP shunt placement or shunt revision as the principal procedure were included. Main outcome measures were in-hospital mortality rates, length of stay (LOS), and total hospital charges.<br>Overall, 5955 admissions were analyzed (253 hospitals, 411 surgeons). Mortality rates were lower at high-volume centers and for high-volume surgeons. In terms of hospital volume, the mortality rate was 0.8% at lowest-quartile-volume centers ( 121 admissions/year). In terms of surgeon volume, the mortality rate was 0.8% for lowest-quartile-volume providers ( 65 admissions/year). After multivariate adjustment for demographic variables, emergency admission and presence of infection, hospital volume of care remained a significant predictor of death (odds ratio [OR] for a 10-fold increase in caseload 0.38; 95% confidence interval [CI] 0.18-0.81). Surgeon volume of care was statistically significant in a similar multivariate model (OR for a 10-fold increase in caseload 0.3; 95% CI 0.13-0.69). Length of stay was slightly shorter and total hospital charges were slightly higher at higher-volume centers, but the differences were not statistically significant.<br>CONCLUSIONS: Pediatric shunt procedures performed at high-volume hospitals or by high-volume surgeons were associated with lower in-hospital mortality rates, with no significant difference in LOS or hospital charges. |
| Ward, Gourin & Francis (2012).<br>Vestibular schwannoma surgical volume and short-term outcomes in maryland.<br>*Archives of Otolaryngology - Head and Neck Surgery, 138*(6), 577-583. | Objective: To characterize contemporary practice patterns and outcomes of vestibular schwannoma surgery. | Design: Cross-sectional analysis. Setting: Maryland Health Service Cost Review Commission database. Patients: The study included patients who underwent surgery for vestibular schwannoma between 1990 and 2009. Main Outcome Measures: Temporal trends and relationships between volume and in-hospital deaths, central nervous system (CNS) complications, length of hospitalization, and costs. Results: A total of 1177 surgical procedures were performed by 57 surgeons at 12 hospitals. Most cases were performed by high-volume surgeons (47%) at highvolume hospitals (79%). The number of cases increased from 474 in 1999-2000 to 703 in 2000-2009. Vestibular schwannoma surgery in 2000-2009 was associated with a decrease in CNS complications (odds ratio [OR] 0.4; P<.001) and an increase in cases performed by intermediate-volume (OR, 4.2; P=.002) and high-volume |

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| | | (OR, 3.2; P=.005) hospitals and intermediate-volume (OR, 1.9; P=.004) and high-volume (OR, 1.8; P=.006) surgeons. High-volume care was inversely related to the odds of urgent and emergent surgery (OR, 0.2; P<.001) and readmissions (OR, 0.1; P=.02). Surgeon volume accounted for 59% of the effect of hospital volume for urgent and emergent admissions and 20% for readmissions. After all other variables were controlled for, there was no significant association between hospital or surgeon volume and in-hospital mortality or CNS complications; however, surgery at high-volume hospitals was associated with significantly lower hospital-related costs (P<.001).<br>Conclusions: These data suggest increased centralization of vestibular schwannoma surgery, with an increase in cases performed by intermediate- and high-volume providers and meaningful differences in high-volume surgical care that are mediated by surgeon volume and are associated with reduced hospital-related costs. Further investigation is warranted. |
| Witt et al. 1998<br>Palatoplasty<br>The effect of surgeon experience on velopharyngeal functional outcome following palatoplasty: is there a learning curve?<br>Plastic and reconstructive surgery, October 1998, Vol.102 (5), pp.1375-84. | There is little information in the cleft palate literature concerning the relationship between surgeon volume and clinical outcomes. It is unknown whether such a relationship applies specifically to velopharyngeal dysfunction and the need for secondary physical management of the velopharynx.<br>The purpose of this paper was to explore the concept of an operative learning curve for different surgeons with respect to palatoplasty. | Impact of case volume and procedure type on the occurrence of secondary palatal management (the main outcome measure) was assessed. The charts of 472 consecutive palatoplasty patients were reviewed by one speech and language pathologist to determine when the palatoplasty was performed, which surgeon (n = 9) performed the palatoplasty, whether velopharyngeal status was documented at a minimum of 6 years of age, and whether secondary palatal management was prescribed. The results were analyzed by year of palatoplasty, by surgeon, and by number of operations per surgeon to determine total and individual surgeon rates of secondary palatal management. There were 401 palatoplasties (85 percent recovery) with adequate documentation of velopharyngeal status by at least 6 years of age. Palatoplasty rates ranged between 1 and 258 palatoplasties per surgeon. Over the 12 years reviewed, secondary palatal management was performed for 92 patients (23 percent) of the study population. Examination of the proportion of palatoplasty patients receiving secondary palatal management by surgeon and by year showed only one surgeon with a pattern suggesting a learning curve. The proportion of patients receiving secondary palatal management was plotted against the total number of surgeries the surgeon performed. There was a strong relationship between experience and success. The number of procedures this surgeon performed per year increased at approximately the same time as the success rate improved. The categories of "total procedures" and "procedure per year" were highly correlated with each other. Success rates were analyzed by number of procedures performed per year, and there was a clear association between the two variables. To separate the effect of the two variables, a multiple regression model was constructed. The category of "total procedures" was statistically significant in the model, whereas procedures per year was not, suggesting that the key to the dominant surgeon's improvement was cumulative experience rather than frequency of performance of the operation. Palatoplasties performed by high-volume surgeons are more likely to result in better postoperative outcomes (i.e., lower rates of secondary palatal management) as compared with palatoplasties performed by low-volume surgeons. The influence of the surgeon's cumulative experience on improvement seems to be more important than the frequency of performance of primary palatoplasty. |

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| Ly, Liao & Burd (2005).<br>Pyloromyotomy<br>US<br>Effect of surgeon and hospital characteristics on outcome after pyloromyotomy. Archives of Surgery (Chicago, Ill.: 1960), 140(12), 1191-1197. | BACKGROUND: Previous studies have suggested that the outcome after pyloromyotomy is improved with increased surgeon experience. Others have proposed that infants with pyloric stenosis are best treated by specialty-trained pediatric surgeons or at children's hospitals.<br>HYPOTHESIS: Surgeon and hospital characteristics affect complications, length of stay, and hospital charges after pyloromyotomy. | DESIGN: Data for a nationally representative sample of infants (n = 1277) who underwent pyloromyotomy in 2000 in the United States were obtained from the Kids' Inpatient Database. Surgeon and hospital volumes were stratified into quintiles. Multivariate analyses were performed to analyze the impact of surgeon and hospital volume on length of stay, charges, and major operative complications using models that accounted for the hierarchical structure of patient-, surgeon-, and hospital-level covariates.<br>RESULTS: No association between surgeon volume and either length of stay or charges was observed. Higher surgeon volume, however, was associated with fewer complications (P<.001). Surgeons with the highest volume had a 90% lower risk of complications than those with the lowest volume. Higher hospital volume was associated with shorter length of stay (P<.001). No association between hospital volume and either charges or risk of complications was observed.<br>CONCLUSIONS: Higher surgeon and hospital volumes are associated with better outcome among infants who are treated for pyloric stenosis. Identification of aspects of medical and surgical treatment that account for this finding may lead to improvement in the outcome of infants undergoing pyloromyotomy. |
| Hyder, Dodson, et al. (2013)<br>Pancreatoduodenectomy<br>US<br>Influence of patient, physician, and hospital factors on 30-day readmission following pancreatoduodenectomy in the united states.<br>JAMA Surgery, 148(12), 1095-1102. | IMPORTANCE It is not known whether hospital and surgeon volumes have an association with readmission among patients undergoing pancreatoduodenectomy.<br>OBJECTIVE: To evaluate patient-, surgeon-, and hospital-level factors associated with readmission. | DESIGN, SETTING, AND PARTICIPANTS: Retrospective cohort study using the Surveillance, Epidemiology, and End Results (SEER)-Medicare data with cases diagnosed from January 1, 1998, to December 31, 2005, and followed up until December 2007. Population-based cancer registry data were linked to Medicare data for the corresponding patients. A total of 1488 unique individuals who underwent a pancreatoduodenectomy were identified. INTERVENTIONS: Undergoing pancreatoduodenectomy at hospitals classified by volume of pancreatoduodenectomy procedures performed at the facility were either very-low, low, medium, or high volume. Undergoing pancreatoduodenectomy by surgeons classified by volume of pancreatoduodenectomy procedures performed by the surgeon were either very-low, low, medium, or high volume. MAIN OUTCOMES AND MEASURES: In-hospital morbidity, mortality, and 30-day readmission were examined.<br>RESULTS: The median age was 74 years, and 1436 patients (96.5%) had a least 1 medical comorbidity. Patients were treated by 575 distinct surgeons at 298 distinct hospitals. Length of stay was longest (median, 17 days) and 90-day mortality highest (17.2%) at very-low-volume hospitals (P < .001). Among all pancreatoduodenectomy patients, 292 (21.3%) were readmitted within 30 days of discharge. There was no effect of surgeon volume and a modest effect of hospital volume (odds ratio for highest- vs lowest-volume quartiles, 1.85; 95% CI, 1.22-2.80; P = .02). The presence of significant preoperative medical comorbidities was associated with an increased risk for hospital readmission after pancreatoduodenectomy. A comorbidity score greater than 13 had a pronounced effect on the chance of readmission following pancreatoduodenectomy (odds ratio, 2.06; 95% CI, 1.56-2.71; P < .001). The source of variation in readmission was primarily attributable to patient-related factors (95.4%), while hospital factors accounted for 4.3% of the variability and physician factors for only 0.3%. |

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| | | CONCLUSIONS AND RELEVANCE: Nearly 1 in 5 patients are readmitted following pancreatoduodenectomy. While variation in readmission is, in part, attributable to differences among hospitals, the largest share of variation was found at the patient level. |
| Clark, et al. (2010).<br>Pancreaticoduodectomy<br>US<br>Surgery residency training programmes have greater impact on outcomes after pancreaticoduodenectomy than hospital volume or surgeon frequency.<br>HPB: The Official Journal of the International Hepato Pancreato Biliary Association, 12(1), 68-72. | BACKGROUND: Hospital volume of pancreaticoduodenectomy (PD) and surgeon frequency of PD have been shown to impact outcomes. The impact of surgery residency training programmes after PD is unknown.<br>This study was undertaken to determine the impact of surgery training programmes on outcomes after PD, as well as their importance relative to hospital volume and surgeon frequency of PD. | METHODS: The State of Florida Agency for Healthcare Administration Database was queried for patients undergoing PD during 2002-2007. Measures of outcome were compared for patients undergoing PD at centres with vs. without surgery residency training programmes.<br>RESULTS: A total of 2345 PDs were identified, of which 1478 (63%) were undertaken at training centres and 867 (37%) were performed at non-training centres. Patients undergoing PD at training centres had shorter lengths of stay, lower hospital charges and lower in-hospital mortality. Relative to surgeon frequency of PD, training centres had a greater favourable impact on hospital length of stay, hospital charges and in-hospital mortality ($P < 0.001$ for each, ancova). Relative to hospital volume of PDs undertaken, training centres had a greater impact on hospital charges ($P < 0.001$, ancova).<br>CONCLUSIONS: Surgery residency training programmes have a favourable effect on outcomes following PD and their impact on outcome is greater than the impact of hospital volume or surgeon frequency of PD. |
| Cox, Miller, Edge & Kuvshinoff (2010)<br>Pancreatic resection<br>US<br>Regionalization of pancreatic resection for malignancy in NY state and the effect of hospital volume on perioperative mortality. Annals of Surgical Oncology, 17, S80 | INTRODUCTION: The relationship between hospital case volume and perioperative mortality in pancreas resection is well documented. A statewide data from New York (1984-1991)showed that high volume hospitals had substantially lower operative mortality (5.5%) compared to low volume (18.9%)and that only 19% of patients had pancreatic cancer surgery at high volume hospitals.<br>The current study uses the same Statewide Planning and Research Cooperative System (SPARCS) hospital data to determine the change in regionalization of pancreatectomy for cancer is occurring in New York State and the impact on perioperative mortality. | METHODS: Hospital discharge abstracts were obtained from the SPARCS for all patients who underwent pancreaticoduodenectomy or total pancreatectomy for malignancy in New York between 2002 and 2007. Logistic regression analysis was used to determine the relationship between hospital and surgeon volume to perioperative mortality and length of hospital stay (LOS).<br>RESULTS: A total of 3051 procedures were performed at 121 hospitals by 392 surgeons. Overall perioperative mortality was 143(4.7%), which was lower than 15 years earlier (12.9%). Most cases (58.6%) were done at high volume centers and 47.3% of procedures performed by high volume surgeons. Mortality and LOS at high volume centers was 2.9% and 14.7 days, respectively, compared to 12.2% and 25.4 days for minimal volume centers. Mortality and LOS for high volume surgeons was 2.6% and 14.6 days compared to moderate (4.0%, 17.6) and low (9.9%, 24.1) volume surgeons. Compared to hospitals and surgeons with high caseloads, the odds of death are 3.8 times higher in a minimal volume hospital ($p<0.001$) and 3.6 times higher for low volume surgeons ($p<0.001$).<br>CONCLUSION: An increased proportion of pancreatic resections for malignancy in New York now occurs in high volume centers and by high volume surgeons. This has occured in the absence of imposed regulatory or legislative authority. The result is decreased mortality and LOS when compared to minimal volume centers and low volume surgeons. |
| Schmidt, Turrin, Parikh et al. (2010).<br>Pancreaticoduodenectomy<br>US<br>Effect of hospital volume, surgeon experience, and surgeon volume | OBJECTIVE: To determine the importance of hospital volume, surgeon experience, and surgeon volume in performing pancreaticoduodenectomy (PD). | DESIGN, SETTING, AND PATIENTS: From 1980 through 2007, 1003 patients underwent PD by 19 surgeons at a university hospital. MAIN OUTCOME MEASURES: Patient morbidity and mortality, quality of resection, and learning curve were examined according to hospital volume (period 1: 1980-2003 vs |

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| on patient outcomes after pancreaticoduodenectomy: A single-institution experience. Archives of Surgery (Chicago, Ill.: 1960), 145(7), 634-640. | | period 2: 2004-2007), surgeon experience (total number of PDs), and surgeon volume (number of PDs per year).<br>RESULTS: Perioperative morbidity and mortality for all 1003 PDs were 41% and 3%, respectively. Differences existed between period 1 and period 2 in percentage of PDs performed in elderly patients (7% vs 17%), mortality (4% vs 2%), estimated blood loss (1817 mL vs 780 mL), length of stay (18 days vs 12 days), and proportion of International Study Group on Pancreatic Fistula grade C pancreatic fistulae (29% vs 12%). Surgeons with less experience (or = 50 PDs). Experienced surgeons had comparable outcomes irrespective of annual volume. Mortality, margins, and number of lymph nodes resected were not affected by surgeon experience or surgeon volume. Learning curves projected that less experienced surgeons would achieve morbidity and mortality rates equivalent to those of experienced surgeons when they reached 20 and 60 PDs, respectively.<br>CONCLUSIONS: Improvement in PD outcomes, including mortality, occurred with increased PD volume at a pancreatic center. Surgeon experience remained an important determinant of overall morbidity. Experienced surgeons, however, had comparable outcomes irrespective of annual volume. |
| Wellner et al. (2011).<br>Pancreatic surgery<br>US<br>Detailed analysis of learning curve in pancreatic surgery - surgeon and hospital volume are equally important.<br>*Gastroenterology. 140*(5 SUPPL. 1), S1039. | The aim of this study was to evaluate the learning curve effect for pancreatic surgery, which can only be studied at a high-volume center. | Methods: Over period of ten years, outcome of pancreatic operations performed by two "senior" pancreatic surgeons (SPS) and one specializing "junior" pancreatic surgeon (JPS) were evaluated relative to increasing experience. Three equally sized blocks of consecutive operations were analyzed for JPS versus SPS. Statistical testing was done with SPSS Ver 17.0 at a significance level of p=0.05.<br>Results: From 2001 to 2010, n=583 pancreatic operations were performed at our institution. Of these, n=245 were performed by two SPS, n=212 by the JPS and n=126 by other surgeons. For the JPS, significant postoperative morbidity rate decreased significantly (from 25% to 9%, p=0.022) with increasing case load to reach a level at the average SPS level (15%) after around 70 pancreatic operations. This was due to a decreasing rate of reoperations (from 21% to 12%, p=n.s.), postoperative bleeding (from 16% to 0% p=0.001) as well as mortality (from 4% to 0%, p=n.s.). Decreasing complication rates were accompanied by a rise in technically demanding procedures and oncologic radicality, as demonstrated by an increasing rate of portal venous resections (from 14% to 23%, p=n.s.) and laparoscopic or laparoscopically assisted procedures (from 0% to 20%, p<0.001).<br>Conclusion: With increasing experience, the pancreatic surgeon can minimize his complication rate while simultaneously increasing technically demanding procedures. The learning curve in this field of surgery requires a relatively high case load even for the setting of a high-volume center and reflects the importance of individual surgeon volume. This constitutes a strong argument for centralization of pancreatic surgery. |
| Rosemurgy et al. (2001)<br>Pancreaticoduodenectomy<br>US<br>Frequency with which surgeons undertake pancreaticoduodenectomy determines length of stay, | Others have suggested that in certain technically challenging operations, outcome and experience are related. Because pancreaticoduodenectomy is a technically complex proce- | The database of the State of Florida Agency for Health Care Administration was queried for pancreaticoduodenectomies undertaken during a recent 33-month period. Length of stay, hospital charges, and in-hospital mortality were stratified by the frequency of pancreaticoduodenectomy. A total of 282 surgeons performed 698 pancreaticoduodenectomies over 33 months. Eighty-nine percent of surgeons performed |

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| hospital charges, and in-hospital mortality.<br>Journal of Gastrointestinal Surgery: Official Journal of the Society for Surgery of the Alimentary Tract, 5(1), 21-26. | dure, this study was undertaken to evaluate mortality, length of hospital stay, and hospital charges when compared to volume of experience. | one pancreaticoduodenectomy per year or less and accounted for 52% of the procedures. Overall mortality rate was 5.1%. Average hospital charges were dollar 72,171.64.<br>The more frequently pancreaticoduodenectomy was undertaken, the shorter the hospital stay (P = 0.025, regression analysis) and the lower the hospital charges (P = 0.008, regression analysis) and in-hospital mortality (P = 0.036, log likelihood ratio test). Surgeons who undertake pancreaticoduodenectomy more frequently have patients with shorter hospital stays, lower hospital charges, and lower in-hospital mortality rates, independent of hospital volume. Variations exist among surgeons and among different areas of the state. |
| Schneider, Hyder et al. (2013).<br>Pancreaticoduodenectomy<br>US<br>Provider versus patient factors impacting hospital length of stay after pancreaticoduodenectomy.<br>Surgery, 154(2), 152-161. | BACKGROUND: Studies reporting perioperative outcomes after pancreaticoduodenectomy (PD) have focused on morbidity and mortality.<br>Understanding factors that impact hospital duration of stay may have cost-saving implications. We sought to examine variation in duration of stay after PD occurring at the patient, surgeon, and hospital levels. | METHODS: Year-specific PD volumes for both surgeons and hospitals were determined from the 2003-2009 Nationwide Inpatient Sample and grouped into terciles. Patient age, gender, and comorbidities were examined. Median duration of stay was calculated and modified Poisson regression examined factors associated with duration of stay.<br>RESULTS: Among 5,190 individuals undergoing PD, median age was 65 years and 49.3% were female. Median duration of stay was 13 days (range, 0-234). Older patients and those with comorbid illness were more likely to have duration of stay of >/= 14 days (P /= 14 days (both P < .001).<br>CONCLUSION: PD patients treated by higher volume surgeons and at higher volume hospitals had a shorter duration of stay. Although some patient-level factors impact duration of stay after PD, nonclinical factors such as surgeon and hospital volume were also important contributors to duration of stay. |
| Shi, Wang & Lee (2014).<br>Pancreaticoduodenectomy with periampullary cancers<br>Temporal trends and volume-outcome associations in periampullary cancer patients: A propensity score-adjusted nationwide population-based study.<br>American Journal of Surgery, 207(4), 512-519. | BACKGROUND: The purpose of this study was to evaluate temporal trends in the incidence of pancreaticoduodenectomy (PD) with periampullary cancers and the impact of hospital volume and surgeon volume on patient outcomes and to explore predictors of these outcomes. | METHODS: This population-based cohort study retrospectively analyzed 4,039 PD procedures performed from 1998 to 2009. The odds ratio and 95% confidence interval were calculated to assess the relative change rate. Hierarchical regression models were used to predict these outcomes.<br>RESULTS: The incidence of PDs per 10(5) persons increased from .97 to 1.89, whereas the length of stay and hospital treatment cost declined. Current treatment in a low-volume hospital and current treatment by a low-volume surgeon showed significant positive associations with these outcomes (P < .001).<br>CONCLUSIONS: The data indicate that analysis and emulation of the treatment strategies used by high-volume hospitals and high-volume surgeons may reduce overall hospital resource use. Because high-volume hospitals and surgeons consistently achieve superior outcomes of PD, their treatment strategies should be carefully analyzed and emulated. |
| Shaw, Santry & Shah (2013)<br>Hepatectomy<br>Specialization and utilization after hepatectomy in academic medical centers.<br>Journal of Surgical Research,185(1), pp.433-440 | Background: Specialized procedures such as hepatectomy are performed by a variety of specialties in surgery. We aimed to determine whether variation exists among utilization of resources, cost, and patient outcomes by specialty, surgeon case volume, and center case volume for hepatectomy. | Methods: We queried centers (n = 50) in the University Health Consortium database from 2007–2010 for patients who underwent elective hepatectomy in which specialty was designated general surgeon (n = 2685; 30%) or specialist surgeon (n = 6277; 70%), surgeon volume was designated high volume (>38 cases annually) and center volume was designated high volume (>100 cases annually). We then stratified our cohort by primary diagnosis, defined as primary tumor (n = 2241; 25%), secondary tumor (n = 5466; 61%), and benign (n = 1255; 14%).<br>Results: Specialist surgeons performed more cases for primary malignancy (primary 26% versus 15%) |

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| | | while general surgeons operated more for secondary malignancies (67% versus 61%) and benign disease (18% versus 13%). Specialists were associated with a shorter total length of stay (LOS) (5 d versus 6 d; P < 0.01) and lower in-hospital morbidity (7% versus 11%; P < 0.01). Patients treated by high volume surgeons or at high volume centers were less likely to die than those treated by low volume surgeons or at low volume centers, (OR 0.55; 95% CI 0.33–0.89) and (OR 0.44; 95% CI 0.13–0.56).<br>Conclusions: Surgical specialization, surgeon volume and center volume may be important metrics for quality and utilization in complex procedures like hepatectomy. Further studies are necessary to link direct factors related to hospital performance in the changing healthcare environment. |
| Scarborough, Pietrobon et al. (2008).<br>Orthotopic liver transplantation<br>Relationship between provider volume and outcomes for orthotopic liver transplantation. *Journal of Gastrointestinal Surgery: Official Journal of the Society for Surgery of the Alimentary Tract, 12*(9), 1527-1533. | INTRODUCTION: Recent data suggests that the previously demonstrable relationship between hospital volume and outcomes for liver transplant procedures may no longer exist.<br>Furthermore, to our knowledge, no study has been published examining whether individual surgeon volume is associated with outcomes in liver transplantation. | MATERIALS AND METHODS: The Nationwide Inpatient Sample database was used to obtain early clinical outcome and resource utilization data for liver transplant procedures performed in the USA from 1988 through 2003. The relationship between surgeon and hospital volume and early clinical outcomes was analyzed with and without adjustment for certain confounding variables such as patient age and presence of co-morbid disease.<br>RESULTS: The in-hospital mortality rate, major postoperative complication rate, and length of hospital stay after liver transplantation did not differ significantly based on hospital procedural volume. These outcome variables did, however, exhibit a statistically significant inverse relationship with individual surgeon volume of liver transplant procedures. A significant relationship between procedure volume and outcomes for liver transplantation cannot be demonstrated at the level of transplant center, but does appear to exist at the level of the individual transplant center.<br>CONCLUSION: Minimal volume requirements for individual liver transplant surgeons may be justified, pending validation of this volume-outcomes relationship using a clinical data source. |
| Porembka, Rubin, Gonen (2014).<br>Liver surgery<br>US<br>Impact of volume on outcomes in liver surgery: Hospital volume may outweigh surgeon volume. *Annals of Surgical Oncology. Conference: 67th Annual Cancer Symposium of the Society of Surgical Oncology.Phoenix, AZ United States. Conference Publication: (Var.Pagings), 21*(1 SUPPL. 1), S99. | Background: Favorable outcomes have been associated with institutions and surgeons that perform a high-volume of complex surgical procedures. However, there are limited data describing the impact of institutional volume on liver surgery outcomes performed by high-and low-volume surgeons.<br>We used a statewide database to investigate the association between surgeon caseload, hospital volume, and outcome. | Methods: Patients undergoing elective liver resection for malignancy between 1994 and 2000 were identified from the New York State Statewide Planning and Research Cooperative System (SPARCS) database. The SPARCS data system collects patient level data on patient characteristics, diagnoses, treatments, and charges for every hospital discharge in NewYork State. Centers with 3 or more liver surgeons were selected for analysis. Surgeons and institutions were considered high-volume if they performed greater than 15 and 30 cases per year, respectively. Outcomes including 30-day mortality were compared between high-and low-volume surgeons and institutions. Multivariate analysis was conducted to identify factors associated with improved outcome.<br>Results: 2549 elective liver resections were performed at 35 institutions by 50 individual surgeons. A trend toward improved outcome was observed with high-volume centers (HVC, n=2) compared to low-volume centers (LVC, n=33) (mortality: 3.6% vs. 4.5%). Outcomes by high-volume surgeons (HVS, n=9) and low-volume surgeons (LVS, n=41) were comparable (mortality: 4.0% vs. 4.0%). LVS operating atHVChad a significantly lower mortality than HVS operating at LVC (3.4% vs. 5.3%; p0.05). |

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| | | Conclusion: In this study, hospital volume was a significant predictor of mortality in hepatectomy performed for cancer while individual surgeon volume was not. Consideration should be given to referral patterns that favor performance of hepatic surgery in HVC over HVS in LVC. |
| Rutegard & Lagergren (2008).<br>Esophageal cancer<br>Sweden<br>No influence of surgical volume on patients' health-related quality of life after esophageal cancer resection.<br>*Annals of Surgical Oncology, 15*(9), 2380-2387. | BACKGROUND: Studies on factors that can counteract the negative impact of esophagectomy on patients' health-related quality of life (HRQL) have been sparse.<br>This study was undertaken to examine the question whether hospital or surgeon volume influences HRQL as evaluated 6 months after such surgery. | MATERIALS AND METHODS: A Swedish prospective, population-based cohort study of esophageal cancer patients treated surgically in 2001-2005 was conducted. All patients completed validated HRQL questionnaires, developed by EORTC, addressing general HRQL (QLQ-C30) and esophageal-specific symptoms (QLQ-OES18), 6 months postoperatively. Mean scores with 95% confidence intervals were calculated. Clinically relevant mean score differences (>/=10) between groups were further analyzed in a linear regression model, adjusted for several potential confounders.<br>RESULTS: Some 355 patients were included (80% of eligible). No clinically relevant differences were found between low-volume (0-9 operations/year) and high-volume hospitals (>9 operations/year) or between low-volume (0-6 operations/year) and high-volume surgeons (>6 operations/year). Stratified analyses for tumor location did not reveal any differences between hospital or surgeon volume groups. Moreover, no material differences were found between the four individual high-volume hospitals.<br>CONCLUSION: This study revealed no HRQL advantages of being treated at high-volume hospitals or by high-volume surgeons, as measured 6 months after esophageal cancer resection. |
| Decker & Koerkamp (2012)<br>Esophagectomy<br>US<br>Esophagectomy for cancer: Surgeon case volume may be more important than hospital volume for good quality of outcome.<br>Diseases of the Esophagus, 25, 115A. | Esophagectomy for cancer is considered to be one of the operations with the strongest volume outcome-relationships. Numerous studies have shown that so-called "high-volume" hospitals achieve lower mortality and morbidity rates and also better oncological outcome than "low-volume" hospitals.<br>However, definitions and ideal volume cut-offs remain controversial and the real determinants of good quality of care in esophageal cancer surgery remain to be clearly defined. These determinants are important to be found since in some areas, "centralization" may not be a realistic option. | Methods: We retrospectively analyzed the outcome of 63 cancer esophagectomies performed by a single surgeon between 2002 and 2011 in 2 subsequent "low-volume" community hospitals (34 resections over 7 years and 29 resections over 5 years). In fact, the 2 hospitals were "low-volume" but the surgeon was a "high-volume" surgeon as he had also performed more than 190 cancer esophagectomies in another University hospital during the same time period.<br>Results: Sixty-three patients of median age 65 years (36 to 83) underwent subtotal esophagectomy with partial gastrectomy and radical lymph node dissection (2 field in 56 patients, 3-field in 7 patients). Induction chemo- or chemoradiation was administered in 14% of patients. Tumor histology was adenocarcinoma in 71% and squamous cell cancer in 27%. All but 1 patient had a trans-thoracic resection, the majority by left thoraco-abdominal and cervical approach. All but 5 patients (92%) had their anastomosis in the neck. Ninety-day mortality was 1.6% due to respiratory failure in one patient. Prospective complication assessment found deviations from the ideal protocol in 67% of patients and reoperations in 11% of patients. Complete resections (R0) were obtained in 92% of patients. A median of 37 lymph nodes (8 to 69) were examined and 68% of patients had at least one lymph node involved (median 2). After 30 months of follow-up, the overall median survival was 29 months and KM 5-year survival probability was 46% despite the fact that 65% of all patients were in pTNM stages 3 or 4. Estimated 5-year survival for N+ patients was 37% versus 61% in N0 patients (p = 0.03).<br>Discussion: The individual surgeon's experience may be a much more important determinant of outcome than "hospital volumes". To the contrary of general |

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| | | believe, "lowvolume" hospitals with adequate organization and equipment can achieve surgical and oncological outcome similar to large tertiary reference centers. |
| Derogar et al. (2013)<br>Esophageal cancer surgery<br>Sweden<br>Hospital and surgeon volume in relation to survival after esophageal cancer surgery in a population-based study.<br>Journal of Clinical Oncology: Official Journal of the American Society of Clinical Oncology, 31(5), 551-557. | The influence of hospital and surgeon volume on survival after esophageal cancer surgery deserves clarification, particularly the prognosis after the early postoperative period.<br>The interaction between hospital and surgeon volume, and the influence of known prognostic factors need to be taken into account. | A nationwide Swedish population-based cohort study of 1,335 patients with esophageal cancer who underwent esophageal resection in 1987 to 2005, with follow-up for survival until February 2011, was conducted. The associations between annual hospital volume, annual surgeon volume, and cumulative surgeon volume and risk of mortality were calculated with multivariable parametric survival analysis, providing hazard ratios (HRs) with 95% CIs. HRs were mutually adjusted for the surgery volume variables and further adjusted for the prognostic factors age, sex, comorbidity, calendar period, tumor stage, tumor histology, and neoadjuvant therapy.<br>RESULTS: There was no independent association between annual hospital volume and overall survival, and hospital volume was not associated with short-term mortality after adjustment for hospital clustering effects. A combination of higher annual and cumulative surgeon volume reduced the mortality occurring at least 3 months after surgery (P trend < .01); the HR was 0.78 (95% CI, 0.65 to 0.92) comparing surgeons with both annual and cumulative volume above the median with those below the median. These results remained when hospital and surgeon clustering were taken into account.<br>CONCLUSION: Because surgeon volume rather than hospital volume independently influences the prognosis after esophageal cancer surgery, centralization of this surgery to fewer surgeons seems warranted. |
| Gopaldas, Bhamidipati, Dao & Markley (2013)<br>Esophageal resections<br>US<br>Impact of surgeon demographics and technique on outcomes after esophageal resections: A nationwide study. The Annals of Thoracic Surgery, 95(3), 1064-1069. | BACKGROUND: Thoracic, cardiac, and general surgeons perform esophageal resections in the United States.<br>This article examines the impact of surgeon subspecialty on outcomes after esophagectomy. | METHODS: Esophagectomies performed between 1998 and 2008 were identified in the Nationwide Inpatient Sample. Surgeons were classified as thoracic, cardiac, or general surgeons if greater than 65% of their operative case mix was representative of their specialty. Surgeons with less than 65% of a specialty-specific case mix served as controls. Regression equations calculated the independent effect of surgeon specialty, surgeon volume, and operative approach (transhiatal versus transthoracic) on outcomes.<br>RESULTS: Of the 40,589 patients who underwent esophagectomies, surgeon identifiers were available for 23,529 patients. Based on case mix, thoracic, cardiac, and general surgeons performed 3,027 (12.9%), 688 (2.9%), and 4,086 (17.4%) esophagectomies, respectively. Operative technique did not independently affect risk-adjusted outcomes-mortality, morbidity, and failure to rescue (defined as death after a complication). Surgeon volume independently lowered mortality and failure to rescue by 4% (p 12 procedures/year) independently lowered mortality (adjusted odds ratio [AOR], 0.67, 95% confidence interval [CI], 0.46-0.96), and failure to rescue (AOR, 0.64; 95% CI, 0.44-0.94). Esophageal resections performed by general surgeons were associated with higher mortality (AOR, 1.87; 95% CI 1.02-3.45) and failure to rescue (AOR, 1.95; 95% CI, 1.06-3.61) but not complications (AOR, 0.97; 95% CI, 0.64-1.49).<br>CONCLUSIONS: General surgeons perform the major proportion of esophagectomies in the United States. Surgeon subspecialty is not associated with the risk of complications developing but instead is associated with mortality and failure to rescue from complications. Surgeon subspecialty case mix is an |

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| | | important determinant of outcomes for patients undergoing esophagectomy. |
| Rodgers, Jobe et al. (2007).<br>Esophagectomy<br>US<br>Case volume as a predictor of inpatient mortality after esophagectomy. Archives of Surgery (Chicago, Ill.: 1960), 142(9), 829-839. | HYPOTHESIS: Volume criteria are poor predictors of inpatient mortality after esophagectomy. Because many factors influence mortality for complex procedures, this study was designed to quantify such factors and analyze the volume-outcome relationship for esophagectomy. | DESIGN: Retrospective review of the Nationwide Inpatient Sample database for esophagectomies. We performed multivariate analysis to identify patient and institution risk factors for death and, by using all reported volume thresholds, calculated the probability of choosing a provider with a low mortality. PATIENTS AND SETTING: Patients undergoing esophagectomy between January 1, 1988, and December 31, 2000, included in the Nationwide Inpatient Sample database. MAIN OUTCOME MEASURE: Inpatient mortality.<br>RESULTS: We identified 8075 cases of esophagectomy; 3243 had complete data sets. The national average mortality rate was 11.4%. Independent risk factors for mortality included comorbidity, age (> 65 years), female sex, race, and surgeon volume. Choosing a surgeon or hospital on the basis of a particular volume threshold had a modest influence on the probability of that provider having a low mortality. A low-volume hospital (defined by the Leapfrog Group criterion as < 13 cases per year) had a probability of 61% of having a mortality of less than 10%, whereas a high-volume hospital had a probability of 68%.<br>CONCLUSIONS: Patient factors have a greater influence on inpatient mortality than case volume does. Although there is generally an inverse relationship between case volume and mortality, there is wide scatter between individual surgeons and hospitals, with a complex volume-outcome relationship. Using volume criteria alone to choose a provider may in some instances increase the risk of mortality. |
| Jeganathan et al. (2009)<br>Oesophagectomy for cancer<br>A surgeon's case volume of oesophagectomy for cancer does not influence patient outcome in a high volume hospital.<br>*Interactive Cardiovascular and Thoracic Surgery, 9*(1), 66-69. | The aim of this study is to assess if individual case volume of oesophageal resections influences the operative mortality rate in a high volume hospital. | Between June 1994 and June 2006, 252 total thoracic oesophageal resections (75% male, mean age 63 years) were performed by five surgeons in tertiary referral centre. Operative approach was standardised in all cases and consisted of left thoracolaparotomy, resection of all intrathoracic and abdominal oesophagus and left cervical incision for anastomosis. Operative mortality, defined as in-hospital death irrespective of length of stay, was compared among consultants and also trainees.<br>A total of 207 operations were performed by five consultants with nine deaths (4.3%) compared to two deaths after 45 operations by 17 trainees (4.4%) [Fisher's exact test, P=0.61 (CI=0.84-1.26)]. Individual case volume for consultants ranged from 5 to 10.5 cases/years [chi2-test, P=0.34 (CI=0.89-1.29)] with 0-5.4% mortality rate [chi2-test, P=0.24 (CI=0.96-1.19)]. Overall hospital volume ranged from 17 to 57 cases/years. This study confirms that surgeons with appropriate training in oesophageal resection may get good results despite lower individual case volumes when a standardised approach is taken in an institution with a high case volume. |
| Bachmann, Alderson et al. (2002)<br>Oesophageal and gastric cancers.<br>UK<br>Cohort study in south and west england of the influence of specialization on the management and outcome of patients with oesophageal and gastric cancers. | BACKGROUND: To evaluate specialization in National Health Service (NHS) cancer care, volume-outcome relationships were examined. | METHODS: This was a cohort study of 1512 patients with oesophageal or gastric cancer in 23 acute NHS hospitals. Outcomes were survival time and operative (30 day) mortality. Multiple regression analysis was performed, adjusted for diagnoses, prognoses and treatments.<br>RESULTS: For oesophageal cancer, the operative mortality rate decreased by 40 per cent (odds ratio 0.60 (95 per cent confidence interval (c.i.) 0.36 to 0.99 per cent); P = 0.047) for each increase of ten |

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| The British Journal of Surgery, 89(7), 914-922. | | patients in doctors' annual surgical caseloads, and the risk of death decreased by 8 per cent (hazard ratio 0.92 (95 per cent c.i. 0.85 to 0.99); P = 0.021) for each increase of ten patients in doctors' annual caseloads. For gastric cancer, the operative mortality rate decreased by 41 per cent (odds ratio 0.59 (95 per cent c.i. 0.32 to 1.07)) for each increase of ten patients in doctors' annual surgical caseloads, and the risk of death decreased by 7 per cent (hazard ratio 0.93 (95 per cent c.i. 0.89 to 0.98); P = 0.009) for each increase of ten patients in hospitals' annual caseloads. Patients of higher-volume doctors were more likely to receive most investigations and treatments, independently of presenting features.<br>CONCLUSION: The study supports concentration of services for oesophageal and gastric cancers. Specialization of doctors and their teams is at least as important as specialization of hospitals. |
| Munksgaard et al. (2007).<br>Gastric surgery<br>Denmark<br>Centralization on fewer surgeons--an example from gastric surgery. [Centralisering pa den enkelte kirurg--et eksempel fra ventrikelkirurgi] Ugeskrift for Laeger, 169(21), 2009-2012. | INTRODUCTION: Previous studies have shown an association between surgical volume and a decreased mortality rate for departments as a whole as well as for individual surgeons.<br>The background for this study was to investigate whether it would be beneficial to centralize gastric surgery, not only in fewer departments but also in fewer hands in the department. | MATERIALS AND METHODS: The study was based on the patient records of the 93 patients operated between 1 January 2000 and 1 September 2005. The surgeons were divided into two groups based on whether they had performed more than 15 or less than 5 operations during the period.<br>RESULTS: Of the 93 operations, 3 surgeons performed 80 and 7 surgeons performed the remaining 13 operations. The mortality was significantly increased in patients operated by surgeons with a low operation volume, p = 0.0004. The 12 acute operations were performed as often by a surgeon with low operation volume as by a surgeon with high operation volume. Again, mortality increased when the operation was performed by a surgeon with low operation volume, p = 0.015.<br>CONCLUSION: The results argue for a centralization of gastric resections on a few surgeons and for an organisation of acute surgery so that these procedures are performed by only a few experienced surgeons. |
| Liu, Chou, Teng, et al. (2015)<br>Colorectal cancer<br>US<br>Association of surgeon volume and hospital volume with the outcome of patients receiving definitive surgery for colorectal cancer: A nationwide population-based study.<br>Cancer, 121(16), 2782-2790. | BACKGROUND: Patients with colorectal cancer (CRC) who undergo cancer surgeries with higher-volume providers may have better outcomes. The current debate focuses on whether it is hospital volume or surgeon volume that matters more. | METHODS: The authors conducted a nationwide population-based study in Taiwan that enrolled all patients who underwent definitive surgery for newly diagnosed CRC between 2005 and 2011. All patients were divided into 4 quartiles according to hospital and surgeon volume. The main outcome was the 5-year mortality rate, which was analyzed using a frailty model for Cox regression. The authors also conducted fixed and random effects multivariate regression models to examine short-term outcomes and resource use, including operative mortality, hospital stay, emergency department visits within 30 days, and medical expenses. Analyses were adjusted for patient and provider characteristics.<br>RESULTS: A total of 61,728 patients with CRC were included in the current study. The 5-year mortality rates were 38.7%, 32.8%, 32.0%, and 29.1% in descending order of hospital volume quartiles and were 41.4%, 34.1%, 29.8%, and 27.4% in descending order of surgeon volume quartiles. After adjustment for the individual and provider characteristics, surgeon volume, but not hospital volume, remained a significantly predictive factor of death (P<.001). In addition, those patients with CRC who underwent definitive surgeries performed by higher-volume surgeons had a relatively lower risk of operative mortality, shorter hospital length of stay, and lower medical expenses.<br>CONCLUSIONS: Patients with CRC who underwent definitive surgery performed by higher-volume providers were found to have better outcomes. Surgeon |

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| | | volume may play a more important role than hospital volume. |
| Schrag, Panageas et al. (2002)<br>Rectal cancer resection<br>US<br>Hospital and surgeon procedure volume as predictors of outcome following rectal cancer resection.<br>Annals of Surgery, 236(5), 583-592. | OBJECTIVE: To compare surgeon and hospital procedure volume as predictors of outcomes for patients with rectal cancer.<br>SUMMARY BACKGROUND DATA: Although a "volume-outcome" relationship exists for several major cancer operations, the impact of procedure volume on outcomes following rectal cancer surgery remains uncertain, and it has not been determined whether hospital or surgeon volume is a more important predictor of outcomes. | METHODS: A retrospective population-based cohort study utilizing the Surveillance, Epidemiology and End Results (SEER)-Medicare linked database identified 2,815 rectal cancer patients aged 65 and older who had surgery for a primary tumor diagnosed in 1992-1996 in a SEER area. Hospital- and surgeon-specific procedure volume was ascertained based on the number of claims submitted over the 5-year study period. Outcome measures were mortality at 30 days and 2 years, overall survival, and the rate of abdominoperineal resections. Age, sex, race, comorbid illness, cancer stage, and socioeconomic status were used to adjust for differences in case mix.<br>RESULTS: Neither hospital- nor surgeon-specific procedure volume was significantly associated with 30-day postoperative mortality or rates of rectal sphincter-sparing operations. Although an association between hospital volume and mortality at 2 years was evident, this finding was no longer significant once surgeon-specific volume was controlled for. In contrast, surgeon-specific volume was associated with 2-year mortality and remained an important predictor even after adjustment for hospital volume. Surgeon volume was also better than hospital procedure volume at predicting long-term survival.<br>CONCLUSIONS: Surgeon-specific experience as measured by procedure volume can have a significant impact on survival for patients with rectal cancer. |
| Etzioni, Young-Fadok et al. (2014).<br>Rectal cancer<br>US<br>Patient survival after surgical treatment of rectal cancer: Impact of surgeon and hospital characteristics. Cancer, 120(16), 2472-2481. | BACKGROUND: Surgeon and hospital factors are associated with the survival of patients treated for rectal cancer. The relative contribution of each of these factors toward determining outcomes is poorly understood. | METHODS: We used data from the Surveillance, Epidemiology, and End Results-Medicare database to analyze the outcomes of patients aged 65 years and older undergoing operative treatment for nonmetastatic rectal cancer, diagnosed in the United States between 1998 and 2007. These data were linked to a registry to identify whether the treating surgeon was a board-certified colorectal surgeon versus a noncolorectal surgeon. Hospital volume and hospital certification as a National Cancer Institute-designated Comprehensive Cancer Centers were also analyzed. The primary outcome of interest was long-term survival.<br>RESULTS: Our data source yielded 6432 patients. Initial analysis demonstrated improved long-term survival in patients treated by higher-volume colorectal surgeons, higher-volume hospitals, teaching hospitals, and National Cancer Institute (NCI)-designated Comprehensive Cancer Centers. Based on an iterative approach to modeling the interactions between these various factors, we found a robust effect of surgeon subspecialty status, hospital volume, and NCI designation. Surgeon volume was not distinctly associated with long-term survival.<br>CONCLUSIONS: Patients treated for rectal cancer by board-certified colorectal surgeons in centers that are higher volume and/or NCI-designated Comprehensive Cancer Centers experience better overall survival. These differences persist after adjustment for a broad range of patient and contextual risk factors, including surgeon volume. Patients and payers can use these results to identify surgeons and hospitals where outcomes are most favorable. |
| Devapriya et al. (2016)<br>Colorectal surgery<br>US | In this study, we seek to analyze the relationship between colorectal surgery outcome and annual sur- | This study was conducted using retrospective data from Geisinger Health System (GHS), a large tertiary care medical center in rural Pennsylvania. Surgeon volume data was extracted from electronic health rec- |

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| The impact of surgeon volume on postoperative colorectal surgery outcome.<br>Diseases of the Colon and Rectum, 59(5), e306. | geon volume to 1) help patients make an informed choice on where to seek care from 2) contribute to the ongoing policy debate on setting minimum volume standards for hospitals and procedures 3) advocate re-engineering of surgical systems to find an alternative solution to low volume procedures. | ords from of GHS and associated risk adjusted outcome data was extracted from Quality AdvisorTM database. risk adjusted outcomes were measured using Observed to Expected ratio ( O / E ratio) for 30-day mortality, 30-day readmissions, complications, and postoperative length of stay (LOS). Each surgeon was classified as a high or low volume based on an annual case volume threshold of 37 surgeries. Outcomes for 1) elective, 2) emergent, 3) all (elective and emergent together) colorectal surgeries were compared between high and low volume surgeon groups.<br>Results: We included a total of 2, 629 adult patients who had a colorectal surgery between 2006 and 2014 at GHS; 1,077 patients who did not have a risk adjusted O/E ratio were removed. The high volume surgeon group performed 54.9 surgeries on average per year compared to 5.74 of the low volume surgeon group. AISO, the high volume surgeon group had operated on a significantly older (p=0.0281) and more chronically ill (p = 0.0017) patient population. Sixty six percent of the emergent surgeries were performed by the low volume surgeon group and 71% of the patients who had an ASA score 4 or more were operated on by the low volume surgeon group. The postoperative complications were significantly higher in the low volume surgeon group (elective p = 0.0017, emergent p<0.0001, all p<0.0001). the postoperative LOS was significantly higher in the low volume surgeon group (elective p<0.0001, emergent p=0.0012, all p<0.0001).<br>Conclusions: Surgeon volume outcome analysis should be performed considering the elective and emergent status of a surgery to obtain meaningful results. Postoperative complications and LOS outcomes are significantly better when high volume surgeons perform the surgery. However, there is no significant difference in mortality or readmission outcomes in relation to surgeon volume. We recommend studying the causal relationships to understand the factors contributing to complications and longer LOS when surgeries are performed by low volume surgeons. |
| Burns, Bottle, et al. (2013)<br>Colorectal surgery<br>England<br>Hierarchical multilevel analysis of increased caseload volume and postoperative outcome after elective colorectal surgery.<br>The British Journal of Surgery, 100(11), 1531-1538. | BACKGROUND: The study aimed to explore the impact of surgeon and institution volume on outcome following colorectal surgery in England using multilevel hierarchical analysis. | METHODS: An observational study design was used. All patients undergoing primary elective colorectal resection between 2000 and 2008 were included from the Hospital Episode Statistics database. Consultant surgeons and hospitals were divided into tertiles (low, medium and high volume) according to their mean annual colorectal cancer resection caseload. Outcome measures examined were postoperative 30-day mortality, 28-day readmission and reoperation, and length of stay. Hierarchical multiple regression analysis adjusted for age, sex, co-morbidity, social deprivation, year of surgery, operation type and surgical approach.<br>RESULTS: A total of 109 261 elective cancer colorectal resections were included. High-volume consultant surgeons and hospitals were defined as performing more than 20.7 and 103.5 elective colorectal cancer procedures per year respectively. Consultant and hospital operative volumes increased throughout the study period. In hierarchical regression models, greater surgeon and institutional volume independently predicted only shorter length of hospital stay. No statistical association was observed between higher provider volume and postoperative mortality, 28-day reoperation or readmission rates. |

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| | | CONCLUSION: Increasing elective colorectal cancer caseload alone may have marginal postoperative benefit. |
| Karanicolas, Dubois et al. (2009).<br>Colorectal resection.<br>Canada<br>The more the better? The impact of surgeon and hospital volume on in-hospital mortality following colorectal resection.<br>*Annals of Surgery, 249*(6), 954-959 | OBJECTIVE: To determine the in-hospital mortality rates for patients undergoing colorectal resection for malignant or benign conditions, and to identify risk factors for in-hospital death, particularly the relationships with surgeon and hospital volume.<br>BACKGROUND: Although there is strong evidence that complex cancer operations are best performed at specialized high-volume centers and by high-volume surgeons, the relationship between surgeon and hospital volume and perioperative outcomes is less well defined for more common procedures such as colorectal resections, particularly for benign diseases. | METHODS: We obtained data from the Canadian Institute for Health Information Discharge Abstract Database on all adult patients who underwent colorectal resection between April 1, 2005 and March 31, 2006. We performed a logistic regression to identify variables associated with a higher likelihood of in-hospital death.<br>RESULTS: Twenty-one thousand seventy-four patients underwent colorectal resection, with the majority being elective (59.4%). Malignancy represented the most common indication for resection (56.8%), followed by diverticular disease (16.2%) and inflammatory bowel disease (7.1%). The overall in-hospital mortality rate among patients undergoing colorectal resection was 5.3%. Increased age (adjusted Odds Ratio [OR]: 1.97 per 10 years, $P < 0.001$), urgent operation (OR: 2.63, $P < 0.001$), indication for resection ($P < 0.001$), nature of the surgery ($P < 0.001$), and several comorbidities were all independently associated with an increased risk of death. Surgeons with higher volumes of colorectal resections achieved significantly lower mortality rates (OR: 0.92 per 20 cases/y, $P = 0.003$), corresponding to an adjusted mortality rate of 5.6% for surgeons in the bottom decile (1 case per year) compared with 4.5% for surgeons in the top decile (greater than 43 cases per year). Hospital volume was not associated with mortality (OR: 1.00 per 10 cases, $P = 0.504$).<br>CONCLUSIONS: This large, population-based study suggests that surgeons who perform high volumes of colorectal resections achieve lower in-hospital mortality rates than surgeons with low volumes, whereas the hospital volume does not influence mortality. |
| Debes et al. (2008)<br>Rectal cancer surgery<br>Norway<br>Curative rectal cancer surgery in a low-volume hospital: A quality assessment.<br>European Journal of Surgical Oncology : The Journal of the European Society of Surgical Oncology and the British Association of Surgical Oncology, 34(4), 382-389. | Hospital volume or caseload is often used as a surrogate measure for quality of care in rectal cancer treatment.<br>The aim of this study was to assess outcome in a low-volume hospital and secondly to examine the impact of surgeon volume on the results. | A retrospective review of 131 patients' charts identified 102 patients receiving apparently curative resections for rectal cancer in the period 1993-2002. Our study population did not differ significantly from the national average except for shift towards more advanced Dukes stage ($p=0.00$) and a higher rate of node positive patients at time of diagnosis ($p=0.00$).<br>RESULTS: There were no significant differences from the national outcome results, neither in perioperative mortality or complications, nor 5-year survival or local recurrences. Thirteen different on-staff surgeons performed rectal cancer surgery in our hospital in the decade, and median annual caseload was four. We detect a difference in 5-year survival when grouping the surgeons by annual caseload, but the significance is inconclusive. It is, however, interesting that in 85% of the resections, two or more certified gastrointestinal surgeons with specific training were involved. A relatively high number (9%) of discrepancies between the Norwegian Rectal Cancer Registry (NRCR) database and the local hospital database were identified.<br>CONCLUSION: Adequate results for surgical outcome can be achieved in a low-volume hospital. Surgeon volume showed inconclusive impact for our results of outcome. A local quality initiative is justified in addition to national registries. |
| Billingsley et al. 2008<br>Rectal cancer resection<br>US | To assess the relationship between surgeon and hospital volume and major postoperative complications after rectal cancer | STUDY DESIGN: This was a retrospective cohort design using data from the Surveillance, Epidemiology, and End Results (SEER) cancer registry program for individuals with stage I to III rectal cancer diagnosed between 1992 and 1999 and treated with resection. |

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| Does surgeon case volume influence nonfatal adverse outcomes after rectal cancer resection?<br>Journal of the American College of Surgeons, 206(6), 1167-1177. | surgery, and to define other surgeon and hospital characteristics that may explain observed volume-complication relationships. | The patients' Surveillance, Epidemiology, and End Results data were linked with Medicare claims data from 1991 to 2000. The primary outcomes were 30-day postoperative procedural interventions (PPI) to treat surgical complications, such as reoperation. The association between surgeon volume and PPI was examined using logistic regression modeling with adjustment for covariates.<br>RESULTS: The odds of a rectal cancer patient requiring a PPI is notably less if the operation is performed by one of a small subset of very high volume surgeons (unadjusted odds ratio 0.53; 95% CI 0.31 to 0.92). Board certification in colorectal surgery did not alter the relationship between surgeon volume and PPI, although surgeon age did, with mid-career surgeons having the lowest rates of PPI, regardless of practice volume. When adjusted for surgeon age, surgeon volume is no longer a marked predictor of complications (adjusted odds ratio 0.57; 95% CI 0.30 to 1.09).<br>CONCLUSIONS: Overall, rectal cancer operations are safe, with a low frequency of severe complications. A subset of very high volume rectal surgeons performs these operations with fewer complications that require procedural intervention or reoperation. Surgeon age, as an indicator of experience, also contributes modestly to outcomes. These data do not justify regionalizing rectal cancer care based on safety concerns. |
| Aquina, Probst et al. (2016)<br>Rectal cancer surgery<br>US<br>High volume improves outcomes: The argument for centralization of rectal cancer surgery.<br>Surgery, 159(3), 736-748. | BACKGROUND: Centralization of care to "centers of excellence" in Europe has led to improved oncologic outcomes; however, little is known regarding the impact of non-mandated regionalization of rectal cancer care in the United States. | METHODS: The Statewide Planning and Research Cooperative System (SPARCS) was queried for elective abdominoperineal and low anterior resections for rectal cancer from 2000 to 2011 in New York with the use of International Classification of Diseases, Ninth Revision codes. Surgeon volume and hospital volume were grouped into quartiles, and high-volume surgeons (>/= 10 resections/year) and hospitals (>/= 25 resections/year) were defined as the top quartile of annual caseload of rectal cancer resection and compared with the bottom 3 quartiles during analyses. Bivariate and multilevel regression analyses were performed to assess factors associated with restorative procedures, 30-day mortality, and temporal trends in these endpoints. RESULTS: Among 7,798 rectal cancer resections, the overall rate of no-restorative proctectomy and 30-day mortality decreased by 7.7% and 1.2%, respectively, from 2000 to 2011. In addition, there was a linear increase in the proportion of cases performed by both high-volume surgeons and high-volume hospitals and a decrease in the number of surgeons and hospitals performing rectal cancer surgery. High-volume surgeons at high-volume hospitals were associated independently with both less nonrestorative proctectomies (odds ratio 0.65, 95% confidence interval 0.48-0.89) and mortality (odds ratio 0.43, 95% confidence interval 0.21-0.87) rates. No patterns of significant improvement within the volume strata of the surgeon and hospitals were observed over time.<br>CONCLUSION: This study suggests that the current trend toward regionalization of rectal cancer care to high-volume surgeons and high-volume centers has led to improved outcomes. These findings have implications regarding the policy of health care delivery in the United States, supporting referral to high-volume centers of excellence. |
| Balik et al. (2010).<br>Rectal cancer | The purpose of the study was to assess the effects | A total of 284 patients who underwent laparoscopic resection for rectal cancer performed by 3 different |

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| Effects of surgical laparoscopic experience on the short-term postoperative outcome of rectal cancer: Results of a high volume single center institution.<br>Surgical Laparoscopy, Endoscopy & Percutaneous Techniques, 20(2), 93-99. | of the surgeon's learning curve on the short-term outcome of laparoscopic resections performed for rectal cancer. | surgical teams between 2005 and 2008 were included in the study. The operative experience was represented by the team's previous surgical case numbers (frequency). Four skill levels were categorized as follows: Level 1: the first 60 cases, Level 2: 61 to 120 cases, Level 3: 121 to 180 cases, and Level 4:>180 cases. Characteristics of the patients, perioperative variables, and the experience levels of the surgeons were analyzed and compared. To investigate the learning curve, we used the following parameters: duration of operative time, conversion rates, general complications, anastomotic leak rates, and oncologic parameters.<br>RESULTS: Operative time gradually decreased with increasing experience. The mean operative times for Level 1, Level 2, and Level 3 were 195.0+/-46.7, 181.7+/-34.2, and 172.3+/-33.0 minutes, respectively, whereas the mean operative time for Level 4 was 151.3+/-27.7 minutes (P<0.05). With increased experience, conversion rates, complication rates, anastomotic leak rates, and hospitalization durations decreased (P<0.05). The resected specimen length was found to be longer with increased surgical experience (P<0.05). There were no significant differences among the groups with regard to tumor size, T stage, harvested lymph node count, lateral margin involvement, and R0 resections.<br>CONCLUSIONS: The operative time is inversely proportional to the level of skill. Laparoscopic surgical procedures do not have any negative effects on short-term surgical outcome. With the strict application of surgical principles, the oncologic quality of the specimen is not influenced by the experience period. With increased experience, the surgeon feels more confident and performs more difficult and complex laparoscopic surgical interventions for rectal cancer. |
| Purves, Pietrobon et al. (2005)<br>Relationship between surgeon caseload and sphincter preservation in patients with rectal cancer.<br>Dis Colon Rectum, 48:195–204. | The aim of this study was to determine by means of a national database whether higher surgeon caseload correlates with greater utilization of sphincter-sparing procedures than of abdominoperineal resections in treatment of patients with rectal cancer. | RESULTS: The study population (n = 477) was 70.4 percent white and 57.9 percent male with an average age of 67.6 years. The mean Deyo comorbidity score was 7.0. Patients treated by surgeons in the highest-volume category (≥10 rectal cancer surgeries per year) compared with those treated by surgeons in the lowest-volume category (1–3 rectal cancer surgeries per year) were significantly more likely to undergo a sphincter-sparing procedure, after adjustment for other covariates (odds ratio = 5.05; 95 percent confidence interval, 2.5–10.22).<br>CONCLUSION: This analysis suggests that rectal cancer patients treated by high-volume surgeons are five times more likely to undergo sphincter-sparing procedures than those treated by low-volume surgeon. This has significant implications for those seeking a sphincter-preserving option for the treatment of their rectal cancer. |
| Purves et al. (1999)<br>Colorectal resection<br>Hospital volume can serve as a surrogate for surgeon volume for achieving excellent outcomes in colorectal resection.<br>Ann Surg. 1999 Sep; 230(3): 404. | To examine the association of surgeon and hospital case volumes with the short-term outcomes of in-hospital death, total hospital charges, and length of stay for resection of colorectal carcinoma. | Results: During the 5-year period, 9739 resections were performed by 812 surgeons at 50 hospitals. The majority of surgeons (81%) and hospitals (58%) were in the low-volume group. The low-volume surgeons operated on 3461 of the 9739 total patients (36%) at an average rate of 1.8 cases per year. Higher surgeon volume was associated with significant improvement in all three outcomes (in-hospital death, length of stay, and cost). Medium-volume surgeons achieved results equivalent to high-volume surgeons when they operated in high- or medium-volume hospitals.<br>Conclusions: A skewed distribution of case volumes by surgeon was found in this study of patients who |

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| | | underwent resection for large bowel cancer in Maryland. The majority of these surgeons performed very few operations for colorectal cancer per year, whereas a minority performed >10 cases per year. Medium-volume surgeons achieved excellent outcomes similar to high-volume surgeons when operating in medium-volume or high-volume hospitals, but not in low-volume hospitals. The results of low-volume surgeons improved with increasing hospital volume but never equaled those of the high-volume surgeons. |
| McGrath, Leong et al. (2005)<br>Colorectal cancer<br>Australia<br>Surgeon and hospital volume and the management of colorectal cancer patients in Australia.<br>ANZ J Surg 2005;75: 901–10. | The evidence for a relationship between patient outcomes and clinician and hospital volume is increasing. The National Colorectal Cancer Care Survey was undertaken to determine the management patterns in Australia for individuals newly diagnosed with colorectal cancer in a 3 month period in the year 2000. | Results: Of 2,383 surgical questionnaires generated, 2,015 (85%) were completed. The majority (58%) of surgeons treated one or two patients with colorectal cancer over the 3 months of the survey. There was variation across surgeon cohorts for preoperative measures including the use of deep vein thrombosis prophylaxis. Patients seen by low volume surgeons were most likely to be given a permanent stoma (P < 0.0001). Patients with rectal cancer who were operated on by high volume surgeons were significantly more likely to receive a colonic pouch (P < 0.0001).<br>CONCLUSION: This nationwide population-based survey of the treatment of colorectal cancer patients suggests that the delivery of care by surgeons (the majority) who treat patients with rectal cancer infrequently should be evaluated. |
| Galandiuk, Mahid, Polk et al. (2006).<br>Colon and rectal resections<br>US<br>Differences and similarities between rural and urban operations. Surgery, 140(4), 589-596. | BACKGROUND: The importance of rural operations is magnified by super-specialization, uneven geographic distribution, and special educational needs. Definition of practice patterns and quality measures are needed. | METHODS: A statewide network of 60 operative specialists studied costs, quality, and outcomes in 17,319 patients undergoing 46 different specialty operations between 1998 and 2003, comparing 9,544 rural to 7,775 urban patients. These data are augmented by additional data from 5,339 operative patients in 2004. RESULTS: Both high volume rural and urban surgeons achieved fewer deaths than less frequent practitioners of colon or rectal resections (2/309 vs 5/167). Urban surgeons had sicker patients undergoing more extensive procedures, and used fewer consultations, but had more complications and reoperations. Laparoscopic cholecystectomy had similar outcomes with 5 deaths among 1,788 patients. Urban surgeons converted to an open procedure more frequently, whereas rural surgeons used hepatobiliary iminodiacetic acid (HIDA) scans as indication for cholecystectomy more often (P < .01). Indications for upper and lower endoscopy varied, but abnormalities were noted in 64%; only 11 of 6,938 patients undergoing endoscopy were admitted for complications, 5 required operations, 3 due to totally obstructing cancers. Hysterectomy, urologic procedures, and tympanostomy had admission/readmission rates as low as 1/400. Documented patient preoperative education occurred in 94% of both groups. Overall, performance measures were addressed more consistently by rural surgeons (P < .001).<br>CONCLUSIONS: Operative practice reaches high standards in both settings; indications for operations vary, and rural practice is broader than urban practice. Rural surgeons exceed their urban colleagues on some quality process measures. |
| Prystowsky et al. (2002)<br>Colon resection<br>US | We examined patient outcomes for colon resection to determine if they varied according to surgeon-specific factors including: (1) American Board of Surgery (ABS) certification, (2) col- | ABS-certification was associated with reduced mortality and morbidity. Increasing years of experience was associated with reduced mortality. Colorectal surgery certification and site of residency training did not significantly affect outcomes.<br>Conclusion. We were able to link patient outcomes with surgeon's training. Certification was an important determinant of patient outcomes for colon resection. |

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| Patient outcomes for segmental colon resection according to surgeon's training, certification, and experience.<br>Surgery, 132(4), 663-672. | orectal surgery subspecialty certification, (3) site of residency training (university-based vs nonuniversity-based), and (4) years of experience since ABS certification. | Increasing surgeon experience also had a favorable effect on outcomes, suggesting a continued learning curve subsequent to residency. |
| Schrag, Panageas et al. (2003).<br>Primary colon cancer resection<br>US<br>Surgeon volume compared to hospital volume as a predictor of outcome following primary colon cancer resection.<br>Journal of Surgical Oncology, 83(2), 68-78; discussion 78-9. | BACKGROUND AND OBJECTIVES: A strong association between high hospital procedure volume and survival following colon cancer resection has been demonstrated.<br>However, the importance of surgeon case volume as a determinant of outcome has been less well studied, and it is unclear whether hospital or surgeon volume is the more powerful predictor of outcomes. | METHODS: A retrospective population-based cohort study utilizing the Surveillance, Epidemiology, and End Results (SEER)-Medicare linked database identified 24,166 colon cancer patients aged 65 years and older who had surgery for a primary tumor diagnosed in 1991-1996 in a SEER area. Hospital and surgeon-specific procedure volume was ascertained based on the number of claims submitted over the 6-year study period. Outcome measures were mortality at 30 days and 2 years, overall survival, and the frequency of operations requiring an intestinal stoma. Age, sex, race, comorbid illness, cancer stage, socioeconomic status, emergent hospitalization, and the presence of obstruction/perforation were used to adjust for differences in case-mix.<br>RESULTS: After adjusting for surgeon procedure volume, high hospital procedure volume remained a strong predictor of low post-operative mortality rates ($P < 0.001$ for each outcome with and without adjustment for surgeon procedure volume). Surgeon-specific procedure volume was also an important predictor of surgical outcomes ($P = 0.002$ for 30-day mortality, $P = 0.001$ for 2-year mortality), although this effect was attenuated after adjusting for hospital volume ($P = 0.03$ for 30-day mortality, $P = 0.02$ for 2-year mortality). Hospital volume and surgeon volume were each an important predictor of the ostomy rate. Among high volume institutions and surgeons, individual providers with unusually high ostomy rates could be identified.<br>CONCLUSIONS: Both hospital and surgeon-specific procedure volume predict outcomes following colon cancer resection; but hospital volume may exert a stronger effect. Therefore, efforts to optimize the quality of colon cancer surgery should focus on multidisciplinary aspects of hospital care rather than solely on intraoperative technique. |
| Egorova, Giacovelli et al. (2008)<br>Ruptured abdominal aortic aneurysm<br>US<br>National outcomes for the treatment of ruptured abdominal aortic aneurysm: Comparison of open versus endovascular repairs.<br>Journal of Vascular Surgery, 48(5), 1092-100, 1100.e1-2. | OBJECTIVES: Endovascular repair (EVAR) of ruptured abdominal aortic aneurysms (rAAA) has been shown to acutely decrease procedural mortality compared to open aortic repair (OAR).<br>However, little is known about the effect of choice of procedure; EVAR vs OAR, or the impact of physician and institution volume on long-term survival and outcome. | METHODS: Patients hospitalized with rAAA who underwent either OAR or EVAR, were derived from the Medicare inpatient dataset (1995-2004) using ICD9 codes. We evaluated long-term survival after OAR and EVAR in the entire fee-for-service Medicare population, and then in patients matched by propensity score to create two similar cohorts for comparison with Kaplan-Meier analysis. Annual surgeon and hospital volumes of EVAR (elective and ruptured), OAR (elective and ruptured), and rAAA (EVAR and OAR) were divided into quintiles to determine if increasing volumes correlate with decreasing mortality. Predictors of survival were determined by Cox modeling.<br>RESULTS: A total of 43,033 Medicare beneficiaries had rAAA repair: 41,969 had OAR and 1,064 had EVAR. The proportions of patients with diabetes, hypertension, cardiovascular, cerebrovascular, renal disease, hyperlipidemia, and cancer were statistically higher in the EVAR than in the OAR group, whereas lower extremity vascular disease was higher in the OAR group. The initial evaluation of EVAR vs OAR, prior to propensity matching, showed no statistical advantage in EVAR-survival after 90 days. The survival analysis of patients matched by propensity |

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| | | score showed a benefit of EVAR over OAR that persisted throughout the 4 years of follow-up (P = .0042). Perioperative and long-term survival after rAAA repair correlated with increasing annual surgeon and hospital volume in OAR and EVAR and also with rAAA experience. EVAR repair had a protective effect (HR = 0.857, P = .0061) on long-term survival controlling for comorbidities, demographics, and hospital and surgeon volume.<br>CONCLUSION: When EVAR and OAR patients are compared using a reliable statistical technique such as propensity analysis, the perioperative survival advantage of rAAA repaired endovascularly is maintained over the long term. Institutional experience with rAAA is critical for survival after either OAR or EVAR. |
| McPhee, Robinson et al. (2011).<br>Elective open abdominal aortic aneurysm repair<br>US<br>Surgeon case volume, not institution case volume, is the primary determinant of in-hospital mortality after elective open abdominal aortic aneurysm repair.<br>*Journal of Vascular Surgery, 53*(3), 591-599.e2. | OBJECTIVE: Studies analyzing the effects of volume on outcomes after abdominal aortic aneurysm (AAA) repair have primarily centered on institutional volume and not on individual surgeon volume.<br>We sought to determine the relative effects of both surgeon and institution volume on mortality after open and endovascular aneurysm repair (EVAR) for intact AAAs. | METHODS: The Nationwide Inpatient Sample (2003-2007) was queried to identify all patients undergoing open repair and EVAR for non-ruptured AAAs. To calculate surgeon and institution volume, 11 participating states that record a unique physician identifier for each procedure were included. Surgeon and institution volume were defined as low (first quintile), medium (second, third, or fourth quintile), and high (fifth quintile). Stratification by institution volume and then by surgeon volume was performed to analyze the primary endpoint: in-hospital mortality. Multivariable models were used to evaluate the association of institution and surgeon volume with mortality for open repair and EVAR, controlling for potential confounders.<br>RESULTS: During the study period, 5972 open repairs and 8121 EVARs were performed. For open AAA repair, a significant mortality reduction was associated with both annual institution volume (low 30) and surgeon volume (low 9). High surgeon volume conferred a greater mortality reduction than did high institution volume. When low and medium volume institutions were stratified by surgeon volume, mortality after open AAA repair was inversely proportional to surgeon volume (8.7%, 3.6%, and 0%; P < .0001, for low, medium, and high-volume surgeons at low-volume institutions; and 6.7%, 4.8%, and 3.3%; P = .02, for low, medium, and high-volume surgeons at medium-volume institutions). High-volume institutions stratified by surgeon volume demonstrated the same trend (5.1%, 3.4%, and 2.8%), but this finding was not statistically significant (P = .57). Multivariable analysis was confirmatory: low surgeon volume independently predicted mortality (odds ratio [OR], 2.0; 95% confidence interval [CI], 1.3-3.1; P < .001); low institution volume did not (P = .1). For EVAR, neither institution volume nor surgeon volume influenced mortality (univariate or multivariable).<br>CONCLUSION: The primary factor driving the mortality reduction associated with case volume after open AAA repair is surgeon volume, not institution volume. Regionalization of AAAs should focus on open repair, as EVAR outcomes are equivalent across volume levels. Payers may need to re-evaluate strategies that encourage open AAA repair at high-volume institutions if specific surgeon volume is not considered. |
| Hannan et al. (1992).<br>Abdominal aortic aneurysm surgery<br>US | To examine the relationship between in-hospital mortality for a patient receiving an abdominal aortic aneurysm resection and the volume of aneurysm operations performed in | This study uses New York State hospital discharge data to examine the relationship between in-hospital mortality for a patient receiving an abdominal aortic aneurysm resection and the volume of aneurysm operations performed in the previous year at the hospital where the operation took place and by the surgeon performing the operation. Previous research on |

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| A longitudinal analysis of the relationship between in-hospital mortality in New York State and the volume of abdominal aortic aneurysm surgeries performed.<br>Health Services Research, 27(4), 517-542. | the previous year at the hospital where the operation took place and by the surgeon performing the operation. | this topic is extended in several respects: (1) A three-year data base is used to examine the manner in which hospital and surgeon volume jointly affect mortality rate and to examine ruptured and unruptured aneurysms separately; (2) a six-year data base is used to study the "practice makes perfect" hypothesis and the "selective referral" hypothesis; and (3) the degree of specialization of high-volume surgeons is contrasted with that of other surgeons.<br>The results demonstrate a significant inverse relationship between hospital volume and mortality rate for unruptured aneurysms. Further, very few surgeons substantially increased their aneurysm surgery volumes in the six-year study period. Weak selective referral effects were found for both surgeons and hospitals, and higher-volume aneurysm surgeons tended to have much higher specialization rates. |
| Dueck, Kucey, Johnston et al. (2004).<br>Elective and ruptured abdominal aortic aneurysm surgery<br>Canada<br>Long-term survival and temporal trends in patient and surgeon factors after elective and ruptured abdominal aortic aneurysm surgery.<br>Journal of Vascular Surgery, 39 (6), Pages 1261-1267 | OBJECTIVE: Records for all patients in Ontario who underwent elective repair of abdominal aortic aneurysms (AAAs) or repair of ruptured AAAs between 1993 and 1999 were studied to determine whether the profile of surgeons or patients changed and to determine whether postoperative mortality changed over time.<br>The secondary objective was to describe long-term survival after AAA surgery. | METHODS: A population-based retrospective cohort was assembled from administrative data. Surgeon billing records were used to identify operations performed between 1993 and 1999. Chi(2) and linear regression analyses were used to determine whether variables changed over time. Kaplan-Meier survival curves were used to estimate long-term survival.<br>RESULTS: For patients undergoing elective AAA repair, average annual surgeon volume (P <.0001) and proportion of patients operated on by vascular surgeons (P =.02) increased over the study period; similar trends were noted for patients undergoing repair of ruptured AAAs. Surgeon volume was clearly correlated with mortality after both elective AAA repair and repair of ruptured AAAs; however, the benefit of this effect was modest beyond a surgeon volume of 6 to 10 ruptured AAA repairs per year or 20 to 30 elective AAA repairs per year. No change in crude 30-day mortality (4.5% for elective AAA repair and 40.4% for repair of ruptured AAAs) was noted during the study.<br>CONCLUSION: Despite the finding that surgery to repair ruptured AAAs and elective repair of AAAs is being increasingly performed by high-volume vascular surgeons, there was no change in early mortality between 1993 and 1999. This may have been because average surgeon volume was already relatively high at the beginning of the study period, which translated into only modest benefit to further increases in surgeon volume. |
| Cowan, Dimick et al. (2003b)<br>Thoracoabdominal aortic aneurysms<br>US<br>Surgical treatment of intact thoracoabdominal aortic aneurysms in the united states: Hospital and surgeon volume-related outcomes.<br>Journal of Vascular Surgery, 37(6), 1169-1174. | OBJECTIVE: Surgical treatment of intact thoracoabdominal aortic aneurysm (TAAA) is crucial to prevent rupture but is associated with high perioperative mortality.<br>We tested the hypothesis that provider volume of surgical treatment of TAAA is an important determinant of operative outcome. | Patients and methods: Clinical information regarding repair of intact TAAA in 1542 patients from 1988 to 1998 was obtained from the Nationwide Inpatient Sample (NIS), a stratified discharge database of a representative 20% of US hospitals. Demographic data included age, sex, race, nature of admission, and comorbid conditions. Annual hospital volume of TAAA treated was grouped into terciles and defined as low (LVH; 1-3 cases [median, 1]), medium (MVH; 2-9 cases [median, 4]), or high (HVH; 5-31 cases [median, 12]). Annual surgeon volume was defined as low (LVS; 1-2 cases [median, 1]) or high (HVS; 3-18 cases [median, 7]). The primary outcome measure was in-hospital postoperative mortality. Secondary outcome measures included length of stay, and cardiac, pulmonary, and renal complications. Adjusted and unadjusted analyses were conducted.<br>RESULTS: Overall mortality was 22.3%. Mortality improved over time. LVH and HVH differed in mortality rates (27.4% vs 15.0%; P <.001). Mortality between LVS and HVS also differed significantly (25.6% vs |

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| | | 11.0%; P <.001). When controlling for patient demographic data, comorbid conditions, and postoperative complications, both hospital and surgeon volume were significant predictors of mortality for intact TAAA repair (LVS: odds ratio [OR] 2.6, P <.001; LVH: OR 2.2, P <.001; and MVH: OR 1.7, P =.004).<br>CONCLUSIONS: Greater hospital and surgeon TAAA treatment volumes contribute to better outcome. Given the relative high perioperative mortality associated with TAAA repair, regionalization of care to high-volume providers with consistently lower postoperative mortality deserves consideration by patients, physicians, and health care planners. |
| Schrag, Earle et al. (2006).<br>Ovarian cancer resection<br>US<br>Associations between hospital and surgeon procedure volumes and patient outcomes after ovarian cancer resection.<br>Journal of the National Cancer Institute, 98(3), 163-171. | BACKGROUND: Strong associations between provider (i.e., hospital or surgeon) procedure volumes and patient outcomes have been demonstrated for many types of cancer operation.<br>We performed a population-based cohort study to examine these associations for ovarian cancer resections. | METHODS: We used the Surveillance, Epidemiology, and End Results (SEER)-Medicare linked database to identify 2952 patients aged 65 years or older who had surgery for a primary ovarian cancer diagnosed from 1992 through 1999. Hospital- and surgeon-specific procedure volumes were ascertained based on the number of claims submitted during the 8-year study period. Primary outcome measures were mortality at 60 days and 2 years after surgery, and overall survival. Length of hospital stay was also examined. Patient age at diagnosis, race, marital status, comorbid illness, cancer stage, and median income and population density in the area of residence were used to adjust for differences in case mix. All P values are two-sided.<br>RESULTS: Neither hospital- nor surgeon-specific procedure volume was statistically significantly associated with 60-day mortality following primary ovarian cancer resection. However, differences by hospital volume were seen with 2-year mortality; patients treated at the low-, intermediate-, and high-volume hospitals had 2-year mortality rates of 45.2% (95% confidence interval [CI] = 42.1% to 48.4%), 41.1% (95% CI = 38.1% to 44.3%), and 40.4% (95% CI = 37.4% to 43.4%), respectively. The inverse association between hospital procedure volume and 2-year mortality was statistically significant both before (P = .011) and after (P = .006) case-mix adjustment but not after adjustment for surgeon volume. Two-year mortality for patients treated by low-, intermediate-, and high-volume surgeons was 43.2% (95% CI = 40.7% to 45.8%), 42.9% (95% CI = 39.5% to 46.4%), and 39.5% (95% CI = 36.0% to 43.2%), respectively; there was no association between 2-year mortality and surgeon procedure volume, with or without case-mix adjustment. After case-mix adjustment, neither hospital volume (P = .031) nor surgeon volume (P = .062) was strongly associated with overall survival.<br>CONCLUSION: Hospital- and surgeon-specific procedure volumes are not strong predictors of survival outcomes following surgery for ovarian cancer among women aged 65 years or older. |
| Wright, Lewin et al. (2011)<br>Radical hysterectomy for cervical cancer<br>US<br>The influence of surgical volume on morbidity and mortality of radical hysterectomy for cervical cancer.<br>American Journal of Obstetrics and Gynecology, 205(3), 225.e1-225.e7. | OBJECTIVE: We examined the influence of physician and hospital volume on the morbidity and mortality of radical hysterectomy for cervical cancer. | STUDY DESIGN: Women who underwent radical hysterectomy for cervical cancer between 2003 and 2007 were examined. The effect of surgeon and hospital volume on morbidity and mortality was examined using multivariable generalized estimating equations.<br>RESULTS: A total of 1536 women who underwent radical hysterectomy were identified. Patients treated by high-volume surgeons had fewer medical complications (odds ratio, 0.55; 95% confidence interval, 0.34-0.88) and shorter lengths of stay (odds ratio, 0.49; 95% confidence interval, 0.25-0.98). After adjustment for case mix and surgeon volume, hospital |

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| | | volume had no independent effect on any of the variables of interest.<br>CONCLUSION: High-volume surgeons have fewer postoperative medical complications, shorter lengths of stay, and lower transfusion requirements. Hospital volume appears to have only a minor influence on outcomes after radical hysterectomy. |
| Althumairi, Canner et al. (2016).<br>Pelvic exenteration<br>US<br>Reduction of costs for pelvic exenteration performed by high volume surgeons: Analysis of the maryland health service cost review commission database. The American Surgeon, 82(1), 46-52. | High volume hospitals (HVHs) and high volume surgeons (HVSs) have better outcomes after complex procedures, but the association between surgeon and hospital volumes and patient outcomes is not completely understood.<br>Our aim was to evaluate the impact of surgeon and hospital volumes, and their interaction, on postoperative outcomes and costs in patients undergoing pelvic exenteration (PE) in the state of Maryland. | A review of the Maryland Health Services Cost Review Commission database between 2000 and 2011 was performed. Patients were compared for demographics and clinical variables. The differences in length of hospital stay , length of intensive care unit (ICU) stay, operating room (OR) cost, and total cost were compared for surgeon volume and hospital volume controlling for all other factors. Surgery performed by HVS at HVH had the shortest ICU stay and lowest OR cost. When PE was performed by a low volume surgeon at an HVH, the OR cost and total cost were the highest and increased by $2,683 (P < 0.0001) and $16,076 (P < 0.0001), respectively. OR costs reduced when surgery was performed by an HVS at an HVH ($-1632, P = 0.008). PE performed by HVS at HVH is significantly associated with lower OR costs and ICU stay. We feel this is indicative of lower complication rates and higher quality care. |
| Huckman & Pisano (2006)<br>Cardiac Surgery<br>US<br>The Firm Specificity of Individual Performance: Evidence from Cardiac Surgery<br>Management Science, Vol. 52, No. 4 (Apr., 2006), pp. 473-488. | While it is often presumed that the performance of freelancers is largely portable across organizations, it is also possible that a given worker's performance may vary across organizations if he or she develops firm-specific skills and knowledge over time.<br>We examine this issue empirically by considering the performance of cardiac surgeons, many of whom perform operations at multiple hospitals within narrow periods of time. | Specifically, we consider the performance of cardiac surgeons across multiple hospitals using data from every patient receiving coronary artery bypass graft (CABG) surgery in Pennsylvania during 1994 and 1995.<br>The data cover 38,577 procedures performed by 203 surgeons operating at 43 hospitals.<br>Using patient mortality as an outcome measure, we find that the quality of a surgeon's performance at a given hospital improves significantly with increases in his or her recent procedure volume at that hospital but does not significantly improve with increases in his or her volume at other hospitals. Our findings suggest that surgeon performance is not fully portable across hospitals (i.e., some portion of performance is firm specific).<br>Further, we find that firm specificity in surgeon performance is not simply an artifact of a surgeon's influence or power relative to other cardiac surgeons at a particular hospital. That is, this effect is not solely explained by the fact that a surgeon with high volume at a given hospital may be able to command superior resources relative to her colleagues.<br>Rather, we provide preliminary evidence suggesting that this result may be driven by the familiarity that a surgeon develops with the assets of a given organization e.g. specific employees, team structures, or operating routines. |
| Kurlansky et al. (2012).<br>Coronary artery bypass surgery<br>US<br>Quality, not volume, determines outcome of coronary artery bypass surgery in a university-based community hospital network.<br>The Journal of Thoratic and Cardiovascular Surgery, 143(2), 287-293. | To examine the relationship between hospital and surgeon coronary artery bypass grafting procedural volume, mortality, morbidity, and National Quality Forum care processes in a university-based community hospital quality improvement program. | METHODS: The study population consisted of 2218 consecutive patients undergoing isolated coronary artery bypass grafting from 2007 to 2009 in a university-based quality improvement program that emphasizes involvement of all surgeons in the academic quality endeavor. The endpoints included operative mortality, major morbidity, and National Quality Forum-endorsed process measures as defined by the Society of Thoracic Surgeons. The procedural volume was analyzed as a categorical and continuous variable using general estimating equations, which accounted for clustering effects and which were adjusted for Society of Thoracic Surgeons risk scores |

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| | | and the propensity for operation in a low- versus high-volume program.<br>RESULTS: The annual program volume ranged from 67 to 292 (median, 136; interquartile range, 88-224) and surgeon volume from 1 to 124 (median, 58; interquartile range, 30-89). The mortality rate among the hospitals was 0.47% to 2.23% (0.8% overall), and the observed/expected mortality ranged from 0 to 1.20 (0.41 overall). When comparing low-volume (<200 cases/year) and high-volume centers, no difference was found in the mortality (odds ratio [OR], 1.08; 95% confidence interval [CI], 0.46-2.54, P = .85), morbidity (OR, 1.34; 95% CI, 0.73-2.43), or any of the medication process measures. No difference was found in mortality (OR, 1.59; 95% CI, 0.81-3.13; P = .18), morbidity (OR, 1.20; 95% CI, 0.86-1.66; P = .28), or medication failure (OR, 0.57, 95% CI, 0.3-1.10; P = .10) between the high- and low-volume surgeons (<87). After adjustment for both the Society of Thoracic Surgeons risk score and the propensity score, no association was found for either hospital or surgeon volume with mortality or morbidity. However, a lack of compliance with National Quality Forum measures was highly predictive of morbidity (OR, 1.51; 95% CI, 1.18-1.93; P = .001), regardless of volume, even after adjustment for predicted risk.<br>CONCLUSION: In the setting of a university-based community hospital quality improvement program, excellent surgical results can consistently be obtained even in relatively low-volume programs. The surgical outcomes were not associated with program or surgeon volume, but were directly correlated with the focus on quality as manifested by compliance with evidence-based quality standards. Meaningful university affiliation might represent a new quality paradigm for cardiac surgery in the community hospital setting. |
| Wu, Hannan, Ryan et al. (2004).<br>Coronary artery bypass graft surgery<br>US<br>Is the impact of hospital and surgeon volumes on the in-hospital mortality rate for coronary artery bypass graft surgery limited to patients at high risk?<br>Circulation, 110(7), 784-789. | BACKGROUND: Restriction of volume-based referral for CABG surgery to high-risk patients has been suggested, and earlier studies have reached different conclusions regarding volume-based referral for low-risk patients. | METHODS AND RESULTS: Patients who underwent isolated CABG surgery in New York from 1997 through 1999 (n=57 150) were separated into low-risk and moderate-to-high-risk groups with a predicted probability of in-hospital death of 2% as the cutoff point. The provider volume-mortality relationship was examined for both groups. For annual hospital volume thresholds between 200 and 600 cases, the adjusted ORs of in-hospital mortality for high-volume to low-volume hospitals ranged from 0.45 to 0.77 and were all significant for the low-risk group; for the moderate-to-high-risk group, ORs ranged from 0.62 to 0.91, and most were significant. The number needed to treat at higher-volume hospitals to avoid 1 death was greater for the low-risk group (a range of 114 to 446 versus 37 to 184). As the annual surgeon volume threshold increased from 50 to 150 cases, the ORs for high- to low-volume surgeons increased from 0.43 to 0.74 for the low-risk group; for the moderate-to-high-risk group, ORs ranged from 0.79 to 0.86. Compared with patients treated by surgeons with volumes of <125 in hospitals with volumes of <600, patients treated by higher-volume surgeons in higher-volume hospitals had a significantly lower risk of death; in particular, the OR was 0.52 for the low-risk group.<br>CONCLUSIONS: For both low-risk and moderate-to-high-risk patients, higher provider volume is associated with lower risk of death. |
| Hannan, Wu, Ryan et al. (2003)<br>Coronary artery bypass graft surgery | BACKGROUND: Studies that are the basis of recommended volume thresholds for CABG surgery are | METHODS AND RESULTS: Data from New York's clinical CABG surgery registry from 1997 to 1999 (total number of procedures, 57 150) were used to examine the individual and combined impact of annual |

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| US<br>Do hospitals and surgeons with higher coronary artery bypass graft surgery volumes still have lower risk-adjusted mortality rates? Circulation, 108(7), 795-801. | outdated and not reflective of recent advances in the field. This study examines both hospital and surgeon volume-mortality relations for CABG surgery through the use of a population-based clinical data set. | hospital volume and annual surgeon volume on in-hospital mortality rates after adjusting for differences in severity of illness. Significantly lower risk-adjusted mortality rates occurred above all annual hospital volume thresholds between 200 and 800 and above all surgeon volume thresholds between 50 and 200. The number needed to treat (NNT) at higher-volume providers to avoid a death was minimized for a hospital threshold volume of 100 (NNT=50) and a surgeon threshold volume of 50 (NNT=118). The risk-adjusted mortality rate (RAMR) for patients undergoing surgery performed by surgeons with volumes of > or =125 in hospitals with volumes of > or =600 was 1.89%. The RAMR was significantly higher (2.67%) for patients undergoing surgery performed by surgeons with volumes of <125 in hospitals with volumes of <600.<br>CONCLUSIONS: Higher-volume surgeons and hospitals continue to have lower risk-adjusted mortality rates, and patients undergoing surgery performed by higher-volume surgeons in higher-volume hospitals have the lowest mortality rates. |
| Auerbach, Hilton et al. (2009)<br>Coronary artery bypass surgery<br>US<br>Shop for quality or volume? Volume, quality, and outcomes of coronary artery bypass surgery<br><br>Annals of internal medicine, Vol.150(10), pp.696-704 | Care from high-volume centers or surgeons has been associated with lower mortality rates in coronary artery bypass surgery, but how volume and quality of care relate to each other is not well understood.<br>To determine how volume and differences in quality of care influence outcomes after coronary artery bypass surgery. | Observational cohort. 164 hospitals in the United States. 81,289 patients 18 years or older who had coronary artery bypass grafting from 1 October 2003 to 1 September 2005. Hospital and surgeon case volumes were estimated by using a data set. Quality measures were defined by whether patients received specific medications and by counting the number of measures missed. Hierarchical models were used to estimate effects of volume and quality on death and readmission up to 30 days.<br>After adjustment for clinical factors, lowest surgeon volume and highest hospital volume were associated with higher mortality rates and lower readmission risk, respectively. Patients who did not receive aspirin (odds ratio, 1.89 [95% CI, 1.65 to 2.16) or beta-blockers (odds ratio, 1.29 [CI, 1.12 to 1.49]) had higher odds for death, after adjustment for clinical risk factors and case volume. Adjustment for individual quality measures did not alter associations between volume and readmission or death. However, if no quality measures were missed, mortality rates at the lowest-volume centers (adjusted mortality rate, 1.05% [CI, 0.81% to 1.29%]) and highest-volume centers (adjusted mortality rate, 0.98% [CI, 0.72% to 1.25%]) were similar. Because administrative data were used, the quality measures may not replicate measures collected through chart abstraction. Maximizing adherence to quality measures is associated with improved mortality rates, independent of hospital or surgeon volume. |
| Zacharias, Schwann et al. (2005).<br>Coronary artery bypass surgery<br>US<br>Is hospital procedure volume a reliable marker of quality for coronary artery bypass surgery? A comparison of risk and propensity adjusted operative and midterm outcomes.<br>*The Annals of Thoracic Surgery, 79*(6), 1961-1969. | BACKGROUND: Worse operative mortality has been reported for hospitals with low versus high coronary artery bypass grafting surgery volumes. Despite a lack of comparisons beyond the early postoperative period and evidence of surgeon-volume confounding, some have suggested that regionalization of coronary artery bypass grafting in favor of high volume institutions is warranted. | METHODS: We retrospectively compared operative mortality and 3-year survival in coronary artery bypass grafting patients (2001 to 2003) at a low-volume hospital (n = 504; 160 per year [median]) versus a high-volume hospital (n = 1,410; 487 per year) served by the same high-volume surgeon team. Covariate risk adjustment was done via multivariate and propensity modeling.<br>RESULTS: The two hospital cohorts exhibited multiple demographic and risk factor differences. Unadjusted low-volume hospital vs high-volume hospital operative mortality was similar overall (2.38% vs 2.98%; p = 0.59) with nearly identical Society of Thoracic Surgeons observed-to-expected ratios (0.83 vs 0.82), irrespective of preoperative risk category. Hospital volume did not predict operative mortality (odds ratio, 95% confidence interval = 0.82; p = 0.602). At |

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| | | follow-up, a total of 28 low-volume hospital deaths (5.6%) and 135 high-volume hospital deaths (9.6%) occurred at similar surgery-to-death intervals (p = 0.7). Unadjusted 0 to 3-year survival was significantly worse for high-volume hospitals (risk ratio = 1.59; 1.06 to 2.39; p = 0.026). Yet procedure volume was not independently associated with worse midterm survival after covariate (risk ratio = 1.28; 0.84 to 1.96; p = 0.247) or propensity score (risk ratio = 1.11; 0.72 to 1.71; p = 0.648) adjustment.<br>CONCLUSIONS: Hospital and surgeon volume effects on coronary artery bypass grafting outcomes are interdependent, and therefore hospital coronary artery bypass grafting volume per se is not a reliable marker of quality. Instead, outcome quality markers should rely on thorough risk-adjustment based on detailed clinical databases, possibly including annual and cumulative surgeon volume. |
| Hannan, Racz, Ryan et al. (1997)<br>Coronary angioplasty<br>US<br>Coronary angioplasty volume-outcome relationships for hospitals and cardiologists.<br>Jama, 277(11), 892-898. | OBJECTIVE: To assess the relationship between each of 2 provider volume measures (annual hospital volume and annual cardiologist volume) for percutaneous transluminal coronary angioplasty (PTCA) and 2 outcomes of PTCA (in-hospital mortality and same-stay coronary artery bypass graft [CABG] surgery). | DESIGN: Cohort study, using data from January 1, 1991, through December 31, 1994, from the Coronary Angioplasty Reporting System of the New York State Department of Health. SETTING: Thirty-one hospitals in New York State in which PTCA was performed during 1991-1994. PATIENTS: All 62670 patients discharged after undergoing PTCA in these hospitals during 1991-1994. MAIN OUTCOME MEASURES: Rates of in-hospital mortality and CABG surgery during the same stay as the PTCA.<br>RESULTS: The overall in-hospital mortality rate for patients undergoing PTCA in New York during 1991-1994 was 0.90%, and the same-stay CABG surgery rate was 3.43%. Patients undergoing PTCA in hospitals with annual PTCA volumes less than 600 experienced a significantly higher risk-adjusted in-hospital mortality rate of 0.96% (95% confidence interval [CI], 0.91%-1.01%) and risk-adjusted same-stay CABG surgery rate of 3.92% (95% CI, 3.76%-4.08%). Patients undergoing PTCA by cardiologists with annual PTCA volumes less than 75 had mortality rates of 1.03% (95% CI, 0.91%-1.17%) and same-stay CABG surgery rates of 3.93% (95% CI, 3.65%-4.24%); both of these rates were also significantly higher than the rates for all patients. Also, same-stay CABG surgery rates for patients undergoing PTCA in hospitals with annual volumes of 600 to 999 performed by cardiologists with annual volumes of 75 to 174 (2.99%; 95% CI, 2.69%-3.31 %) and 175 or more (2.84%; 95% CI, 2.57%-3.14%) were significantly lower than the overall statewide rate (3.43%).<br>CONCLUSIONS: In New York State, both hospital PTCA volume and cardiologist PTCA volume are significantly inversely related to in-hospital mortality rate and same-stay CABG surgery rate for patients undergoing PTCA. |
| Hannan, Wu, Walford et al. (2005)<br>Percutaneous coronary interventions<br>UK<br>Volume-outcome relationships for percutaneous coronary interventions in the stent era. Circulation, 112(8), 1171-1179. | BACKGROUND: Most studies that are the basis of recommended volume thresholds for percutaneous coronary interventions (PCIs) predate the routine use of stent placement. | METHODS AND RESULTS: Data from New York's Percutaneous Coronary Interventions Reporting System in 1998 to 2000 (n=107 713) were used to examine the impact of annual hospital volume and annual operator volume on in-hospital mortality, same-day coronary artery bypass graft (CABG) surgery, and same-stay CABG surgery after adjustment for differences in patients' severity of illness. For a hospital-volume threshold of 400, the odds ratios for low-volume hospitals versus high-volume hospitals were 1.98 (95% CI, 1.17, 3.35) for in-hospital mortality, 2.07 (95% CI, 1.36, 3.15) for same-day CABG surgery, and 1.51 (95% CI, 1.03, 2.21) for same-stay CABG surgery. For an operator-volume threshold of |

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| | | 75, the odds ratios for low-volume versus high-volume operators were 1.65 (95% CI, 1.05, 2.60) for same-day CABG surgery and 1.55 (95% CI, 1.10, 2.18) for same-stay CABG surgery. Operator volume was not significantly associated with mortality. Also, for hospital volumes below 400 and operator volumes below 75, the respective odds of mortality, same-day CABG surgery, and same-stay CABG surgery were 5.92, 4.02, and 3.92 times the odds for hospital volumes of 400 or higher and operator volumes of 75 or higher.<br>CONCLUSIONS: Higher-volume operators and hospitals continue to experience lower risk-adjusted PCI outcome rates. |
| Hulme, Sperrin et al. (2016).<br>Post percutaneous coronary intervention<br>UK<br>Is there a relationship of operator and center volume with access site-related outcomes? an analysis from the British cardiovascular intervention society. Circulation. Cardiovascular Interventions, 9(5). | BACKGROUND: Transradial access is associated with reduced access site-related bleeding complications and mortality post percutaneous coronary intervention. The objective of this study is to examine the relationship between access site practice and clinical outcomes and how this may be influenced by operator and center experience/expertise. | METHODS AND RESULTS: The influence of operator and center experience/expertise was studied on 30-day mortality, in-hospital major adverse cardiovascular events (a composite of in-hospital mortality and in-hospital myocardial infarction and target vessel revascularization) and in-hospital major bleeding based on access site adopted (radial versus femoral). Operator/center experience/expertise were defined by both total volume and transradial access proportion. A total of 164 395 procedures between 2012 and 2013 in the National Health Service in England and Wales were analyzed. After case-mix adjustment, transradial access was associated with an average odds reduction of 39% for 30-day mortality compared with transfemoral access (odds ratio, 0.61; 95% confidence interval, 0.55-0.68; P<0.001). The magnitude of this risk reduction was modified by increases in total procedural volume and radial proportion at the operator level (odds ratio reduction of 11% per 100 extra procedures, 95% confidence interval, 3%-19%; odds ratio reduction of 6% per 10%-point increase in radial proportion, 95% confidence interval, 1%-11%) with no significant impact of operator radial volume, center total volume, center radial volume, and center radial proportion. CONCLUSIONS: The lower mortality associated with transradial access adoption relates to both the total procedural volume and the proportion of procedures undertaken radially by operator, with operators undertaking the greatest proportion of their procedures radially having the largest relative reduction in mortality risk. |
| Xie, Rizzo & Brown (2008).<br>Percutaneous coronary intervention<br>US<br>A modified method for estimating volume-outcome relationships: Application to percutaneous coronary intervention. Journal of Medical Economics, 11(1), 57-70. | OBJECTIVE: The objective of the current study was to propose an alternative method for measuring individual operator and peer volumes to use as predictors for adverse outcomes. | STUDY DESIGN: A retrospective analysis was performed to assess the volume-outcome relationship for percutaneous coronary intervention (PCI) performed in New York State between 1996 and 1999. This relationship was calculated using a modified method whereby physician volume was calculated using the previous year's volume, and hospital volume was calculated after subtracting the operator of interest's annual volume from the total. The primary outcome of interest was in-hospital mortality.<br>RESULTS: Using the modified method, the odds ratio (OR) of in-hospital mortality was 0.74 (95% confidence interval (CI) 0.55-0.99; p=0.04) for cardiologists who performed 75-174 procedures annually and 0.80 (95% CI 0.61-1.04; p=0.1) for cardiologists who performed > or =175 procedures annually compared with the lowest-volume operators. With the conventional approach to volume measurement, no relationship between cardiologist volume and mortality was found. Patients who underwent PCI in hospitals where their physician's peers had an annual volume of 600-999 or > or =1,000 cases had a significantly reduced odds of mortality (OR = 0.73; 95% CI 0.57-0.92; p=0.01; and OR = 0.77; 95% CI 0.62-0.95; |

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| | | p=0.01) compared with patients treated by physicians with an annual peer volume of <600 cases. The conventional method did not detect any significant correlation between hospital volume and in-hospital mortality.<br>CONCLUSION: The alternative approach to measuring cardiologist and peer volumes proposed in this study leads to more precise estimates of volume-outcome relationships than the conventional approach. |
| Thompson, Jayne et al. (2009).<br>Percutaneous intervention for coronary chronic total occlusions<br>US<br>Retrograde techniques and the impact of operator volume on percutaneous intervention for coronary chronic total occlusions an early U.S. experience. JACC. Cardiovascular Interventions, 2(9), 834-842 | OBJECTIVES: Our purpose was to determine if "Japanese style" technical strategies can be successfully applied in the U.S. practice environment and to better understand the learning curve for chronic total occlusion (CTO) percutaneous coronary intervention (PCI). | BACKGROUND: Procedural technical success remains the major limiting factor for CTO PCI, and has been unchanged over time. METHODS: Demographic, procedural, and outcome data were collected on 636 consecutive patients between January 2005 and March 2008 having CTO PCI (514 antegrade, 122 retrograde attempts) at 2 U.S. medical centers. Operators were divided into 2 groups: higher CTO volume, retrograde operators (ROs) (>75 total CTO PCI cases and >20 retrograde attempts during the study period) and lower CTO volume, non-retrograde operators (NROs) to evaluate the impact of CTO-specific operator case volume and retrograde techniques on procedural outcomes.<br>RESULTS: Two operators met the criteria for RO category and 10 were NRO. ROs performed 395 CTO PCI cases (mean total CTO case experience = 197.5, 60 retrograde) and NROs performed 241 CTO PCI cases (mean total CTO case experience = 24.1, <1 retrograde) during the observed timeframe. The overall technical success was 58.9% for NROs and 75.2% for ROs (p < 0.0001). The technical success rate of NROs did not change, but the technical success for the ROs increased to 90% over time (p < 0.0001 for trend, 94.4% for retrograde and 85.7% for antegrade approaches). Observed major adverse events were similar between ROs and NROs.<br>CONCLUSIONS: Complex antegrade and retrograde "Japanese style" PCI approaches can be applied in the U.S. practice environment with high technical success and low adverse event rates. Higher CTO-specific operator case volume is associated with improved technical success rates. |
| LaPar, Ailawadi, Isbell et al. (2014).<br>Mitral valve repair<br>US<br>Mitral valve repair rates correlate with surgeon and institutional experience.<br>*The Journal of Thoracic and Cardiovascular Surgery, 148*(3), 995-1003; discussion 1003-4. | OBJECTIVES: Mitral valve (MV) repair rates have lagged despite reported superior outcomes in patients with mitral regurgitation.<br>The purpose of the present study was to evaluate the relationship between procedure volume and the propensity for MV repair in a multi-institution, regional patient cohort. | METHODS: Society of Thoracic Surgeons-certified patient records of those undergoing MV repair or MV replacement (MVR) for moderate or severe mitral regurgitation were evaluated from 17 different centers (2001-2011). The relationship between the annual hospital and surgeon volume and the propensity for MV repair over MVR was analyzed using multivariable, mortality risk-adjusted models with restricted cubic splines.<br>RESULTS: A total of 4194 patients were evaluated (MV repair, 2516; MVR, 1662). The median annual mitral procedure volume was 54 operations for hospitals and 13 operations for surgeons. The overall MV repair rate was 60%, with significant variations among hospitals (range, 35%-70%) and surgeons (range, 0%-90%). The MVR patients presented with higher Society of Thoracic Surgeons Predicted Risk of Mortality scores (6% vs 2%, P /= 20 procedures annually. Among surgeons and hospitals performing >/= 20 mitral operations annually, MV repair rates were greater (73% vs 26% and 62% vs 37%, respectively, P 20 procedures annually.<br>In the upcoming era of percutaneous MV repair, surgeon volume and expertise as a gatekeeper should |

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| | | dictate access to this technology and the decisions for the best approach to MV repair. |
| Davis, Hohmann, Doukky, Levine & Johnson (2016)<br>Left ventricular assist devices<br>US<br>The impact of hospital and surgeon volume on in-hospital mortality of ventricular assist device recipients.<br>Journal of Cardiac Failure, 22(3), 226-231. | BACKGROUND: The use of left ventricular assist devices (LVADs) in the United States has increased since the Food and Drug Administration approved the 1st device in 1994. Despite a rapid increase in the number of LVADs implanted per year, there are substantial variations in procedure volume among hospitals and surgeons. This study evaluated the association between hospital and surgeon volumes of LVAD procedures and in-hospital mortality. | METHODS AND RESULTS: We conducted a retrospective cross-sectional analysis of all patient discharges after an LVAD implantation from University HealthSystem Consortium (UHC) academic medical center members from January 2007 through June 2012. With the use of International Classification of Diseases-9th Edition, Clinical Modification, procedure code 37.66, we identified 7714 patients who received an LVAD from 581 surgeons across 88 hospitals. The primary outcome was all-cause in-hospital mortality. Annual hospital and surgeon LVAD procedure volumes were evaluated as both continuous variables and quintiles. Hierarchical binary logistic regression models were fitted to test the association of in-hospital mortality with hospital and surgeon volume, controlling for hospital and patient characteristics.<br>Hospital volume was not associated with lower in-hospital mortality. Highest annual surgeon volume quintile was a significant predictor of lower in-hospital mortality (odds ratio 1.69; P < .001); this model had the highest predictive accuracy, with area under the receiver operating characteristic curve of 0.79.<br>CONCLUSIONS: Surgeons' LVAD procedure volume, not annual hospital procedure volume, was associated with in-hospital mortality. |
| Shortell & Logerfo (1981)<br>Acute myocardial infarction and appendicitis<br>US<br>Hospital Medical Staff Organization and Quality of Care: Results for Myocardial Infarction and Appendectomy<br>Medical Care, Vol.19 (10), p.1041-1055. | This article examines the relationships among hospital structural characteristics, individual physician characteristics, medical staff organization characteristics and quality of care for two conditions: acute myocardial infarction and appendicitis. | Using data obtained from the Commission on Professional and Hospital Activities (CPHA), approximately 50,000 acute myocardial infarction cases and 8,183 appendectomy cases collected from 96 hospitals in the East North Central Region of the country (Illinois, Indiana, Michigan, Ohio and Wisconsin) were examined. These data were merged with medical staff organization and related data on hospital characteristics obtained from the American Hospital Association.<br>The results indicate that such medical staff organization factors as involvement of the medical staff president with the hospital governing board, overall physician participation in hospital decision-making, frequency of medical staff committee meetings and percentage of active staff physicians on contract are positively associated with higher quality-of-care outcomes, independent of the effects of hospital and physician characteristics. Further, the medical staff organization factors appear to be somewhat more strongly associated with higher quality-of-care outcomes than the hospital and physician characteristics. For acute myocardial infarction, higher volume of patients treated per family practitioner and internist and presence of a coronary care unit were also associated with better outcomes. Given the restricted number of conditions studied, the geographically limited sample and the fact that specific variables were not consistently related to quality of care for both conditions, the results are viewed as preliminary. However, they are consistent with and extend other developing findings in this area. They also suggest that more attention needs to be given to the organization of the hospital medical staff and its articulation with the overall hospital decision-making structure and process in attempts to improve outcomes of hospitalization. |
| Nuttall, van der Meulen, McIntosh, Gillatt & Emberton (2004).<br>Urological cancer surgery | OBJECTIVE: To determine minimum threshold levels of activity set by surgeons for urological cancer sur- | METHODS: In all, 307 consultant urological surgeons were sent a questionnaire asking them to state for four urological cancer operations of different complexity their current procedural volume; whether mini- |

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| UK<br>Threshold volumes for urological cancer surgery: A survey of UK urologists.<br>BJU International, 94(7), 1010-1013. | gery, and to relate threshold levels to stated current procedural volume. | mum volume thresholds per surgeon should be implemented; and if so, the level of such thresholds; 212 (69%) replied.<br>RESULTS: For all four procedures >/= 75% of surgeons advocated the setting of a minimum volume threshold. Overall, surgeons set the highest thresholds for radical prostatectomy and the lowest for radical cystectomy with continent diversion. There was no significant association between either the principle of supporting minimum volume thresholds or the level of such a threshold and the number of years worked as a consultant surgeon. The level of surgeon-derived minimum thresholds increased with increasing surgeon procedural volume.<br>CONCLUSION: Most surgeons supported the principle of setting minimum volume thresholds. These thresholds appear to be influenced by current procedural volume and by procedural complexity. By setting thresholds greater than their current volume, some surgeons implicitly indicate that their current volume is insufficient to maintain their surgical competency. |
| McCabe, Jibawi & Javle (2007).<br>Radical cystectomy<br>England<br>Radical cystectomy: Defining the threshold for a surgeon to achieve optimum outcomes.<br>*Postgraduate Medical Journal, 83*(982), 556-560. | BACKGROUND: The reorganisation of cancer services in England will result in the creation of specialist high volume cancer surgery centres. Studies have suggested a relationship between increasing surgical volume and improved outcomes in urological pelvic cancer surgery, although to date, they have pre-defined the definition of "high" and "low" volume surgeons.<br>AIM: To derive the minimum caseload a surgeon requires to achieve optimum outcomes and to examine the effect of the operating centre size upon individual surgeon's outcomes. | METHODS: All cystectomies performed for bladder cancer in England over 5 years were analysed from Hospital Episode Statistics (HES) data. Statistical analysis was undertaken to describe the relationship between each surgeon's annual case volume and two OUTCOME MEASURES: in-hospital mortality rate, and hospital stay. The surgeon's outcomes were then analysed with respect to the overall level of activity in their operating centre.<br>RESULTS: A total of 6308 cystectomies were performed; the mean number of surgeons performing them annually was 327 with an overall mortality rate of 5.53%. A significant inverse correlation (-0.968, $p<0.01$) was found between case volume and mortality rate. Applying 95% confidence interval estimation, the minimum caseload required to achieve the lowest mortality rate was eight procedures per year. Increasing caseload beyond eight operations per year did not produce a significant reduction in mortality rate.<br>CONCLUSION: Analysis of HES data confirms an inverse relationship between surgeon's caseload and mortality for radical cystectomy. A caseload of eight operations per year is associated with the lowest mortality rate. |
| Santos et al. (2015).<br>Radical cystectomy<br>Canada<br>High hospital and surgeon volume and its impact on overall survival after radical cystectomy among patients with bladder cancer in quebec.<br>World Journal of Urology, 33(9), 1323-1330. | INTRODUCTION AND OBJECTIVES: Previous studies reported improved outcomes for bladder cancer patients who had radical cystectomy (RC) performed by surgeons and hospitals with high annual RC volumes.<br>The objective of this study was to determine the effect of high hospital and surgeon volume on overall survival after RC for bladder cancer in Quebec. | METHODS: We conducted a retrospective cohort study using data of patients who underwent RC for bladder cancer from 2000 to 2009. The cohort was obtained with the linkage of two health databases: the RAMQ database (data on medical services) and the ISQ database (vital status data). Hospital and surgeon volumes were defined as the average annual number of RC performed at an institution or by surgeon, respectively, during the study period. We considered high hospital and surgeon volume those found in the third and fourth quartiles of the distribution of hospital and surgeon volumes. The effect of high hospital and surgeon volume on survival was assessed by multivariate Cox proportional hazards models.<br>RESULTS: We analyzed a total of 2,778 patients who met inclusion criteria (75 % males). High hospital volume and surgeons were found to be significantly associated with improved overall survival (HR = 0.87, 95 % CI: 0.78-0.97 and HR = 0.81, 95 % CI: 0.71-0.91, respectively). The combined effect of high-volume hospital and high-volume surgeon decreased by |

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| | | 20 % the risk of long-term mortality (HR = 0.80, 95 % CI: 0.70-0.91).<br>CONCLUSIONS: Compared to low-volume providers, having RC for bladder cancer performed in high-volume hospitals or by high-volume surgeon was associated with improved overall survival. |
| Konety et al. (2005)<br>Radical cystectomy<br>US<br>Impact of hospital and surgeon volume on in-hospital mortality from radical cystectomy: Data from the health care utilization project.<br>The Journal of Urology, Vol.173(5), pp.1695-1700 | To determine the influence of hospital and surgeon volume on various outcome parameters after radical cystectomy for bladder cancer. | Lower mortality rate existed for high volume hospitals.<br>Surgeon volume does not have an independent effect on mortality except for patients in the 50-69 year group.<br>Patients operated on by high volume surgeons had lower length of stay. |
| Leow, Jiang, Reese et al. (2013)<br>Radical cystectomy<br>US<br>The effect of surgeon volume on the morbidity of radical cystectomy in the united states: A contemporary populationbased analysis.<br>Journal of Endourology, 27, A137. | INTRODUCTION AND OBJECTIVES: Radical cystectomy, the gold standard treatment for invasive bladder cancer, is a morbid procedure associated with high costs. In an effort to improve quality and safety, the Leapfrog Initiative calls for hospitals to meet volume/year criteria; otherwise referral to a high volume center is warranted.<br>This study evaluates the evidence behind this public health policy by examining the relationship between surgeon volume and radical cystectomy morbidity including the impact of the increasing common robotic approach. | METHODS: We captured all who underwent a radical cystectomy (ICD-9 code 57.71) between 2004 to 2010, from a nationally representative discharge database representing over 600 nonfederal hospitals across the United States. Review of the hospital chargemaster was performed to identify robotic procedures. Patient-level (age, gender, race, insurance status, Charlson comorbidity) and hospital-level (bed size, teaching status, location) characteristics were evaluated. Volume was based on the annual number of cystectomies performed by surgeon in the year the procedure was performed on a given patient (low: 6 cases). Propensity-weighting statistical techniques were employed to reduce selection bias. Survey weighting with cluster analysis was performed to ensure nationally representative estimates. The outcomes of interest were 90-day major complications (Clavien 3-5) as defined by ICD-9 diagnosis codes, and mean inpatient length of stay (LOS).<br>RESULTS: The weighted cohort included 43,506 radical cystectomies (41,484 non-robotic and 2022 robotic) during the study period with an overall major complication rate of 17.2%. High volume surgeons were associated with a 20% decreased odds for major complications (OR 0.80, p = 0.03) and 1.2 days shorter LOS (p = 0.02). Compared to non-robotic surgery, robotic radical cystectomy had similar 90-day major complication rates (p = 0.63) but a 1.9 day shorter LOS (p < 0.01) (Fig 1).<br>CONCLUSIONS: Our contemporary evaluation of radical cystectomy suggests that by encouraging centralization of complex (Graph Presented) surgical procedures to high-volume providers, the Leapfrog Initiative would reduce the overall burden of disease associated with radical cystectomy. The impact of robotic cystectomy warrants further evaluation. |
| Morgan, Barocas, et al. (2012).<br>Radical cystectomy<br>US<br>Volume outcomes of cystectomy-is it the surgeon or the setting?<br>The Journal of Urology, 188(6), 2139-2144. | PURPOSE: Hospital volume and surgeon volume are each associated with outcomes after complex oncological surgery. However, the interplay between hospital and surgeon volume, and their impact on these outcomes has not been well characterized.<br>We studied the relationship between surgeon and hospital volume, and overall | MATERIALS AND METHODS: The SEER (Surveillance, Epidemiology and End Results)-Medicare linked database was used to identify 7,127 patients with urothelial carcinoma of the bladder who underwent radical cystectomy from 1992 to 2006. Hospital volume and surgeon volume were expressed by tertile. The primary outcome measure was overall survival. Covariates included age, Charlson comorbidity index, stage, grade, node count, node density, number of positive nodes, urinary diversion and year of surgery. Multivariate analyses using generalized linear multilevel models were used to determine the independent association between hospital and surgeon volume and survival. |

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| | mortality after radical cystectomy. | RESULTS: When hospital volume or surgeon volume was included in the multivariate model, a significant volume-survival relationship was observed for each. However, when both were in the model, hospital volume attenuated the impact of surgeon volume on mortality while the significant hospital volume-mortality relationship persisted (HR 1.18, 95% CI 1.08-1.30, p <0.01). In addition, the adjusted 3-year probability of survival was significantly correlated with hospital volume in each distinct surgeon volume stratum while survival was not correlated with surgeon volume in each hospital volume stratum.<br>CONCLUSIONS: After adjustment for patient and disease characteristics, the relationship between surgeon volume and survival after radical cystectomy is accounted for by hospital volume. In contrast, hospital volume remained an independent predictor of survival, suggesting that structure and process characteristics of high volume hospitals drive long-term outcomes after radical cystectomy. |
| Chen, Cheung & Sosa (2012)<br>Pediatric cholecystectomies<br>US<br>Surgeon volume trumps specialty: outcomes from 3596 pediatric cholecystectomies<br>Journal of Pediatric Surgery, Vol.47(4), pp.673-680 | Background: Laparoscopic cholecystectomy is the standard surgical management of biliary disease in children, but there has been a paucity of studies addressing outcomes after pediatric cholecystectomies, particularly on a national level.<br>We conducted the first study to address the effect of surgeon specialty and volume on clinical and economic outcomes after pediatric cholecystectomies on a population level. | Methods:We conducted a retrospective cross-sectional study using the Health Care Utilization Project Nationwide Inpatient Sample. Children (≤17 years) who underwent laparoscopic cholecystectomy from 2003 to 2007 were selected. Pediatric surgeons performed 90% or higher of their total cases in children. High-volume surgeons were in the top tertile (n ≥ 37 per year) of total cholecystectomies performed. χ2, Analyses of variance, and multivariate linear and logistic regression analyses were used to assess in-hospital complications, median length of hospital stay (LOS), and total hospital costs (2007 dollars).<br>Results: A total of 3596 pediatric cholecystectomies were included. Low-volume surgeons had more complications, longer LOS, and higher costs than high-volume surgeons. After adjustment in multivariate regression, surgeon volume, but not specialty, was an independent predictor of LOS and cost.<br>Conclusions: High-volume surgeons have better outcomes after pediatric cholecystectomy than low-volume surgeons. To optimize outcomes in children after cholecystectomy, surgeon volume and laparoscopic experience should be considered above surgeon specialty. |
| Leow, Feldman et al. (2014)<br>Partial nephrectomy<br>US<br>The impact of surgeon volume on the morbidity and costs of partial nephrectomy in the united states: A contemporary population-based analysis.<br>Journal of Urology.Conference: 2014 Annual Meeting of the American Urological Association, AUA.Orlando, FL United States.Conference Start: 20140516.Conference End: 20140521.Conference Publication: (Var.Pagings), 191(4 SUPPL. 1), e708. | INTRODUCTION AND OBJECTIVES: Partial nephrectomy (PN), the standard treatment for T1 renal cell carcinoma, is associated with substantial morbidity and costs.<br>This study evaluates the relationship between hospital volume of PN and postoperative morbidity as well as the economic burden of kidney cancer in the United States. | METHODS: We captured all patients who underwent a PN (ICD-9 code 55.4) using a nationwide hospital discharge database that gathers data from over 600 non-federal hospitals across the United States. Multivariable regression models were developed to evaluate outcomes including 90-day complications (grouped by Clavien classification) and direct patient costs. We adjusted for patient (age, gender, race, Charlson comorbidity, insurance status), hospital (bedsize, teaching status, urban vs rural, region) and surgical (year of surgery, type of approach, surgeon volume and hospital volume) characteristics, including clustering by hospitals and survey weighting to achieve nationally representative estimates.<br>RESULTS: The weighted cohort included 134,215 patients undergoing PN. The median cost of surgery was $14,068. The overall 90-day mortality (Clavien 5), major (Clavien 3-5), minor (Clavien 1-2) complication and readmission rate of 0.28%, 4.4%, 24.8% and 6.4% respectively. Compared to patients who did not have any complications, those who suffered a major complication incurred significantly higher costs (+$14260, p<0.001). With every 10-case increase in annual surgeon volume, there was a 4.0% decreased |

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| | | odds of major complications (OR: 0.96, p=0.03) and $189 decrease in 90-day direct hospital costs (p=0.002). Hospital volume was collinear with surgeon volume and was not found to be a predictor of complications or costs in the multivariable model.<br>CONCLUSIONS: We demonstrate an inverse relationship between surgeon volume and the development of postoperative 90-day major complication rates for patients undergoing PN. Higher volume surgeons are also associated with modestly lower direct hospital costs. Surgeon volume appears to be a major driver for reducing morbidity and costs. Centralization of PN to high volume surgeons may reduce the development of postoperative major complications and disease burden of kidney cancer. |
| Toren, Abouassaly et al. (2012).<br>Nephrectomy<br>Canada<br>Does surgeon and hospital volume affect outcomes for surgery for renal cell carcinoma with inferior vena cava involvement? - results of a national population based study.<br>Journal of Urology.Conference: 2012 Annual Meeting of the American Urological Association, AUA.Atlanta, GA United States. (Var.Pagings), 187(4 SUPPL. 1), e523. | INTRODUCTION AND OBJECTIVES: In several major surgical procedures, an association with provider volume and outcomes has been seen, justifying a centralization of these procedures. Radical nephrectomy with removal of inferior vena cava (IVC) thrombus is a relatively rare, but large and complex operation in urology.<br>Using Canada-wide population based data, we determined to assess whether surgeon or hospital volume had an effect on in-hospital mortality and complications. | METHODS: The Canadian Institute for Health Information- (CIHI) Canadian Classification of Health Intervention(CCI) codes and Canadian Classification of Diagnostic, Therapeutic, and Surgical Procedures (CCP) codes were used to identify all nephrectomies associated with IVC thrombus performed in 9/10 Canadian provinces from 1998-2007. The CIHI Discharge Abstract Database (DAD) was used to assess in-hospital mortality and surgical complication rates for each procedure. The Charlson Co-morbidity Index (CCI) for each patient was calculated from ICD-9 and ICD-10 codes. Patients were excluded who underwent a partial nephrectomy, laparoscopic nephrectomy or had incomplete data.<br>RESULTS: During the study period, 816 nephrectomies associated with venous thrombus were performed on 521 men and 295 women. The in-hospital mortality rate was 7% (59 patients); surgical complications were noted in 122 (15%) of patients. Age and comorbidity were the strongest predictors of in hospital mortality on multivariate logistic analysis. Multivariate logistic regression analysis showed a trend to lower in-hospital mortality with higher surgeon volume which was significant at the highest quartile (OR for highest vs lowest quartile 0.42(0.0.18-0.98; P=0.05)). This relationship was not seen with hospital volume (P= 0.34). Over time, more surgeries were performed by the higher quartile surgeons. Most (65%) surgical complications were split between the highest and lowest quartiles of surgeon volume. With increasing hospital volume, there was a trend for increased complications on multivariate analysis (OR 2.1 (2.1-4.1; P=0.03).<br>CONCLUSIONS: For radical nephrectomies associated with IVC thrombus, increasing surgeon volume, but not hospital volume, corresponded to lower in-hospital mortality rates. Age and co-morbidity remain the strongest predictors of in-hospital mortality. Higher hospital volume quartile was associated with higher surgical complications. |
| Park, Roman & Sosa (2009)<br>Adrenalectomies<br>US<br>Outcomes From 3144 Adrenalectomies in the United States: Which Matters More, Surgeon Volume or Specialty?<br>Archives of Surgery, Vol.144(11), p.1060 | To assess the effect of surgeon volume and specialty on clinical and economic outcomes after adrenalectomy. | Population-based retrospective cohort analysis. Healthcare Cost and Utilization Project Nationwide Inpatient Sample. Adults (≥18 years) undergoing adrenalectomy in the United States (1999-2005). Patient demographic and clinical characteristics, surgeon specialty (general vs urologist), surgeon adrenalectomy volume, and hospital factors were assessed. The X... test, analysis of variance, and multivariate linear and logistic regression were used to assess in-hospital complications, mean hospital length of stay (LOS), and total inpatient hospital costs. A total of 3144 adrenalectomies were included. Mean patient age was 53.7 years; 58.8% were women and 77.4% |

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| | | white. A higher proportion of general surgeons were high-volume surgeons compared with urologists (34.1% vs 18.2%, P < .001). Low-volume surgeons had more complications (18.2% vs 11.3%, P < .001) and their patients had longer LOS (5.5 vs 3.9 days, P < .001) than did high-volume surgeons; urologists had more complications (18.4% vs 15.2%, P = .03) and higher costs ($13 168 vs $11 732, P = .02) than did general surgeons. After adjustment for patient and provider characteristics in multivariate analyses, surgeon volume, but not specialty, was an independent predictor of complications (odds ratio = 1.5, P < .002) and LOS (1.0-day difference, P < .001). Hospital volume was associated only with LOS (0.8-day difference, P < .007). Surgeon volume, specialty, and hospital volume were not predictors of costs. To optimize outcomes, patients with adrenal disease should be referred to surgeons based on adrenal volume and laparoscopic expertise irrespective of specialty practice. |
| Munoz, Boiardo, Mulloy, Goldstein, Brewster & Wise (1990)<br>Economies of scale, physician volume for urology patients, and DRG prospective hospital payment system.<br>Urology, 36(5), 471-476. | Diagnosis Related Group (DRG) hospital payment has begun to squeeze hospitals financially and is likely to do so in the future. This study analyzed the relationship between the volume of urologic procedures by an individual urologist, hospital costs per patient, and outcome. | We used a three-year DRG database of urology patients (N = 2,980) at an academic medical center to analyze these. Low-volume urologists (arbitrarily defined by us) had higher hospital costs per patient, financial losses versus profits under DRGs, and a poorer outcome when compared with high-volume urologists. Pearson correlation showed a positive relationship between cost per patient and physician volume for nonemergency patients (-0.129, p less than 0.0001) and emergency patients (-0.368, p less than 0.0001). This may have been explained (in part) by a greater severity of illness for patients of low-volume urologists.<br>These findings suggest, however, that the volume of urologic procedures per urologist may be related to hospital resource consumption. The health care financing environment of the future should provide substantial interest in this finding for those involved in the consumption of urologic services. |
| Bianco, Riedel et al. (2005).<br>Radical prostatectomy<br>US<br>Variations among high volume surgeons in the rate of complications after radical prostatectomy: Further evidence that technique matters. The<br>Journal of Urology, 173(6), 2099-2103. | PURPOSE: A strong association between surgeon, hospital volume and postoperative morbidity of radical prostatectomy has been demonstrated. While better outcomes are associated with high volume surgeons, the degree of variation in outcomes among surgeons has not been fully examined. | MATERIALS AND METHODS: Using a linked database from Surveillance, Epidemiology and End Results registries and federal Medicare claims data, we analyzed outcomes of consecutive patients treated with radical prostatectomy between 1992 and 1996. We focused on variations in several measures of morbidity (perioperative complications, late urinary complications and long-term incontinence) among patients of high volume surgeons, defined as those with 20 or more patients in the study period. After adjusting for hospital, surgeon volume and case mix, we examined the extent to which variations in the rates of adverse outcomes differed among surgeons for all 3 end points.<br>RESULTS: Of the 999 surgeons 16% (159) performed 48.7% (5,238) of the 10,737 radical prostatectomies during the study. The 30-day mortality rate was 0.5%, the major postoperative complication rate was 28.6%, late urinary complications 25.2% (major events 16%) and long-term incontinence 6.7%. For all 3 morbidity outcomes the variation among surgeons in the rate of complications was significantly greater than that expected by chance (p =0.001 for each) after adjustment of covariates. Furthermore, surgeons with better (or worse) than average results with regard to 1 outcome were likely to have better (or worse, respectively) results with regard to the other 2 outcome measures. |

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| | | CONCLUSIONS: Morbidity end points that directly affect quality of life showed significant variability among high volume providers. Surgeons who performed well in 1 area (eg postoperative complications) performed well in others. These results further suggest that variations in surgical technique and postoperative care lead to variations in outcomes after radical prostatectomy, indicating that outcomes of this operation are sensitive to small differences in performance. |
| Begg, Riedel, Bach et al. (2002)<br>Radical prostatectomy for prostate cancer<br>US<br>Variations in morbidity after radical prostatectomy.<br>The New England Journal of Medicine, 346(15), 1138-1144. | BACKGROUND: Recent studies of surgery for cancer have demonstrated variations in outcomes among hospitals and among surgeons. We sought to examine variations in morbidity after radical prostatectomy for prostate cancer. | METHODS: We used the Surveillance, Epidemiology, and End Results-Medicare linked data base to evaluate health-related outcomes after radical prostatectomy. The rates of postoperative complications, late urinary complications (strictures or fistulas 31 to 365 days after the procedure), and long-term incontinence (more than 1 year after the procedure) were inferred from the Medicare claims records of 11,522 patients who underwent prostatectomy between 1992 and 1996. These rates were analyzed in relation to hospital volume and surgeon volume (the number of procedures performed at individual hospitals and by individual surgeons, respectively).<br>RESULTS: Neither hospital volume nor surgeon volume was significantly associated with surgery-related death. Significant trends in the relation between volume and outcome were observed with respect to postoperative complications and late urinary complications. Postoperative morbidity was lower in very-high-volume hospitals than in low-volume hospitals (27 percent vs. 32 percent, P=0.03) and was also lower when the prostatectomy was performed by very-high-volume surgeons than when it was performed by low-volume surgeons (26 percent vs. 32 percent, P<0.001). The rates of late urinary complications followed a similar pattern. Results for long-term preservation of continence were less clear-cut. In a detailed analysis of the 159 surgeons who had a high or very high volume of procedures, wide surgeon-to-surgeon variations in these clinical outcomes were observed, and they were much greater than would be predicted on the basis of chance or observed variations in the case mix.<br>CONCLUSIONS: In men undergoing prostatectomy, the rates of postoperative and late urinary complications are significantly reduced if the procedure is performed in a high-volume hospital and by a surgeon who performs a high number of such procedures. |
| Gonzalez-Sanchez et al. (2013)<br>Morbidity following thyroid surgery: Does surgeon volume matter?<br>Langenbeck's Archives of Surgery, 398(3), 419-422. | PURPOSE: The aim of our study was to analyze the relationship between surgeon volume and morbidity in patients operated on by surgeons with endocrine specialization (EndS group) and those operated on by general surgeons (GenS group) in a single tertiary institution. | METHODS: We present the results of a prospective cohort study of all patients undergoing thyroid surgery in our institution between January 2008 and January 2010, all of whom attended for follow-up for at least 12 months. We assessed pre- and postoperative recurrent laryngeal nerve (RLN) function by laryngoscopy. We monitored serum calcium concentrations in all patients until these values were normal without vitamin D and oral calcium supplementation.<br>RESULTS: We studied 225 patients: 30 in the GenS group (six surgeons performing 40 procedures per surgeon per year). The total number of exposed RLN was 46 and 325, respectively. The incidence of RLN palsy persisting beyond 12 months was higher in the GenS group (2/46 vs. 1/325 exposed RLNs, p = 0.04). The incidence of hypocalcaemia persisting beyond 12 months (bilateral procedures) was also higher in the GenS group (3/16 vs. 3/130 patients, p = 0.028).<br>CONCLUSIONS: Morbidity in terms of permanent RLN palsy and hypocalcaemia was less frequent |

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| | | among patients operated on by endocrine-dedicated surgeons. Differences in surgical volume and specialized training in neck endocrine surgery may explain these variations in morbidity. |
| Adkisson, Howell et al. (2014)<br>Thyroidectomy<br>Surgeon volume and adequacy of thyroidectomy for differentiated thyroid cancer.<br>Surgery, 156(6), 1453-59; discussion 1460. | INTRODUCTION: We aimed to determine influence of surgeon volume on (1) frequency of appropriate initial surgery for differentiated thyroid cancer (DTC) and (2) completeness of resection. | METHODS: We reviewed all initial thyroidectomies (Tx; lobectomy and total) performed in a health system during 2011; surgeons were grouped by number of Tx cases per year. For patients with histologic DTC >/= 1 cm, surgeon volume was correlated with initial extent of the operation, and markers of complete resection including uptake on I(123) prescan, thyrotropin-stimulated thyroglobulin levels, and I(131) dose administered.<br>RESULTS: Of 1,249 patients who underwent Tx by 42 surgeons, 29% had DTC >/= 1 cm without distant metastasis. At a threshold of >/= 30 Tx per year, surgeons were more likely to perform initial total Tx for DTC >/= 1 cm (P = .01), and initial resection was more complete as measured by all 3 quantitative markers. For patients with advanced stage disease, a threshold of >/= 50 Tx per year was needed before observing improvements in I(123) uptake (P = .004).<br>CONCLUSION: Surgeons who perform >/= 30 Tx a year are more likely to undertake the appropriate initial operation and have more complete initial resection for DTC patients. Surgeon volume is an essential consideration in optimizing outcomes for DTC patients, and even higher thresholds (>/= 50 Tx/year) may be necessary for patients with advanced disease. |
| Stavrakis, Ituarte et al. (2007).<br>Endocrine surgery<br>US<br>Surgeon volume as a predictor of outcomes in inpatient and outpatient endocrine surgery. Surgery, 142(6), 887-99. | Background: Surgeon experience correlates with improved outcomes for complex operations. Endocrine operations are increasingly performed in the outpatient setting, where outcomes have not been systematically studied.<br>We examined the effect of surgeon volume on clinical and economic outcomes for thyroid, parathyroid, and adrenal surgery across inpatient and outpatient settings. | Methods: New York and Florida state discharge data (2002) were studied. Surgeons were grouped by annual endocrine operative volume: Group A, 1 to 3 operations; B, 4 to 8; C, 9 to 19; D, 20 to 50; E, 51 to 99; and F, ≥100. Multiple regression analyses were applied to analyze complications, length of stay (LOS), and total charges (TC), while controlling for comorbidity, economic factors, and hospital-centric variables.<br>Results: We identified 13,997 discharges, with 28% of operations performed on an outpatient basis (admission/discharge on same calendar day). For all cases, group A contributed disproportionately more complications (observed/expected [O/E] 1.65, *P* < .001) and Group F contributed disproportionately less (0.52; *P* < .001). High surgeon volume was associated with decreased LOS and reduced TC. Hospital volume had a negligible effect on outcomes.<br>Conclusions: Surgeon volume correlates inversely with complication rates, LOS, and TC, in endocrine surgery. The lowest complication rates are achieved by surgeons performing ≥100 endocrine operations annually. |
| Bell, Hatch, Cernat et al. (2007)<br>Cataract surgery<br>Surgeon volumes and selected patient outcomes in cataract surgery: A population-based analysis.<br>Ophthalmology, 114(3), 405-410. | OBJECTIVE: To study the association of annual surgeon volume of cataract procedures with the risk of postoperative adverse events.<br>DESIGN: We used population-based administrative health records to conduct a retrospective cohort study from 2001 through 2003. | METHODS: We calculated cataract surgery volume for each surgeon and tested for the presence of a volume-outcome association. We used generalized estimating equations to account for the effect of clustering of patients according to individual surgeons and to adjust estimates for the potential confounding effects of patient age and gender.<br>MAIN OUTCOME MEASURES: We used a composite outcome of postoperative adverse events from cataract surgery that included billing claims for vitrectomy, vitreous aspiration or injection of medication, vitreous air or fluid exchange, and dislocated lens extraction performed by any ophthalmologist between 1 and 14 days after cataract surgery. These procedures |

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| | PARTICIPANTS: The number of surgeons who performed more than 50 cataract surgeries annually ranged from 231 to 243 over the 3 years. There were 284 797 cataract surgeries in patients older than 20 years performed at 70 hospitals or eye surgery centers in the province of Ontario, Canada. | are surrogate markers for the outcomes of retinal detachment, lost lens or lens fragment, and suspected endophthalmitis.<br>RESULTS: In each year, fewer than 1 in 200 patients experienced an adverse event (range, 0.33%-0.41%). Surgeons performing 50 to 250 cataract surgeries per year had an adverse event rate of 0.8%. Surgeons performing 251 to 500 cataract surgeries per year had an adverse event rate of 0.4% and an adjusted odds ratio of postoperative adverse events of 0.52 (95% confidence interval [CI], 0.39-0.69) compared with surgeons performing 50 to 250 procedures per year. Surgeons performing 501 to 1000 cataract surgeries per year had an adverse event rate of 0.2% and an adjusted odds ratio of 0.31 (95% CI, 0.22-0.43), and surgeons performing more than 1000 cataract surgeries per year had an adverse event rate of 0.1% and an adjusted odds ratio of 0.14 (95% CI, 0.09-0.23). CONCLUSIONS: Selected adverse event rates for surgeons performing more than 50 cataract surgeries per year are low. There is a volume-outcomes relationship for cataract surgery, and this relationship persists even for very high-volume surgeons. |
| Kantonen et al. (1998a).<br>Surgery for chronic critical leg ischemia<br>Finland<br>Factors affecting the results of surgery for chronic critical leg ischemia--a nationwide survey. finnvasc study group.<br>Journal of Vascular Surgery, 27(5), 940-947. | PURPOSE: To assess the factors affecting immediate outcome of surgery for chronic critical leg ischemia, especially the influence of surgeon's caseload and hospital volume. | METHODS: The data of Finnvasc registry were retrospectively analyzed. A total of 11,747 surgical vascular reconstructions included 1,761 operations for chronic critical leg ischemia during 1991 to 1994.<br>RESULTS: The 30-day postoperative leg amputation rate was 7.5% and the mortality rate 4.7%. Diabetes, previous vascular surgery or amputation, preoperative ulcer or gangrene, a surgeon's annual caseload fewer than 10 operations, and hospital volume fewer than 20 operations for chronic critical leg ischemia adversely affected amputation rates. The presence of coronary artery disease and renal dysfunction increased postoperative mortality rates. Both amputation rates and postoperative mortality rates were affected by the type of procedure.<br>CONCLUSIONS: A surgeon's caseload and hospital volume affect amputation rate, but not mortality rate, in patients operated for chronic critical leg ischemia. |
| Kantonen et al. (1998b)<br>Carotid surgery<br>Finland<br>Influence of surgical experience on the results of carotid surgery. The finnvasc study group.<br>European Journal of Vascular and Endovascular Surgery: The Official Journal of the European Society for Vascular Surgery, 15(2), 155-160. | OBJECTIVE: To assess the 30-day mortality and morbidity rates related to carotid endarterectomy on a nation-wide basis.<br>DESIGN: Retrospective cross-sectional study based on vascular registry Finnvasc. | MATERIALS AND METHODS: A total of 17,465 recorded vascular and endovascular procedures included exactly 1600 carotid endarterectomies performed by 104 surgeons in 23 hospitals. Fourteen per cent of the patients were operated on for asymptomatic carotid stenosis.<br>RESULTS: The combined mortality and permanent stroke rate was 3.3%, without any difference between operations done on symptomatic or asymptomatic patients. There was a clear inverse association between surgeon's carotid case load and poor outcomes in carotid surgery ($p < 0.005$), the critical patient mass per surgeon and year being 10 operations. There was no association between outcome after carotid surgery and hospital volume of carotid operations.<br>CONCLUSIONS: Surgeon's experience in carotid surgery clearly improves the results of carotid surgery. |
| Matsen, Perler et al. (2002).<br>Carotid endarterectomy<br>US<br>The distribution of carotid endarterectomy procedures among surgeons and hospitals in new york state: Is regionalization | INTRODUCTION: In a published analysis of all carotid endarterectomies (CEAs) performed in New York state from 1990 to 1995, perioperative mortality rate was inversely correlated with surgeon and | METHODS: The database of the Center for Medical Consumers was queried to determine the volume distribution among surgeons and hospitals of all CEAs performed in New York state in 1999 and 2000.<br>RESULTS: During 1999, 695 surgeons in 169 hospitals performed 9458 CEAs (mean, 13.6 per surgeon). Three hundred fifty-three surgeons (51%) performed |

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| of specialized vascular care occurring? Journal of Vascular Surgery, 36(6), 1146-1153. | hospital CEA volume, was significantly higher when CEAs were performed by surgeons who performed less than five CEAs annually, and was significantly lower in hospitals where surgeons performed more than 100 CEAs annually.<br>The purpose of this study was to determine whether this information has influenced practice patterns in New York state. | less than five CEAs, and 180 (26%) performed only one CEA during the year. Only 41 surgeons (6%) performed more than 50 CEAs. Likewise, in only 28 of the hospitals (17%) were more than 100 CEAs performed during 1999, whereas in 73 of the hospitals (43%) 20 or less CEAs were carried out during the year. During 2000, 684 surgeons performed 8196 CEAs in 165 hospitals. Three hundred fifty-three (52%) performed less than five CEAs, and 229 (33%) performed only one CEA during the year. Only 33 surgeons (5%) performed more than 50 CEAs during 2000. In only 26 hospitals (16%) were more than 100 CEAs performed during 2000, whereas in 71 hospitals (43%) 20 or less CEAs were carried out.<br>CONCLUSION: It appears that published compelling evidence that operator and institutional volume influence outcome has not influenced referral patterns or led to a regionalization of CEA care in New York state. Robust educational programs directed to patients and referring physicians appear indicated. |
| Hawkins et al. (2015).<br>Carotid stenting<br>Hospital variation in carotid stenting outcomes. JACC.Cardiovascular Interventions, 8(6), 858-863. | OBJECTIVES: The aim of this study was to examine variation in outcomes for patients receiving carotid artery stenting (CAS) across a sample of U.S. hospitals and assess the extent to which this variation was attributable to differences in case mix and procedural volume.<br>BACKGROUND: As CAS is increasingly being used throughout the United States, assessing hospital variation in CAS outcomes is critical to understanding and improving the quality of care for patients with carotid artery disease. | METHODS: Hospitals participating in the National Cardiovascular Data Registry-Carotid Artery Endarterectomy and Revascularization Registry contributing more than 5 CAS procedures from 2005 through 2013 were eligible for inclusion. We estimated unadjusted and risk-standardized rates of in-hospital stroke or death for each participating hospital using a previously validated prediction model and applying hospital-level random effects.<br>RESULTS: There were 188 hospitals contributing 19,381 CAS procedures during the period of interest. Unadjusted and risk-standardized in-hospital stroke or death rates ranged from 0% to 18.8% and 1.2% to 4.7%, respectively. Operator and hospital volumes were not significant predictors of outcomes after adjustment for case mix (p = 0.15 and p = 0.09, respectively).<br>CONCLUSIONS: CAS outcomes vary 4-fold among hospitals, even after adjustment for differences in case mix. Future work is needed to identify the sources of this variation and develop initiatives to improve patient outcomes. |
| Jalber et al. (2015).<br>Carotid artery stenting<br>US<br>Relationship between physician and hospital procedure volume and mortality after carotid artery stenting among medicare beneficiaries.<br>Circulation.Cardiovascular Quality and Outcomes, 8(6 Suppl 3), S81-9. | BACKGROUND: Clinical trials demonstrated the efficacy of carotid artery stenting (CAS) relative to carotid endarterectomy when performed by physicians with demonstrated proficiency.<br>It is unclear how CAS performance may be influenced by the diversity in CAS and non-CAS provider volumes in routine clinical practice. | METHODS AND RESULTS: We linked Medicare claims to the Centers for Medicare and Medicaid Services' CAS Database (2005-2009). We assessed the association between 30-day mortality and past-year physician (0, 1-4, 5-9, 10-19, >/=20) and hospital (/=40) CAS volumes and past-year hospital coronary and peripheral stenting volumes (/=850) among beneficiaries at least 66 years of age. Unadjusted 30-day mortality risk was 1.8% (95% confidence interval [CI], 1.6-2.0) for 19 724 patients undergoing CAS by 2045 physicians in 729 hospitals. Median past-year CAS volume was 9 (interquartile range, 4-19) for physicians and 23 (interquartile range, 12-41) for hospitals. Compared to physicians performing >/=20 CAS in the past year, lower CAS volumes were associated with higher adjusted risks of 30-day mortality (P value for trend < 0.05): 1.4 (95% CI, 0.9-2.3) for 0 past-year CAS, 1.3 (95% CI, 0.9-1.8) for 1 to 4, 1.1 (95% CI, 0.8-1.6) for 5 to 9, and 0.9 (95% CI, 0.7-1.4) for 10 to 19. An inverse relationship between 30-day mortality and past-year CAS hospital volume as well as past-year hospital non-CAS volume, past-year hospital non-CAS volume, and 30-day mortality was also noted. |

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| | | CONCLUSIONS: Among Medicare patients, an inverse relationship exists between physician and hospital CAS volumes and hospital non-CAS stenting volume and 30-day mortality, even after adjusting for all pertinent patient- and hospital-level factors. |
| Badheka et al. (2014a)<br>Carotid artery stenting<br>US<br>Impact of symptoms, gender, comorbidities, and operator volume on outcome of carotid artery stenting (from the nationwide inpatient sample [2006 to 2010]).<br>The American Journal of Cardiology, 114(6). | The main objectives of our study were to evaluate the postprocedural mortality and complications after CAS and the patterns of resource utilization in terms of length of stay (LOS) and cost of hospitalization. | A total of 13,564 CAS procedures (weighted n = 67,344) were analyzed. The overall postprocedural mortality was low at 0.5%, whereas the complication rate was 8%, both of which remained relatively steady over the time frame of the study. Greater postoperative mortality and complications were noted in symptomatic patients, women, and those with greater burden of baseline co-morbidities. A greater operator volume was associated with a lower rate of postoperative mortality and complications, as well as shorter LOS and lesser hospitalization costs.<br>In conclusion, the postprocedural mortality after CAS has remained low over the recent years. Operator volume is an important predictor of postprocedural outcomes and resource utilization. |
| Vogel, Dombrovskiy et al. (2010).<br>Carotid artery stenting<br>US<br>Carotid artery stenting in the nation: The influence of hospital and physician volume on outcomes. Vascular and Endovascular Surgery, 44(2), 89-94. | OBJECTIVES: To assess national outcomes of carotid artery stenting (CAS) with respect to hospital and practitioner volume. | METHODS: The 2005 to 2006 Nationwide Inpatient Sample (NIS) was used to assess CAS with respect to hospital volume, physician volume, and associated complications.<br>RESULTS: Eighteen thousand five hundred ninety-nine CAS interventions were identified. The top 25% was used to define high-volume hospitals (>60 CAS/2 years) and practitioners (>30 CAS/2 years). The stroke rate after CAS was significantly different between low- and high-volume hospitals (2.35% vs 1.78%, respectively; P = .0206). The stroke rate after CAS was also significantly different between low- and high-volume practitioners (2.19% vs 1.51%, P = .0243). Hospital resource use varied significantly between low- and high-volume hospitals (length of stay [LOS]: 1.64 +/- 2.10 vs 1.45 +/- 11.21, P = .0006; total charges: $32 261 +/- 20 562 vs $30 131 +/- 19 592, P = .0047) and practitioners (LOS: 1.70 +/- 2.14 vs 1.36 +/- 1.36; P < .0001; total charges: $33 762 +/- 21 081 vs $23 957 +/- 19 713; P < .0001).<br>CONCLUSIONS: This analysis demonstrates that hospital and physician volume are associated with outcomes and utilization after CAS. High-volume hospitals and practitioners were associated with lower procedure stroke rates and decreased hospital resource utilization. |
| Burns, Bottle, Aylin et al. (2011)<br>Proctocolectomy<br>England<br>Volume analysis of outcome following restorative proctocolectomy. The British Journal of Surgery, 98(3), 408-417. | BACKGROUND: This observational study aimed to determine national provision and outcome following pouch surgery (restorative proctocolectomy, RPC) and to examine the effect of institutional and surgeon caseload on outcome. | METHODS: All patients undergoing primary RPC between April 1996 and March 2008 in England were identified from the administrative database Hospital Episode Statistics. Institutions and surgeons were categorized according to the total RPC caseload performed over the study interval.<br>RESULTS: Some 5771 primary elective pouch procedures were undertaken at 154 National Health Service hospital trusts. Median follow-up was 65 (interquartile range (i.q.r.) 28-106) months. The 30-day in-hospital mortality rate was 0.5 per cent and the 1-year overall mortality rate 1.5 per cent. Some 30.5 per cent of trusts performed fewer than two procedures per year, and 91.4 per cent of surgical teams (456 of 499) carried out 20 or fewer RPCs over 8 years. Median surgeon volume was 4 (i.q.r. 1-9) cases. Failure occurred in 6.4 per cent of cases. Low-volume surgeons operated on more patients at the extremes of age (P < 0.001) and a lower proportion with ulcerative colitis (P < 0.001). Older age, increasing co-morbidity, increasing social deprivation, and |

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| | | both lower provider and surgeon caseload were independent predictors of longer length of stay. Older patient age and low institutional volume status were independent predictors of failure.<br>CONCLUSION: Many English institutions and surgeons carry out extremely low volumes of RPC surgery. Case selection differed significantly between high- and low-volume surgeons. Institutional volume and older age were positively associated with increased pouch failure. |
| Falcoz et al. (2014).<br>Lung cancer surgery<br>France<br>The impact of hospital and surgeon volume on the 30-day mortality of lung cancer surgery: A nation-based reappraisal. The Journal of Thoracic and Cardiovascular Surgery, 148(3), 841-8; discussion 848. | OBJECTIVE: Our objective was to analyze the time trend variation of 30-day mortality after lung cancer surgery, and to quantify the impact of surgeon and hospital volumes over a 5-year period in France. | METHODS: We used Epithor, the French national thoracic database and benchmark tool, which catalogues more than 180,000 procedures of 89 private and public hospitals in France. From January 2005 to December 2010, 19,556 patients who underwent major lung resection (lobectomy, bilobectomy, pneumonectomy) were included in our study. Multilevel logistic models were designed to investigate the relationship between 30-day mortality and surgeon (model 1) or hospital (model 2) volumes. The 3 levels considered were the patient, the surgeon, and the hospital.<br>RESULTS: From 2005 to 2007, the 30-day mortality of patients who underwent major lung resection averaged 10%, and then decreased until it reached 3.8% in 2010 (P < .0001). A significant decrease in 30-day mortality was observed over time (P = .0046). During the study period, the mean annual number of procedures per surgeon was 46.1 (standard deviation [SD] = 23.6) and per hospital was 97.9 (SD = 50.8). Model 1 showed that surgeon volume had a significant impact on 30-day mortality (P = .03), whereas model 2 failed to show that hospital volume influenced 30-day mortality (P = .75).<br>CONCLUSIONS: Since 2007, when France's first National Cancer Plan became effective, 30-day mortality of primary lung cancer surgery has decreased and currently measures 3.8%. Low mortality was correlated with higher surgeon volume but was not influenced by hospital volume, which cannot be considered a proxy measure for determining the safety of lung cancer surgery. |
| Hannan et al. (1998).<br>Pediatric cardiac surgery<br>US<br>Pediatric cardiac surgery: The effect of hospital and surgeon volume on in-hospital mortality.<br>Pediatrics, 101(6), 963-969. | To examine the relationship between annual provider (hospital and surgeon) volume of pediatric cardiac surgery and in-hospital mortality. | DESIGN: Population-based retrospective cohort study using a clinical database. SETTING: The 16 acute care hospitals in New York with certificate of need approval to perform pediatric cardiac surgery. PATIENTS: All children undergoing congenital heart surgery in New York from 1992 to 1995. MAIN OUTCOME MEASURES: Risk-adjusted mortality rates for various hospital and surgeon volume ranges. Adjustments were made for severity of illness using logistic regression.<br>RESULTS: A total of 7169 cases were analyzed. After controlling for severity of preprocedural illness using clinical risk factors, hospitals with annual pediatric cardiac surgery volumes of fewer than 100 had significantly higher mortality rates (8.26%) than hospitals with volumes of 100 or more (5.95%), and surgeons with annual volumes of fewer than 75 had significantly higher mortality rates (8.77%) than surgeons with annual volumes of 75 or more (5.90%).<br>CONCLUSIONS: Both hospital volume and surgeon volume are significantly associated with in-hospital mortality, and these differences persist for both high-complexity and low-complexity pediatric cardiac procedures. |

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| Harjai, Berman et al. (2004).<br>Coronary angioplasty<br>US<br>Impact of interventionalist volume, experience, and board certification on coronary angioplasty outcomes in the era of stenting.<br>The American Journal of Cardiology, 94(4), 421-426. | We assessed the effect of operator characteristics (volume of PCI, years in practice, and board certification status) on contemporary outcomes of PCI in a busy center with high-volume operators. | We assessed the effect of operator characteristics (volume of PCI, years in practice, and board certification status) on contemporary outcomes of PCI in a busy center with high-volume operators. Between 1999 and 2001, 12,293 PCIs were performed at our center by 28 interventionalists. Patients' clinical risk was assessed with the previously validated Beaumont PCI Risk Score. Operators were classified as producing low, medium, or high volume (tertiles of annual PCI volume 140, respectively), as less, medium, or great experience (tertiles of years in practice 14 years, respectively), and board certified (68%) or not. In-hospital death rate and a composite end point (death, coronary artery bypass graft surgery, myocardial infarction, or stroke) occurred in 0.99% and 2.59% of patients, respectively. Operator volume, experience, and board certification showed no univariate or multivariate relation with the study end points. The Beaumont PCI Risk Score showed a strong independent relation with in-hospital death rate (adjusted odds ratio 1.37, 95% confidence interval 1.31 to 1.43, p <0.0001) and composite end point (odds ratio 1.19, 95% confidence interval 1.16 to 1.22, p <0.0001).<br>We conclude that, in contemporary PCI practice at a large center with high-volume operators, in-hospital outcomes are not affected by operator volume, experience, or board certification. Rather, patients' clinical risk score is the overriding determinant of clinical outcomes. Our findings emphasize the power of a well-organized high-volume system to minimize the impact of operator factors on outcomes of PCI. |
| Auerbach et al. (2010a)<br>Coronary artery bypass surgery<br>US<br>Case volume, quality of care, and care efficiency in coronary artery bypass surgery.<br>Archives of Internal Medicine, 170(14), 1202-1208. | To examine the relationship between surgeon and hospital volume, and costs and length of stay. | We conducted an observational study of patients 18 years or older who underwent coronary artery bypass grafting surgery in a network of US hospitals. Case volumes were estimated using our data set. Quality wasassessed by whether recommended medications and services were not received in ideal patients, as well as the overall number of measures missed. We used multivariable hierarchical models to estimate the effects of case volume and quality on hospital cost and LOS.<br>Because diagnosis codes cannot reliably distinguish between complications and preexisting conditions, we measured the proportion of ideal candidates for each care process who failed to receive them—a missed quality measure. We developed these measures by translating recommendations from the Surgical Care Improvement Project)15 and American Heart Association/American College of Cardiologists Guidelines16 into a series of dichotomous quality measures.These measures, many of which are also included in recently published recommendations, included whether antimicrobials were used to prevent surgical site infection on the operative day, whether that antimicrobial was discontinued in 48 hours, whether serial compression devices were used to prevent venous thromboembolism in the 2 days following surgery, and whether aspirin, _-blockers, or lipidlowering statin drugs were administered in the 2 days following surgery.<br>The majority of hospitals (51%) and physicians (78%) were lowest-volume providers, and only 18% of patients received all quality of care measures. Median LOS was 7 days (interquartile range [IQR], 6-11 days), and median costs were $25 140 (IQR, $19 677-$33 121). In analyses adjusted for patient and site characteristics, lowest-volume hospitals had 19.8% higher costs (95% CI, 3.9%-38.0% higher); adjusting for care quality did not eliminate differences in |

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| | | costs. Low surgeon volume was also associated with higher costs, though less strongly (3.1% higher costs [95% CI, 0.6%-5.6% higher]). Individual quality measures had inconsistent associations with costs or LOS, but patients who had no quality measures missed had much shorter LOS and lower costs than those who missed even one.<br>The proportion of patients with 1 or more missed quality measure was slightly higher as volume rose. |
| Badheka et al. (2014b).<br>Percutaneous coronary intervention<br>US<br>Impact of annual operator and institutional volume on percutaneous coronary intervention outcomes: A 5-year united states experience (2005-2009).<br>Circulation, 130(16). | The relationship between operator or institutional volume and outcomes among patients undergoing percutaneous coronary interventions (PCI) is unclear. | Annual operator and institutional volumes were calculated using unique identification numbers and then divided into quartiles. Three-level hierarchical multivariate mixed models were created. The primary outcome was in-hospital mortality; secondary outcome was a composite of in-hospital mortality and peri-procedural complications. A total of 457,498 PCIs were identified representing a total of 2,243,209 PCIs performed in the United States during the study period. In-hospital, all-cause mortality was 1.08%, and the overall complication rate was 7.10%. The primary and secondary outcomes of procedures performed by operators in 4(th) [annual procedural volume; primary and secondary outcomes] [>100; 0.59% and 5.51%], 3(rd) [45-100; 0.87% and 6.40%], and 2(nd) quartile [16-44; 1.15% and 7.75%] were significantly less (P<0.001) when compared with those by operators in the 1(st) quartile [</=15; 1.68% and 10.91%]. Spline analysis also showed significant operator and institutional volume outcome relationship. Similarly operators in the higher quartiles witnessed a significant reduction in length of hospital stay and cost of hospitalization (P<0.001).<br>CONCLUSIONS: Overall in-hospital mortality after PCI was low. An increase in operator and institutional volume of PCI was found to be associated with a decrease in adverse outcomes, length of hospital stay, and cost of hospitalization. |
| McGrath, Wennberg et al. (2000).<br>Percutaneous coronary interventions<br>US<br>Relation between operator and hospital volume and outcomes following percutaneous coronary interventions in the era of the coronary stent. *Jama, 284*(24), 3139-3144 | CONTEXT: Studies have found an association between physician and institution procedure volume for percutaneous coronary interventions (PCIs) and patient outcomes, but whether implementation of coronary stents has allowed low-volume physicians and centers to achieve outcomes similar to their high-volume counterparts is unknown.<br>OBJECTIVE: To assess the relationship between physician and hospital PCI volumes and patient outcomes following PCIs, given the availability of coronary stents. | DESIGN, SETTING, AND PARTICIPANTS: Analysis of data from Medicare National Claims History files for 167 208 patients aged 65 to 99 years who had PCIs performed by 6534 physicians at 1003 hospitals during 1997. Of these procedures, 57.7% involved coronary stents. MAIN OUTCOME MEASURES: Rates of coronary artery bypass graft (CABG) surgery and 30-day mortality occurring during the index episode of care, stratified by physician and hospital PCI volume.<br>RESULTS: Overall unadjusted rates of CABG during the index hospitalization and 30-day mortality were 1.87% and 3.30%, respectively. After adjustment for case mix, patients treated by low-volume (60 Medicare procedures) physicians (2.25% vs 1.55%; P60 Medicare procedures) physicians (2.25% vs 1.55%; P160 Medicare procedures) centers (4.29% vs 3.15%; P<. 001), but there was no difference in the risk of CABG (1.83% vs 1. 83%; P =.96). In patients who received coronary stents, the CABG rate was 1.20% vs 2.78% for patients not receiving stents, and the 30-day mortality rate was 2.83% vs 3.94%. Among patients who received stents, those treated at low-volume centers had an increased risk of 30-day mortality vs those treated at high-volume centers, whereas those treated by low-volume physicians had an increased risk of CABG vs those treated by high-volume physicians.<br>CONCLUSION: In the era of coronary stents, Medicare patients treated by high-volume physicians and |

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| | | at high-volume centers experience better outcomes following PCIs. |
| Vakili et al. (2001)<br>Angioplasty for acute myocardial infarction<br>Volume-outcome relation for physicians and hospitals performing angioplasty for acute myocardial infarction in new york state.<br>*Circulation, 104*(18), 2171-2176. | An inverse relation exists between the number of coronary angioplasty procedures performed by physicians or hospitals and short-term mortality. It is not known, however, whether a similar relation holds for physicians and hospitals that perform primary angioplasty for acute myocardial infarction. | We analyzed data from the 1995 New York State Coronary Angioplasty Reporting System Registry to determine the relation between the number of primary angioplasty procedures performed by physicians and hospitals and in-hospital mortality. Patients who underwent angioplasty procedures within 23 hours of onset of acute myocardial infarction without preceding thrombolytic therapy were included (n=1342).<br>In-hospital mortality was reduced 57% among patients who underwent primary angioplasty by high-volume as opposed to low-volume physicians (adjusted relative risk 0.43; 95% CI 0.21 to 0.83). When patients with acute myocardial infarction were treated with primary angioplasty in high-volume hospitals rather than low-volume institutions, the relative risk reduction for in-hospital mortality was 44% (adjusted relative risk 0.56; 95% CI 0.29 to 1.1). Compared with patients treated at low-volume hospitals by low-volume physicians, patients treated at high-volume hospitals by high-volume physicians had a 49% reduction in the risk of in-hospital mortality (adjusted relative risk 0.51; 95% CI 0.26 to 0.99).<br>CONCLUSIONS: Among hospitals in New York State, a higher volume of primary angioplasty procedures performed by physicians and/or hospitals was associated with a lower mortality rate. |
| Freeman et al. (2012)<br>ICD implantations<br>US<br>Physician procedure volume and complications of cardioverter-defibrillator implantation.<br>Circulation. 2012;125:57-64 | We analyzed the most recent experience of the National Cardiovascular Data Registry (NCDR) ICD registry to examine the relationship between physician procedure volume and in-hospital complications and death. | The study demonstrates that the patients treated by physicians who implant ICDs more frequently are less likely to have an in-hospital complication or die as a result of the procedure.<br>There was no significant interaction between physician procedure volume and physician specialty and the occurrence of any adverse advent.<br>The rate of any adverse event did not differ statistically when the same physicians performed ICD implantations in the higher volume hospitals. The rate of major events and the rate of death also did not differ for implantations done in higher-volume versus lower-volume hospitals by the same physician. |
| Pezzin, Laud, Yen et al. (2015).<br>Breast cancer<br>US<br>Reexamining the relationship of breast cancer hospital and surgical volume to mortality an instrumental variable analysis. *Medical Care, 53*(12), 1033-1039. | Objective: To reexamine the relationship of hospital and surgical volume to all-cause and breast cancer-specific mortality, taking into account the potential selection bias in patients treated at high-volume centers or by high-volume surgeons. | Data Sources: Elderly (65+) women with early-stage, incident breast cancer surgery in 2003. Study Design: A population-based, prospective survey study. Methods: Two-stage, instrumental variable regression models. Principal<br>Findings: Women treated in high-volume hospitals were significantly less likely to die of any cause by 5 years after surgery, even after adjustments for self-selection and a number of other factors. The relationship was larger and more significant for breast cancer-specific mortality. Although the general pattern of better mortality outcomes held for moderately sized hospitals, the relationships were not statistically significant. In contrast, there was no relationship of surgeon volume with all-cause or breast cancer-specific mortality.<br>Conclusions: Hospital volume, but not surgeon volume, is associated with better survival among women with breast cancer. The magnitude of the potential improvement was substantial and comparable with the benefit conferred by many systemic therapies. These findings highlight the importance of accounting for patient self-selection in volume-outcome analyses, and provide support for policy initiatives aimed at regionalizing breast cancer care in the United States. |

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| de Camargo Cancela et al.<br>(2013).<br>Breast cancer surgery<br>Ireland<br>Hospital and surgeon caseload are associated with risk of re-operation following breast-conserving surgery.<br>Breast Cancer Reg Treat, 140(3), 535-544 | We aimed to quantify re-operation rates and identify the factors related to the risk of undergoing subsequent (i) re-operation and (ii) total mastectomy (TM). | Surgeon and hospital volume significantly predicted subsequent re-operation after adjustment for socio-demographic and clinical variables. Women having surgery in lower-volume hospitals by low-volume surgeons significantly increased the risk of re-operation.<br>The fact that factors related to healthcare organisation/service provision are associated with re-operations suggests that it may be possible to reduce the overall re-operation rate. |
| McDermott, Wall et al. (2013)<br>Breast cancer<br>US<br>Surgeon and breast unit volume-outcome relationships in breast cancer surgery and treatment.<br>Annals of Surgery, 258(5), 808-13; discussion 813-4. | OBJECTIVES: To determine whether surgeon case volume and Unit case volume affected specific recognized key performance indicators (KPIs) of breast cancer surgical management.<br>BACKGROUND: An increasing body of evidence suggests that a higher standard of cancer care, demonstrated by improved outcomes, is provided in high-volume units or by high-volume surgeons. The volume-outcome relationship pertaining to screen-detected breast cancers has yet to be thoroughly established and remains a pertinent issue in view of the debate surrounding breast cancer screening. | METHODS: The study population comprised all women with a new screen diagnosed breast cancer between 2004-2005 and 2009-2010. Surgeons' mean annual patient volumes were calculated and grouped as very low (50). The effect of breast screening unit volume was also evaluated. Statistical analyses were performed using Minitab V16.0 software (State College, PA) and R V2.13.0.<br>RESULTS: There were 81,416 patients aged 61 (+/- 6.8) years treated by 682 surgeons across 82 units. There were 209 very low-, 126 low-, 295 medium-, and 51 high-volume surgeons. The proportion of patients managed by very low-, low-, medium-, and high-volume surgeons was 1.2%, 6.9%, 65.5%, and 25.7%, respectively. Patients managed by high-volume surgeons were more likely to have breast-conserving surgery (BCS) than those managed by low-volume surgeons ($P < 0.001$). There was a higher proportion of sentinel lymph node biopsies (SLNB) performed by high-volume surgeons in invasive cancers ($P = 0.005$). High-volume units performed more BCS and SLNB than low-volume units ($P < 0.001$ and $P < 0.001$, respectively).<br>CONCLUSIONS: Even in a setting with established quality control measures (KPIs) surgeon and unit volume have potent influences on initial patient management and treatment. |
| Hawley et al. (2006).<br>Breast cancer treatments<br>US<br>Correlates of between-surgeon variation in breast cancer treatments. Medical Care, 44(7), 609-616. | BACKGROUND: Determinants of between-surgeon variation in breast cancer treatment utilization are not well understood.<br>OBJECTIVES: The objectives of this study were to evaluate variation in receipt of surgical treatment (ie, mastectomy or breast-conserving surgery with or without radiation) for women with stage I, II, or III breast cancer and receipt of breast reconstruction attributable to surgeons, and to assess factors associated with this between-surgeon variation. | METHODS: We surveyed all attending surgeons (n = 456) of a population-based sample of patients with breast cancer diagnosed in Detroit and Los Angeles during 2002 (n = 1844). Our analytic dataset linked data from 1477 patients with that of 311 surgeons. We used random-effects modeling to account for the multilevel dataset and evaluated 2 outcomes: 1) primary surgical treatment (mastectomy vs. BCS); and 2) receipt of reconstruction before being surveyed (yes vs. no). Independent variables included patient-related factors (clinical and demographic), surgeon-related factors (breast procedure volume, practice setting, and demographics), surgeon treatment recommendation, and referral propensity.<br>RESULTS: Surgeons explain some variation in use of both mastectomy and reconstruction (9.9% and 26%, respectively). Patient clinical factors and surgeon volume together explain approximately one-third of the between-surgeon variation in mastectomy. Patient factors and surgeon demographics explain approximately 60% of between-surgeon variation in reconstruction, and surgeon referral propensity explains an additional 15%.<br>CONCLUSION: Our findings suggest that similar patients may get different treatment depending on their surgeon. Broader dissemination of guidelines coupled with increasing patient access to consultations before |

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| | | definitive surgery may reduce between-surgeon variation. Contributing factors such as patient-physician communication should be explored. |
| Hershman, Richards et al. (2012)<br>Post-mastectomy reconstruction<br>Influence of health insurance, hospital factors and physician volume on receipt of immediate post-mastectomy reconstruction in women with invasive and non-invasive breast cancer.<br>*Breast Cancer Research and Treatment, 136*(2), 535-545. | For women with breast cancer who undergo mastectomy, immediate breast reconstruction (IR) offers a cosmetic and psychological advantage.<br>We evaluated the association between demographic, hospital, surgeon and insurance factors and receipt of IR. | We conducted a retrospective hospital-based analysis with the Perspective database. Women who underwent a mastectomy for invasive breast cancer (IBC) and ductal carcinoma in situ (DCIS) from 2000 to 2010 were included. Logistic regression analysis was used to determine factors predictive of IR. Analyses were stratified by age (\50 vs. C50) and IBC versus DCIS. Of the 108,992 women with IBC who underwent mastectomy, 30,859 (28.3 %) underwent IR, as compared to 6,501 (44.2 %) of the 14,710 women with DCIS who underwent mastectomy underwent IR. In a multivariable model for IBC, increasing age, black race, being married, rural location, and increased comorbidities were associated with decreased IR. Odds ratios (OR) of IR increased with commercial insurance (OR 3.38) and Medicare (OR 1.66) insurance (vs. self-pay), high surgeon-volume (OR 1.19), high hospital-volume (OR 2.24), and large hospital size (OR 1.20). The results were identical for DCIS, and by age category. The absolute difference between the proportion of patients who received IR with commercial insurance compared to other insurance, increased over time. Immediate in-hospital complication rates were higher for flap reconstruction compared to implant or no reconstruction (15.2, 4.0, and 6.1 %, respectively, P<.0001). IR has increased significantly over time; however, modifiable factors such as insurance status, hospital size, hospital location, and physician volume strongly predict IR. Public policy should ensure that access to reconstructive surgery is universally available. © Springer Science+Business Media New York 2012. |
| Murr, Martin, Haines et al. (2007).<br>Gastric bypass<br>US<br>A state-wide review of contemporary outcomes of gastric bypass in florida: Does provider volume impact outcomes?<br>Annals of Surgery, 245(5), 699-706. | OBJECTIVES: To report contemporary outcomes of gastric bypass for obesity and to assess the relationship between provider volume and outcomes.<br>BACKGROUND: Certain Florida-based insurers are denying patients access to bariatric surgery because of alleged high morbidity and mortality. | SETTINGS AND PATIENTS: The prospectively collected and mandatory-reported Florida-wide hospital discharge database was analyzed. Restrictive procedures such as adjustable gastric banding and gastroplasty were excluded.<br>RESULTS: The overall complication and in-hospital mortality rates in 19,174 patients who underwent gastric bypass from 1999 to 2003 were 9.3% (8.9-9.7) and 0.28% (0.21-0.36), respectively. Age and male gender were associated with increased duration of hospital stay (P 500 procedures; hospital volume: OR = 2.1, CI: 1.2-3.5; P 500 procedures). The percent change of in-hospital mortality in later years of the study was lowest, indicating higher mortality rates, for surgeons or hospitals with fewer (or =500) procedures.<br>CONCLUSION: Increased utilization of bariatric surgery in Florida is associated with overall favorable short-term outcomes. Older age and male gender were associated with increased morbidity and mortality. Surgeon and hospital procedure volume have an inverse relationship with in-hospital complications and mortality. |
| Regenbogen, Alli et al. (2016).<br>Bariatric surgery<br>US<br>Bariatric surgical outcomes in NY state, the role of hospital and surgeon volume: An analysis of 52,690 patients. | Background: For more than 25 years, there has been an interest in the association between operative volume and outcomes. Accreditation of specialty programs and centers across surgical specialties utilize minimum volume re- | Methods: The New York State Planning and Research Cooperative System (NY SPARCS), a longitudinal administrative database encompassing all inpatient, outpatient and hospital discharges in NY State was utilized to identify a total of 52,690 patients who underwent bariatric surgery [adjustable gastric banding (AGB), laparoscopic sleeve gastrectomy (LSG), or roux-en-Y gastric bypass (RYGB)] from 2010-2014The data encompassed a total of 84 hospitals & |

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| *Gastroenterology.Conference: Digestive Disease Week 2016, DDW 2016.San Diego, CA United States.Conference. Conference Publication: (Var.Pagings), 150*(4 SUPPL. 1), S1265. | quirements. More generally, volume has been utilized as a surrogate marker for quality & patient outcomes surgery.<br>The factors that ultimately determine patient outcomes are multiple, however reliable methods of predicting outcomes based on non-volumetric measures remains lacking. | 360 operating physicians. Patient demographics, surgical details and insurance type, comorbidities, complications were caputured. Hospital and surgeon specific volumes were tabulated. Generalized linear mixed models were used to compare hospital volume & operating physician volume against hospital readmission, emergency department (ED) revisit, admitted ED revisit, & complications within 30 days of index operation.<br>Results: In aggregate, hospital volume & physician volume were not associated with hospital readmission (p= 0.6569 and p= 0.6311 respectively), ED revisit (p=0.9506 and p=0.3828) or admitted ED rates (p=0.7361 and p= 0.3516) within the first 30 days after bariatric surgery. Multivariate analysis revealed that independent of comorbidities & operation type surgeon volume demonstrated a statistically significant impact on complications within 30 days of bariatric surgery (p100 reveals an inflection in complication risk between the 2nd & 3rd quartiles, commensurate with a rise in odds ratio to 1.7.<br>Conclusions: Neither hospital nor surgeon volumes determine presentation to ED, admitted ED, or hospital readmission rates. Lower volume surgeons are more likely to have complications within 30 days of index operation. As bariatric surgery has migrated to outpatient status, with most postoperative stays spanning <48 hours, hospital volume as a surrogate for perioperative care has had less impact on bariatric outcomes than for other operations, namely cardiac and pancreatobiliary surgery. Technical considerations, with surgeon volume serving as a surrogate marker has surfaced as a better predictor of patient outcome. As such, quality improvement should focus on surgeon specific, not site specific volumes as a major component of postoperative outcomes prediction. |
| Smith, Patterson et al. (2010)<br>Bariatric Surgery<br>US<br>Relationship between surgeon volume and adverse outcomes after RYGB in Longitudinal Assessment of Bariatric Surgery (LABS) study.<br>Surg Obes Relat Dis., 6(2):118-25. | BACKGROUND: Bariatric surgery is technically demanding surgery performed on high-risk patients. Previous studies using administrative databases have shown a relationship between surgeon volume and patient outcome after Roux-en-Y gastric bypass (RYGB).<br>We examined the relationship between surgeons' annual RYGB volumes and 30-day patient outcomes at 10 centers within the United States. | METHODS: The Longitudinal Assessment of Bariatric Surgery (LABS)-1 is a prospective study examining the 30-day adverse outcomes after bariatric surgery. The outcomes after RYGB were adjusted by procedure type (open versus laparoscopic), functional status, body mass index, history of deep vein thrombosis, pulmonary embolism, and obstructive sleep apnea. The data were examined to determine the nature and strength of the association between surgeon volume and patients' short-term (30-day) adverse outcomes after RYGB.<br>RESULTS: The analysis included 3410 initial RYGB operations performed by 31 surgeons, 15 of whom averaged <50 cases annually. The crude composite adverse outcome (i.e., death, deep vein thrombosis, pulmonary embolism, reintervention or nondischarge at day 30) incidence was 5.2%. After risk adjustment, a greater surgeon RYGB volume was associated with lower composite event rates, with a continuous relationship (i.e., varying cutpoints differentiated the composite event rates), such that for each 10-case/yr increase in volume, the risk of a composite event decreased by 10%.<br>CONCLUSION: In the LABS, the patient's risk of an adverse outcome after RYGB decreased significantly with the increase in surgeon RYGB volume (cases performed annually). |
| Smith, Patterson et al. (2013)<br>Bariatric Surgery<br>US | The purpose of the present study is to understand possible explanations for the | METHODS: LABS includes a 10-center, prospective study examining 30-day outcomes after bariatric surgery. The relationship between surgeon annual RYGB volume and incidence of a composite endpoint |

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| Can technical factors explain the volume-outcome relationship in gastric bypass surgery?<br>Surgery for Obesity and Related Diseases: Official Journal of the American Society for Bariatric Surgery, 9(5), 623-629. | volume-outcome relationship in the Longitudinal Assessment of Bariatric Surgery (LABS) study.<br>Despite multiple studies demonstrating volume-outcome relationships, fewer studies investigate the causes of this relationship.<br>LABS includes a 10-center, prospective study examining 30-day outcomes after bariatric surgery. | (CE) has been published previously. Technical aspects of RYGB surgery were compared between high and low volume surgeons. The previously published model was adjusted for select technical factors.<br>RESULTS: High-volume surgeons (>100 RYGBs/yr) were more likely to perform a linear stapled gastrojejunostomy, use fibrin sealant, and place a drain at the gastrojejunostomy compared with low-volume surgeons (<25 RYGBs/yr), and less likely to perform an intraoperative leak test. After adjusting for the newly identified technical factors, the relative risk of CE was .93 per 10 RYGB/yr increase in volume, compared with .90 for clinical risk adjustment alone.<br>CONCLUSION: High-volume surgeons exhibited certain differences in technique compared with low-volume surgeons. After adjusting for these differences, the strength of the volume-outcome relationship previously found was reduced only slightly, suggesting that other factors are also involved. |
| Markar, Penna et al. (2012)<br>Bariatric surgery<br>The impact of hospital and surgeon volume on clinical outcome following bariatric surgery.<br>Obesity Surgery, 22(7), 1126-1134. | The dramatic rise in the prevalence of obesity worldwide has led to the rapid growth of bariatric surgery.<br>The aim of this pooled analysis is to evaluate the relationship between institutional and surgeon volume and outcomes following bariatric surgery. | Medical, Embase, trial registries, conference proceedings and reference lists were searched for trials comparing clinical outcome following bariatric surgery at high and low volume hospitals and by high and low volume surgeons. Outcomes analysed were mortality, morbidity and length of hospital stay.<br>Fifteen publications were included in this analysis. In total, 289,732 bariatric procedures were included in the institutional volume analysis, and 32,920 bariatric operations were included in the surgeon volume analysis. Mortality was reduced following surgery at high volume institutions (0.24 vs. 2.18 %; pooled odds ratio = 0.26; P = 0.004) and by high volume surgeons (0.41 vs. 2.77 %; pooled odds ratio = 0.21; P < 0.001). Similarly, morbidity was reduced in high volume institutions (7.84 vs. 8.85 %; pooled odds ratio = 0.52; P < 0.001) and with high volume surgeons (6.92 vs. 7.29 %; pooled odds ratio = 0.47; P < 0.001). There were insufficient data for conclusive statistical analysis of length of hospital stay.<br>This pooled analysis does suggest a benefit in the centralisation of bariatric surgery to high volume institutions and surgeons with respect to mortality and morbidity. Future high-powered studies with adjustment for procedural and patient case mix are required to further define the volume-outcome relationship in bariatric surgery. |
| Weller & Hannan (2006)<br>Bariatric procedures<br>US<br>Relationship between provider volume and postoperative complications for bariatric procedures in new york state.<br>Journal of the American College of Surgeons, 202(5), 753-761. | BACKGROUND: Although the number of bariatric procedures has grown recently, few studies have focused on the relationship between provider volume and outcomes among patients undergoing a bariatric procedure. | STUDY DESIGN: Using New York State's inpatient discharge database, we identified adults undergoing a bariatric procedure in New York State between January 1, 2003 and December 31, 2003 (n=7,868). Separate multivariable statistical models were constructed to examine the relationship between surgeon volume and hospital volume and postoperative complications (using surgeon volume cutpoints of 25, 50, 100, 150 and hospital volume cutpoints of 100, 125, 150, 200) while controlling for demographic characteristics and comorbidity.<br>RESULTS: There was a considerably higher likelihood of postoperative complications among surgeons performing 100 or fewer bariatric procedures compared with those performing more than 100 procedures (odds ratio [OR]: 2.39, 95% CI: 1.59 to 3.59) and for those performing 150 or fewer procedures compared with those performing more than 150 procedures (odds ratio: 2.05, 95% CI: 1.29 to 3.25) after risk adjustment. Likewise, for each of the four hospital volume cutpoints, there was a notably higher likeli- |

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| | | hood of postoperative complications in the lower volume hospitals. Analyses of the interaction between surgeon and hospital volume indicated a markedly higher likelihood of postoperative complications among patients operated on by a low-volume surgeon (100 procedures or fewer) in a low-volume hospital (150 procedures or fewer) or a low-volume surgeon in a high-volume hospital than among patients operated on by a high-volume surgeon in a high-volume hospital.<br>CONCLUSIONS: The likelihood of postoperative complications from bariatric procedures is greater for patients with low-volume surgeons or in low-volume hospitals. |
| Weller, Rosati & Hannan (2007)<br>Bariatric operation<br>Relationship between surgeon and hospital volume and readmission after bariatric operation.<br>Journal of the American College of Surgeons, 204(3), 383-391. | BACKGROUND: Few studies have focused on the relationship between provider volume and short-term readmissions among bariatric operation patients. | STUDY DESIGN: Using New York State's inpatient discharge database, we identified adults undergoing a bariatric procedure between January 1, 2003, and November 30, 2003 (n = 7,868). After preliminary descriptive analyses, a multiple logistic regression model was constructed to examine the relationship between surgeon and hospital volume and readmission after 30 days of discharge for bariatric operation, while controlling for demographics, comorbidity, and length of index hospitalization.<br>RESULTS: Among patients undergoing bariatric operation in New York in 2003, 7.6% were readmitted within 30 days of discharge after their operation. The most common readmission diagnosis was "digestive system complications of surgical care." Multiple logistic regression showed that both surgeon and hospital volume were significantly associated with short-term readmissions. Patients operated on by a low-volume surgeon (150 procedures per year) were also significantly (p 300 procedures per year) (<or= 100 procedures, odds ratio [OR] = 1.57; 95% CI, 1.38-2.16; 101 to 200 procedures, OR = 2.88; 95% CI, 2.17-3.82; 201 to 300 procedures, OR = 2.21; 95% CI, 1.71-2.86).<br>CONCLUSIONS: There is an important relationship between surgeon and hospital volume and short-term readmission after bariatric operation. |
| Courcoulas et al. (2003)<br>The relationship of surgeon and hospital volume to outcome after gastric bypass surgery in pennsylvania: A 3-year summary.<br>Surgery, 134(4), 613-21; discussion 621-3. | BACKGROUND: This study explores the volume-outcome relationship for gastric bypass surgery for obesity to determine whether higher-volume hospitals, higher-volume surgeons, or both are associated fewer adverse outcomes. | METHODS: The Pennsylvania state discharge database was used to identify 4685 cases of gastric bypass surgery for obesity between 1999 and 2001. Statistical modeling analyses were used to determine whether mortality or adverse outcome rate was significantly related to hospital and surgeon volume; the data were controlled for risk factors such as age, gender, comorbidities, and others.<br>RESULTS: There were 28 deaths (0.6%) and 813 adverse outcomes (17.4%). There was a significant risk-adjusted relationship between surgeon volume and adverse outcome, and the same trend was observed for deaths. Surgeons who performed fewer than 10 procedures per year had a 28% risk of adverse outcome and a 5% risk of death, compared with 14% (P<.05) and 0.3% (P=.06), respectively, for high-volume surgeons. Hospital volume did not reach significance, but there was a striking interaction between surgeon and hospital volume; surgeons who performed 10 to 50 cases per year operating in low-volume hospitals had a 55% risk of adverse outcome (P<.01).<br>CONCLUSION: Risk-adjusted in-hospital adverse outcome is significantly lower when gastric bypass is performed by higher-volume surgeons. |

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| Kasbekar, Shivani et al. (2014)<br>Corneal Transplant Surgery for Keratoconus<br>UK<br>Corneal Transplant Surgery for Keratoconus and the Effect of Surgeon Experience on Deep Anterior Lamellar Keratoplasty Outcomes.<br>American Journal of Ophthalmology, December 2014, Vol.158(6), pp.1239-1246 | PURPOSE: To investigate graft survival and surgical experience on clinical outcome following deep anterior lamellar keratoplasty (DALK).<br>DESIGN: Multicenter cohort study. | METHODS: The United Kingdom Transplant Database was used to identify patients who had undergone a first DALK or penetrating keratoplasty (PKP) for keratoconus. Data were collected at the time of surgery and at 1, 2, and 5 years postoperatively. Graft survival, best-corrected visual acuity, and refractive error were analyzed for 3 consecutive time periods. DALK outcomes were analyzed according to surgeon experience.<br>RESULTS: A total of 4521 patients were included. Graft survival was 92% (95% CI: 90-92) for PKP and 90% (95% CI: 88-92) for DALK (P = .09). For corneal transplants undertaken in the periods 1999-2002, 2002-2005, and 2005-2007, graft survival was 90%, 92%, and 88% following DALK, and 93%, 91%, and 92% following PKP, respectively. There was no evidence of a difference between surgeons in terms of case mix (P = .4) or outcome (P = .2). Surgeon experience, in terms of the number of previous DALK undertaken, had no significant effect on outcome. A donor recipient trephine size disparity of 0.5 mm was associated with an increased risk of graft failure for both DALK (P = .03) and PKP (P = .002), whereas ocular surface disease was a significant risk factor for DALK (P = .04) but not PKP.<br>CONCLUSIONS: There has been little change in graft survival for DALK and PKP over the past decade. Ocular surface disease is an important risk factor for graft failure following DALK. A surgical learning curve for DALK could not be demonstrated in terms of clinical outcome. |
| Larkin, Mumford et al. (2011).<br>Corneal transplant<br>UK<br>Centre-specific variation in corneal transplant outcomes in the united kingdom.<br>*Transplantation, 91*(3), 354-359 | BACKGROUND: To examine the influence of center or surgeon transplant workload on corneal transplant outcome. | METHODS: In this database study, centers were categorized as high or low volume if registering more than 50 and less than 10 corneal transplants per year, respectively; surgeons were categorized as high or low volume if registering more than 30 and less than 10 transplants per year, respectively. The participants were patients aged at least 17 years receiving a first penetrating keratoplasty for keratoconus, Fuchs' endothelial disease, or pseudophakic corneal edema in a 7-year period from 1999 in (1) high-volume (n=1724) and low-volume (n=2131) centers and (2) under care of high-volume (n=1332) and low-volume (n=1949) surgeons. Main outcome measures were (1) graft survival at 5 years and (2) 2-year posttransplant best-corrected and day-to-day visual acuity and astigmatism.<br>RESULTS: No significant difference in graft survival was found according to center or surgeon workload. Statistically significantly better day-to-day visual acuity was found only in patients with Fuchs' endothelial disease managed by high-volume surgeons (20/40 or better in 50% vs. 42% for low-volume surgeons). There was statistically significantly better best-corrected visual acuity in high-volume centers for Fuchs' endothelial disease and pseudophakic corneal edema and for high-volume surgeons in all disease groups.<br>CONCLUSIONS: Based on this national transplant cohort, when analyzed according to center volume or surgeon transplant workload, there is no variation in graft survival and only minor variation in transplant functional outcome. |
| Jain, Pietrobon et al. (2004).<br>Shoulder arthroplasty<br>US | BACKGROUND: As far as we know, no previous study has determined the | METHODS: Data on patients undergoing shoulder arthroplasty were extracted from the Nationwide Inpatient Sample databases for the years 1988 through 2000. Logistic regression with generalized estimating equations and multiple linear regression models were |

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| The relationship between surgeon and hospital volume and outcomes for shoulder arthroplasty. The Journal of Bone and Joint Surgery.American Volume, 86-A(3), 496-505. | relationship between volume and outcomes for shoulder arthroplasty.<br>We hypothesized that surgeons and hospitals with higher caseloads of total shoulder arthroplasties and hemiarthroplasties have better outcomes as measured by decreased mortality rate, shorter length of stay in the hospital, reduced postoperative complications, and routine disposition of patients on discharge. | used to estimate the adjusted association between surgeon and hospital volume and outcomes for total shoulder arthroplasty and hemiarthroplasty after adjusting for comorbidity, age, race, household income, and sex.<br>RESULTS: The mortality rates for patients who had a total shoulder arthroplasty performed by surgeons who did fewer than two procedures per year (0.36%) or who did between two and fewer than four procedures per year (0.32%) were higher than those for patients who had a total shoulder arthroplasty performed by surgeons who did four procedures or more per year (0.20%). The risk-adjusted rate of postoperative complications after hemiarthroplasty was significantly higher for patients managed by surgeons who performed fewer than two procedures per year (1.68%) than for those managed by surgeons with a volume of five procedures or more per year (0.97%). The possibility of postoperative complications when total shoulder arthroplasty was performed in hospitals with a volume of fewer than five procedures (1.44%) or in those with a volume of five to ten procedures per year (1.45%) was significantly higher than that in hospitals where ten procedures or more were performed every year (0.64%). The mean lengths of stay in the hospital after total shoulder arthroplasty and hemiarthroplasty were significantly longer when the operations were performed by surgeons who did fewer than two procedures per year or when they were done in hospitals with a volume of fewer than five procedures per year or with a volume of five to fewer than ten procedures per year than when they were done in hospitals or by surgeons in the highest volume category ($p < 0.001$).<br>CONCLUSIONS: Patients who have a total shoulder arthroplasty or hemiarthroplasty performed by a high-volume surgeon or in a high-volume hospital are more likely to have a better outcome. |
| Singh, Yian, Dillon et al. (2014).<br>Shoulder arthroplasty<br>US<br>The effect of surgeon and hospital volume on shoulder arthroplasty perioperative quality metrics.<br>Journal of Shoulder and Elbow Surgery, 23(8), 1187-1194. | BACKGROUND: There has been a significant increase in both the incidence of shoulder arthroplasty and the number of surgeons performing these procedures. Literature regarding the relationship between surgeon or hospital volume and the performance of modern shoulder arthroplasty is limited.<br>This study examines the effect of surgeon or hospital shoulder arthroplasty volume on perioperative metrics related to shoulder hemiarthroplasty, total shoulder arthroplasty, and reverse shoulder arthroplasty. Blood loss, length of stay, and operative time were the main endpoints analyzed. | METHODS: Prospective data were analyzed from a multicenter shoulder arthroplasty registry; 1176 primary shoulder arthroplasty cases were analyzed. Correlation and analysis of covariance were used to examine the association between surgeon and hospital volume and perioperative metrics adjusting for age, sex, and body mass index.<br>RESULTS: Surgeon volume is inversely correlated with length of stay for hemiarthroplasty and total shoulder arthroplasty and with blood loss and operative time for all 3 procedures. Hospital volume is inversely correlated with length of stay for hemiarthroplasty, with blood loss for total and reverse shoulder arthroplasty, and with operative time for all 3 procedures. High-volume surgeons performed shoulder arthroplasty 30 to 50 minutes faster than low-volume surgeons did.<br>CONCLUSIONS: Higher surgeon and hospital case volumes led to improved perioperative metrics with all shoulder arthroplasty procedures, including reverse total shoulder arthroplasty, which has not been previously described in the literature. Surgeon volume had a larger effect on metrics than hospital volume did. This study supports the concept that complex shoulder procedures are, on average, performed more efficiently by higher volume surgeons in higher volume centers. |
| Robinson, Doll & Roy (2011).<br>Arthroscopic cuff repairs | INTRODUCTION: The aim of this study was to characterise current rotator cuff | METHODS: A one-page web-based survey was created. All British Elbow and Shoulder Society (BESS) members and surgeons who listed the shoulder as an |

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| UK<br>Treating the torn rotator cuff: Current practice in the UK.<br>Annals of the Royal College of Surgeons of England, 93(7), 532-536. | repair activity in the UK with emphasis on the management of rotator cuff tears in the elderly population (over 70s). | area of specialist interest on the website http://www.specialistInfo.com/ were invited to complete this.<br>RESULTS: A total of 103 surgeons completed the survey; most (n =89, 86%) were BESS members. They had spent a median of 10 years (range: 9 months - 30 years) in consultant practice and performed an annual median of 200 (range: 0-1,000) arthroscopic shoulder procedures. For rotator cuff repair the favoured method was arthroscopic for 47 consultants (46.5%), open or mini-open for 41 (40.6%) and both for 13 (12.9%). The annual median number of arthroscopic and open cuff repairs was 20 (range: 0-250) and 12 (range: 0-100) respectively. The longer the time in practice, the fewer the reported number of arthroscopic cuff repairs (r(s)=-0.22, p=0.027) and the greater the number of open and mini-open cuff repairs (r(s)=0.33, p=0.001). In the management of a full-thickness rotator cuff tear in a patient over 70 years of age, 27 (26.7%) would perform an open or mini-open repair, 43 (42.6%) an arthroscopic repair and 22 (21.8%) would not attempt a repair.<br>CONCLUSIONS: Surgeons performing a higher volume of arthroscopic cuff repairs annually were more likely to repair cuff tears and they predicted significantly better outcomes of cuff repair for both pain and shoulder movement. Our results reflect the existing conflicting evidence regarding the indications for and methods of treatment of rotator cuff disease. |
| Sherman, Lyman et al. 2008).<br>Arthroscopic rotator cuff repair<br>Risk factors for readmission and revision surgery following rotator cuff repair.<br>Clinical Orthopaedics and Related Research, 466(3), 608-613. | Risk factors for revision surgery and hospitalization following rotator cuff repair (RCR) have not been clearly identified.<br>We hypothesized patient factors and surgeon and hospital volume independently contribute to the risk of readmission within 90 days and revision RCR within one year. | Using the SPARCS database, we included patients undergoing primary RCR in New York State between 1997 and 2002. These patients were tracked for readmission within 90 days and revision RCR within 1 year. A generalized estimating equation was developed to determine whether patient factors, surgeon volume, or hospital volume were independent risk factors for the above outcome measures.<br>The total annual number of RCR increased from 6,656 in 1997 to 10,128 in 2002. Ambulatory cases increased from 57% to 82% during this time period. Independent risk factors for readmission within 90 days included increasing age and increased number of comorbidities. Independent risk factors for revision RCR included increasing age, increased comorbidity, and lower surgeon volume. Hospital volume had a minimal effect on either outcome measure. The shift toward out-patient surgery mirrors the shift from open to arthroscopic rotator cuff repair. The finding that surgeon volume is a predictor of revision RCR reflects the findings in other orthopaedic procedures. |
| Jenkins et al. (2013).<br>Total elbow replacement<br>Scotland<br>Total elbow replacement: Outcome of 1,146 arthroplasties from the scottish arthroplasty project.<br>Acta Orthopaedica, 84(2), 119-123. | Total elbow replacement (TER) is used in the treatment of inflammatory arthropathy, osteoarthritis, and posttraumatic arthrosis, or as the primary management for distal humeral fractures.<br>We determined the annual incidence of TER over an 18-year period. We also examined the effect of surgeon volume on implant survivorship and the rate of systemic and joint-specific complications. | There were 1,146 primary TER procedures (incidence: 1.4 per 10(5) population per year). The peak incidence was seen in the eighth decade and TER was most often performed in females (F:M ratio = 2.9:1). The primary indications for surgery were inflammatory arthropathy (79%), osteoarthritis (9%), and trauma (12%). The incidence of TER fell over the period (r = -0.49; p = 0.037). This may be due to a fall in the number of procedures performed for inflammatory arthropathy ($p < 0.001$).<br>The overall 10-year survivorship was 90%. Implant survival was better if the surgeon performed more than 10 cases per year.<br>INTERPRETATION: The prevalence of TER has fallen over 18 years, and implant survival rates are better in surgeons who perform more than 10 cases |

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| | | per year. A strong argument can be made for a managed clinic network for total elbow arthroplasty. |
| Hustedt, Bohl et al. (2016)<br>Digital replantation<br>The detrimental effect of decentralization in digital replantation in the united states: 15 years of evidence from the national inpatient sample.<br>Journal of Hand Surgery, 41(5), 593-601. | Purpose Recent reports suggest a decrease in success rates in digital replantation in the United States.<br>We hypothesize that this decrease may be associated with decentralization of replants away from high-volume hospitals. | Methods All amputation injuries and digital replants captured by the National Inpatient Sample during 1998 to 2012 were identified. Procedures were characterized as occurring at high-volume hospitals (> 20 replants/y), and as being performed by high-volume surgeons (> 5 replants/y). A successful procedure was defined as one in which a replantation occurred without a subsequent revision amputation. Hospital and surgeon volume were tested for association with the year and the success of the procedure.<br>Results The authors identified 101,693 amputation injuries resulting in 15,822 replants. The overall success of replants dropped from 74.5% during 2004 to 2006 to 65.7% during 2010 to 2012. The percentage of replants being performed at high-volume hospitals decreased from 15.5% during 2004 to 2006 to 8.9% during 2007 to 2009. Similarly, the percentage of replants being performed by high-volume surgeons decreased from 14.4% during 1998 to 2000 to 2.6% during 2007 to 2009. Replants performed by high-volume surgeons operating at high-volume hospitals had higher success rates than low-volume surgeons operating at low-volume hospitals (92.0% vs 72.1%). In addition, high-volume surgeons operating at high-volume hospitals attempted replantation at greater rates than low-volume surgeons operating at low-volume hospitals (21.5% vs 11.0%). Overall, an amputation injury presenting to a high-volume surgeon at a high-volume center had a 2.5 times greater likelihood of obtaining a successful replantation than an amputation injury presenting to a low-volume surgeon at a low-volume hospital.<br>Conclusions: These data suggest that decreased success rates of digital replantation in the United States are correlated with the decentralization of digital replantation away from high-volume hospitals. Clinical relevance The establishment of regional centers for replant referral may greatly increase the success of digital replantation in the United States. |
| Forte, Virnig et al (2010)<br>Hip fracture<br>US<br>Ninety-day mortality after intertrochanteric hip fracture: Does provider volume matter?<br>The Journal of Bone and Joint Surgery.American Volume, 92(4), 799-806. | BACKGROUND: Research on the relationship between orthopaedic volume and outcomes has focused almost exclusively on elective arthroplasty procedures. Geriatric patients who have sustained an intertrochanteric hip fracture are older and have a heavier comorbidity burden in comparison with patients undergoing elective arthroplasty; therefore, any advantage of provider volume in terms of mortality could be overwhelmed by the severity of the hip fracture condition itself.<br>This study examined the association between surgeon and hospital volumes of procedures performed for the treatment of intertrochanteric hip fractures in Medicare beneficiaries and inpatient through ninety- | METHODS: The Medicare 100% files of hospital and physician claims plus the beneficiary enrollment files for 2000 through 2002 identified beneficiaries who were sixty-five years of age or older and who underwent inpatient surgery for the treatment of an intertrochanteric hip fracture with internal fixation. Provider volumes of intertrochanteric hip fracture cases were calculated with use of unique surgeon and hospital provider numbers in the claims. Fixed effects regression analysis using generalized estimating equations was used to model the association between hospital and surgeon intertrochanteric hip fracture volume and inpatient through ninety-day mortality, controlling for age, sex, race, Charlson comorbidity score, subtrochanteric fracture, prefracture nursing home residence, Medicaid-administered assistance, surgical device, and year. The unadjusted inpatient, thirty, sixty, and ninety-day mortality rates and adjusted relative risks are reported.<br>RESULTS: Between March 1, 2000, and December 31, 2002, 192,365 claims met inclusion criteria and matched with provider information. The unadjusted inpatient, thirty-day, sixty-day, and ninety-day mortality rates were 2.91%, 7.92%, 12.34%, and 15.19%, respectively. Patients managed at lower-volume hospitals had significantly higher (10% to 20%) adjusted risks of inpatient mortality than those managed at the |

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| | day postoperative mortality. | highest-volume hospitals. By sixty days postoperatively, the increased mortality risk persisted only among patients managed at the lowest-volume hospitals (six cases per year or fewer). Patients who were managed by surgeons who treated an average of two or three cases per year had the highest mortality risks when compared with patients managed by the highest-volume surgeons.<br>CONCLUSIONS: Only the highest-volume hospitals showed an inpatient mortality benefit for Medicare patients with intertrochanteric hip fractures. Unlike the situation with elective arthroplasty procedures, our findings do not indicate a need to direct patients with routine hip fractures exclusively to high-volume centers, although the higher mortality rates found in the lowest-volume hospitals warrant further investigation. |
| Goldstein, Babikian et al. (2016)<br>Total hip replacement<br>US<br>The cost and outcome effectiveness of total hip replacement: Technique choice and volume-output effects matter.<br>Applied Health Economics and Health Policy, 14(6), 703-718. | Background: Total hip replacement (THR) must be managed in a more sustainable manner. More cost-effective surgical techniques and the centralization/regionalization of services are two solutions. The former requires an assessment of newer minimally invasive and muscle-sparing surgical techniques. The latter necessitates an effective volume-outcome (VO) relationship. Prior studies have failed to evaluate and control for the VO relation. Objective: The objective of this study was to evaluate the relative cost and outcome effectiveness of two minimally invasive and one muscle-sparing techniques while evaluating and controlling for a potentially endogenous VO relation. | Methods: An all payer claims database for all THR performed in Maine in 2011 was used. The cost and outcome effectiveness of newer minimally invasive (modified Hardinge) and muscle-sparing (modified Watson-Jones) techniques were compared with the standard bearer posterior minimally invasive method. Using regression analysis, the outcomes analyzed were as follows: total costs, length of hospital stay, nursing care and home discharges, and use of physical therapy. Regression analysis was also used to evaluate and control for VO effects.<br>Results: (1) Newer muscle-sparing and minimally invasive approaches are substantially more effective; (2) irrespective of technique, higher volume surgeons are more effective; (3) technique-specific VO effects for more complex techniques exist and show substantial savings when yearly volume exceeds 30-50; and (4) the anterolateral muscle-sparing technique is accessible to the average surgeon. Conclusion: Reliance on newer surgical techniques and centralization/regionalization of THR services can reduce costs. |
| Katz, Phillips, Baron et al. (2003).<br>Total hip replacement<br>US<br>Association of hospital and surgeon volume of total hip replacement with functional status and satisfaction three years following surgery.<br>*Arthritis and Rheumatism, 48*(2), 560-568. | OBJECTIVE: To evaluate whether hospital volume and surgeon volume of total hip replacements (THRs) are associated with patient-reported functional status and satisfaction with surgery 3 years postoperatively. | METHODS: We performed a population-based cohort study of a stratified random sample of Medicare beneficiaries who underwent elective primary or revision THR in Ohio, Pennsylvania, or Colorado in 1995. The primary outcomes were the self-reported Harris hip score and a validated scale measuring satisfaction with the results of surgery. Both outcomes were assessed 3 years postoperatively. Hospital volume was defined as the aggregate number of elective primary and revision THRs performed on Medicare beneficiaries in the hospital in 1995. High-volume hospitals were defined as those in which >100 such procedures are performed annually, and low-volume centers were defined as those in which 12 procedures per year.<br>CONCLUSION: Hospital volume and surgeon volume have little effect on 3-year functional outcome following THR, after adjusting for patient sociodemographic and select clinical characteristics. However, satisfaction with primary THR is greater among patients who underwent surgery in high-volume centers, and satisfaction with revisions is greater among patients whose operations were performed by higher-volume surgeons. Referring clinicians should incorporate these findings into their discussion of referral choices with patients considering THR. Conclusions regarding |

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| | | the effect of volume on longevity of the implants must await longer-term followup studies. Finally, further research is warranted to better understand the association between hospital and surgeon procedure volume and patient satisfaction with surgery. |
| Paxton, Inacio et al. (2015).<br>Total hip arthroplasty<br>US<br>Are there modifiable risk factors for hospital readmission after total hip arthroplasty in a US healthcare system? *Clinical Orthopaedics and Related Research, 473*(11), 3446-3455. | BACKGROUND: Although total hip arthroplasty (THA) is a successful procedure, 4% to 11% of patients who undergo THA are readmitted to the hospital. Prior studies have reported rates and risk factors of THA readmission but have been limited to single-center samples, administrative claims data, or Medicare patients. As a result, hospital readmission risk factors for a large proportion of patients undergoing THA are not fully understood.<br>QUESTIONS/PURPOSES: (1) What is the incidence of hospital readmissions after primary THA and the reasons for readmission? (2) What are the risk factors for hospital readmissions in a large, integrated healthcare system using current perioperative care protocols? | METHODS: The Kaiser Permanente (KP) Total Joint Replacement Registry (TJRR) was used to identify all patients with primary unilateral THAs registered between January 1, 2009, and December 31, 2011. The KPTJRR's voluntary participation is 95%. A logistic regression model was used to study the relationship of risk factors (including patient, clinical, and system-related) and the likelihood of 30-day readmission. Readmissions were identified using electronic health and claims records to capture readmissions within and outside the system. Odds ratio (OR) and 95% confidence intervals (CIs) were calculated. Of the 12,030 patients undergoing primary THAs included in the study, 59% (n = 7093) were women and average patient age was 66.5 years (+/- 10.7).<br>RESULTS: There were 436 (3.6%) patients with hospital readmissions within 30 days of the index procedure. The most common reasons for readmission were infection and inflammatory reaction resulting from internal joint prosthetic (International Classification of Diseases, 9(th) Revision, Clinical Modification [ICD-9-CM] 996.66, 7.0%); other postoperative infection (ICD-9-CM 998:59, 5.5%); unspecified septicemia (ICD-9-CM 038.9, 4.9%); and dislocation of a prosthetic joint (ICD-9-CM 996.42, 4.7%). In adjusted models, the following factors were associated with an increased likelihood of 30-day readmission: medical complications (OR, 2.80; 95% CI, 1.59-4.93); discharge to facilities other than home (OR, 1.89; 95% CI, 1.39-2.58); length of stay of 5 or more days (OR, 1.80; 95% CI, 1.22-2.65) versus 3 days; morbid obesity (OR, 1.74; 95% CI, 1.25-2.43); surgeries performed by high-volume surgeons compared with medium volume (OR, 1.53; 95% CI, 1.14-2.08); procedures at lower-volume (OR, 1.41; 95% CI, 1.07-1.85) and medium-volume hospitals (OR, 1.81; 95% CI, 1.20-2.72) compared with high-volume ones; sex (men: OR, 1.51; 95% CI, 1.18-1.92); obesity (OR, 1.32; 95% CI, 1.02-1.72); race (black: OR, 1.26; 95% CI, 1.02-1.57); increasing age (OR, 1.03; 95% CI, 1.01-1.04); and certain comorbidities (pulmonary circulation disease, chronic pulmonary disease, hypothyroidism, and psychoses).<br>CONCLUSIONS: The 30-day hospital readmission rate after primary THA was 3.6%. Modifiable factors, including obesity, comorbidities, medical complications, and system-related factors (hospital), have the potential to be addressed by improving the health of patients before this elective procedure, patient and family education and planning, and with the development of high-volume centers of excellence. Nonmodifiable factors such as age, sex, and race can be used to establish patient and family expectations regarding risk of readmission after THA. Contrary to other studies and the finding of increased hospital volume associated with lower risk of readmission, higher volume surgeons had a higher risk of patient readmission, which may be attributable to the referral patterns in our organization. LEVEL OF EVIDENCE: Level III, therapeutic study. |
| Manley, Ong, Lau & Kurtz (2008).<br>Total hip arthroplasty<br>US | BACKGROUND: Fewer short-term complications following total hip arthro- | METHODS: A subset of the 1997 to 2004 Medicare claims data was used to identify primary and revision total hip arthroplasties. The Kaplan-Meier method and Cox regression analysis were used to determine |

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| Effect of volume on total hip arthroplasty revision rates in the united states medicare population. The Journal of Bone and Joint Surgery. American Volume, 90(11), 2446-2451. | plasty have been associated with greater hospital and surgeon procedure volume. It remains unclear if procedure volume is associated with longer-term clinical outcomes and revision rates.<br>We examined the association between hospital and surgeon procedure volume and total hip arthroplasty revision rates in the Medicare population at six months to eight years postoperatively. | revision rates and hazard ratios associated with hospital and surgeon procedure volumes at 0.5, two, five, and eight years postoperatively.<br>RESULTS: About one-third of the primary hip procedures were done at hospitals with the highest annual volumes of total hip arthroplasties (more than 100). Surgeons with an annual volume of more than fifty procedures performed approximately one-sixth of the primary total hip arthroplasties. Patients who had been operated on by these surgeons had a lower revision rate at six months than did patients treated by surgeons with an annual volume of six to ten or eleven to twenty-five procedures (adjusted hazards ratio, 1.67 and 1.63, respectively). There was no effect of surgeon volume at the time of longer-term follow-up.<br>CONCLUSIONS: The majority of the total hip arthroplasties in the Medicare population from 1997 to 2004 were not performed by the highest-volume hospitals or surgeons. Our findings suggest that patients of low-volume surgeons have a greater risk of arthroplasty revision at six months but no greater risk of revision at the time of longer-term follow-up. There appeared to be no significant association between hospital volume and the rate of revisions of total hip arthroplasties. |
| Ames et al. (2010)<br>Total hip arthroplasty<br>US<br>Does surgeon volume for total hip arthroplasty affect outcomes after hemiarthroplasty for femoral neck fracture? American Journal of Orthopedics (Belle Mead, N.J.), 39(8), E84-9. | We conducted a study to compare complication rates in patients treated with hemiarthroplasty for femoral neck fracture by surgeons with variable experience in primary total hip arthroplasty (THA) and revision THA. | A cohort of Medicare beneficiaries (N = 115,352) was identified from Medicare part A claims from 1994 and 1995. All patients had undergone hemiarthroplasty for femoral neck fracture. Patients were grouped according to surgeon procedure volume (how many primary and revision THAs surgeon performed per year): 0 (no volume), 1-5 (low volume), 6-24 (mid volume), and 25+ (high volume). Claims were evaluated up to 5 years after surgery to identify patient encounters for complications, such as mortality, dislocation, and infection.<br>Compared with patients treated by no-volume surgeons, patients treated by high-volume surgeons had significantly lower rates of mortality, prosthetic dislocation, and superficial infection. The difference was significant for mortality at 30 days (5.6% vs 6.5%), 90 days (10.8% vs 12.8%), and 1 year (22.3% vs 23.8%); for prosthetic dislocation at 1 year (1.2% vs 1.7%); and for superficial infection at 90 days (1.1% vs 1.6%), 1 year (1.4% vs 1.9%), and 5 years (1.5% vs 2.0%). Revision surgery rates, however, were statistically higher for the high-volume group than for the no-volume group at 90 days (0.9% vs 0.7%), 1 year (3.3% vs 2.9%), and 5 years (8.4% vs 7.7%). There were no differences in rates of venous thromboembolism or deep infection between the groups. Surgical experience in primary and revision THA has a significant effect on patient outcomes after hemiarthroplasty for femoral neck fracture. |
| Thompson et al. (2002)<br>Total hip arthroplasty<br>US<br>Complications and short-term outcomes associated with total hip arthroplasty in teaching and community hospitals.<br>The Journal of Arthroplasty, 17(1), 32-40. | To assess the factors associated with better outcomes. | We followed 1,810 consecutive admissions for elective total hip arthroplasty (excluding hip fracture repair and revisions) to 27 Minnesota hospitals in a prospective study to assess the factors associated with better outcomes. Patients were interviewed before surgery and at 6 months, and their medical records were reviewed. The operative complication rate was 6.1%.<br>In general, neither surgeon nor hospital volume had any significant association with the likelihood of operative complications. For the cementless prosthesis group, significantly more operative complications were associated with being in Health Maintenance |

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| | | Organizations or with insurance other than Medicare. General complications were associated positively with a higher caseload per surgeon for patients receiving cemented prostheses. Hospital volume had no significant relationship to the general complication rate. Hospital and surgical volume and most other provider characteristics were not associated with walking and pain outcomes; however, follow-up pain scores for patients with cementless prostheses were lower for board-certified orthopaedists even after adjusting for risk factors. |
| Kreder, Williams, Jaglal et al. (1998).<br>Total hip arthroplasty<br>Canada<br>Are complication rates for elective primary total hip arthroplasty in ontario related to surgeon and hospital volumes? A preliminary investigation.<br>Canadian Journal of Surgery.Journal Canadien De Chirurgie, 41(6), 431-437. | OBJECTIVE: To test the hypothesis that complication rates for elective total hip replacement operations are related to surgeon and hospital volumes. | DESIGN: Retrospective population cohort study. STUDY COHORT: Patients who had undergone elective total hip replacement in Ontario during 1992 as captured in the Canadian Institute for Health Information database. MAIN OUTCOME MEASURES: In-hospital complications, 1- and 3-year revision rates, 1- and 3-year infection rates, length of hospital stay, and 3-month and 1-year death rates.<br>RESULTS: Surgeons with patient volumes above the 80th percentile (more than 27 hip replacements annually) discharged patients approximately 2.4 days earlier (p 0.05).<br>CONCLUSIONS: There is no evidence to support regionalization of elective hip replacement surgery in Ontario based on adverse clinical outcomes. Surgeons who perform a large number of total hip replacements are discharging patients earlier than less experienced surgeons, without any-demonstrable increase in complications leading to hospital readmission. The explanation for this observation remains unknown and will require further study. |
| Varagunam et al. (2015)<br>3 elective operations (hip and knee replacement and hernia repair)<br>Relationship between patient-reported outcomes of elective surgery and hospital and consultant volume. | Our aim was to analyze the relationship for between outcome [patient-reported outcome measures (PROMs) for functional status, health-related quality of life, and postoperative complications] and both hospital and consultant volume. | METHODS: Hospitals (NHS and independent) and consultants undertaking at least 10 NHS-funded procedures during 2011/2012 were included (230 hospitals for hip and knee replacement, 257 for hernia repair; 978 consultants for hip replacement, 1172 for knee replacement, and 1288 for hernia repair). Outcomes (disease-specific and generic PROMs, patient-reported complications) were available from the NHS National PROMs Programme for 2009/2010 to 2011/2012. Relationship between case-mix adjusted outcomes and volume investigated using multilevel modeling.<br>RESULTS:There was considerable variation in hospital volumes (about 10-fold) and consultant volumes (about 5-fold). No significant association was observed between hospital volume and outcome for all 3 procedures. For consultant volume, there was no significant association for knee replacement or hernia repair. However, outcomes were statistically significantly better for hip replacement, although the effect was of little clinical significance: an additional 10 cases was associated with a higher Oxford Hip Score (0.06), higher EQ-5D score (0.001), and lower odds ratio of complications (0.992).<br>CONCLUSIONS: There are unlikely to be any benefits to patients from centralization of elective surgery into higher volume hospitals as regards the effectiveness of surgery or the avoidance of minor complications. There is some evidence that very low volume consultants achieve poorer outcomes than higher volume colleagues but the difference is slight and of little or no clinical significance. |
| Katz, Barrett, Mahomed et al. (2004). | Background: The annual volume of major cardiovas- | Methods: We analyzed claims data for Medicare patients who had elective primary total knee replace- |

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| Total knee replacement<br>US<br>Association between hospital and surgeon procedure volume and the outcomes of total knee replacement. *Journal of Bone and Joint Surgery - Series A, 86*(9), 1909-1916. | cular and oncologic procedures performed in hospitals and by surgeons has been inversely associated with the rates of perioperative mortality and complications. The relationship between hospital and surgeon volume and perioperative outcomes following total knee replacement has received little study. | ment between January 1 and August 31, 2000. Hospital and surgeon volumes were defined as the number of primary and revision total knee replacements performed in the hospital or by the surgeon in Medicare recipients in 2000. We examined the associations between the annual volumes of total knee replacement performed in the hospitals and by the surgeons and the rates of mortality and complications (infection, pulmonary embolus, myocardial infarction, or pneumonia) in the first ninety days postoperatively. The analyses were adjusted for age, gender, comorbid conditions, Medicaid eligibility (a marker of low income), and arthritis diagnosis. Analyses of hospital volume were adjusted for surgeon volume and vice versa.<br>Results: Twenty-five percent of the primary total knee replacements were done by surgeons who performed twelve of these procedures or fewer in the Medicare population annually, and 11% were done in hospitals with an annual volume of twenty-five of these procedures or fewer. Compared with the patients who had a primary total knee replacement in hospitals with an annual volume of twenty-five procedures or fewer, those managed in hospitals with an annual volume exceeding 200 procedures had a lower risk of pneumonia (odds ratio, 0.65; 99% confidence interval, 0.47 to 0.90) and any of the adverse outcomes examined (death, pneumonia, pulmonary embolus, acute myocardial infarction, or deep infection) (odds ratio, 0.74; 99% confidence interval, 0.60 to 0.90). Similarly, patients who had a primary total knee replacement done by surgeons who performed more than fifty such procedures in Medicare recipients annually had a lower risk of pneumonia (odds ratio, 0.72; 99% confidence interval, 0.54 to 0.95) and any adverse outcome (odds ratio, 0.81; 99% confidence interval, 0.68 to 0.98) compared with patients of surgeons with an annual volume of twelve procedures or fewer.<br>Conclusions: Patients managed at hospitals and by surgeons with greater volumes of total knee replacement have lower risks of perioperative adverse events following primary total knee replacement. Patients and clinicians should incorporate these findings into discussions about selecting a surgeon and a hospital for total knee replacement. These data should also be integrated into the policy debate about the advantages and drawbacks of regionalizing total joint replacement to high-volume centers. Level of Evidence: Prognostic study, Level 11-1 (retrospective study). |
| Hervey, Purves et al. (2003).<br>Total knee arthroplasties<br>US<br>Provider volume of total knee arthroplasties and patient outcomes in the HCUP-nationwide inpatient sample.<br>The Journal of Bone and Joint Surgery.American Volume, 85-A(9), 1775-1783. | BACKGROUND: The relationship between volume and outcome of total knee arthroplasties has never been evaluated in a nationally representative sample, to our knowledge. We hypothesized that surgeons and hospitals with higher patient volumes would have better outcomes, as defined by lower mortality rates, shorter hospital stays, and lower postoperative complication rates. | METHODS: The 1997 Healthcare Cost and Utilization Project (HCUP) Nationwide Inpatient Sample, Release 6, provided discharge abstracts of patients undergoing total knee arthroplasty from a national stratified probability sample. Logistic and multiple regression models were used to estimate the adjusted association of surgeon or hospital volume with rates of in-hospital mortality, pulmonary thromboembolism, deep venous thrombosis in the lower extremity, and postoperative wound infection as well as length of hospital stay. Estimates were calculated for a target population of 277,550 patients. Models were adjusted for comorbidity, age, gender, race, household income, and procedure (primary or revision arthroplasty).<br>RESULTS: The patients were mostly white (70.2%) and female (62.7%), with a mean age of 68.9 years. The overall in-hospital mortality rate for the target population was 0.2%, and the average length of stay |

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| | | was 4.6 days for the primary total knee arthroplasties and 4.9 days for the revision procedures. Surgeon volumes of at least fifteen procedures per year and hospital volumes of at least eighty-five per year were significantly and linearly associated with lower mortality rates (odds ratio = 0.56 [0.24 to 1.31] for surgeon volume of > or = 60). No other association demonstrated a significant and directionally consistent linear trend for improved outcomes.<br>CONCLUSION: Patients treated by providers with lower caseload volumes had higher rates of mortality following total knee arthroplasty in 1997. Proposing volume standards could decrease patient mortality following this procedure. |
| Kreder, Grosso et al. (2003).<br>Total knee arthroplasty<br>Canada<br>Provider volume and other predictors of outcome after total knee arthroplasty: A population study in ontario. Canadian Journal of Surgery, 46(1), 15-22. | INTRODUCTION: Because of rationing of the limited pool of health care resources, access to total knee arthroplasty (TKA) is limited, but investigation of variables that predict complications, length of hospital stay, cost and outcomes of TKA may allow us to optimize the available resources.<br>The objective of this study was to examine the effect of various factors on complication rates after TKA in patients managed in Ontario. | METHODS: Patients who had undergone an elective TKA between 1993 and 1996, as captured in the Canadian Institute for Health Information (CIHI) database, formed the study cohort. The CIHI dataset was used to obtain information regarding in-hospital complications, hospital length of stay, revision rates, infection rates and mortality. Generalized estimating linear or logistic regression equations were used to model outcomes as a function of age, gender, comorbidity, diagnosis and provider volume.<br>RESULTS: During the study period, 14,352 patients in Ontario underwent TKA. Mortality at 3 months was associated with patient age, gender and comorbidity. There was no association between provider volume and mortality or the infection rate. Higher revision rates at 1 and 3 years were significantly associated with lower patient age and low hospital volume (p 80th percentile). Complications during admission were associated with increased patient age and comorbidity, and higher hospital volume. Longer hospital stay was associated with female gender, increasing patient comorbidity and age, and lower provider volume. Surgeons who performed fewer than 14 TKAs annually (80th percentile).<br>CONCLUSIONS: Patient variables significantly affect the rate of complications. Age, sex and comorbidity were significant predictors of complications, length of hospital stay and mortality after TKA. Although low surgeon volume was related to longer hospital stay, there was no association between surgeon volume and complication rates. The increased early revision rate for low-volume hospitals demands further study. |
| Muilwijk, van den Hof & Wille (2007).<br>9 different types of orthopedic surgery, general surgery, and gynecology.<br>The Netherlands<br>Associations between surgical site infection risk and hospital operation volume and surgeon operation volume among hospitals in the dutch nosocomial infection surveillance network.<br>*Infection Control and Hospital Epidemiology, 28*(5), 557-563. | OBJECTIVE: To examine the association between hospital operation volume and surgeon operation volume and the risk of surgical site infection (SSI). | DESIGN: Prospective, multicenter cohort study based on surveillance data. METHODS: Data were obtained from the Dutch surveillance network for nosocomial infections (Preventie Ziekenhuisinfecties door Surveillance [PREZIES]) on 9 different types of orthopedic surgery, general surgery, and gynecology procedures performed during 1996-2003. Multilevel logistic regression analysis was performed to assess the independent effect of hospital volume and surgeon volume on SSI risk.<br>RESULTS: Hospital volume was not significantly associated with SSI risk for any of the selected procedures. Low surgeon volume was associated with an increased risk for an infection for 7 of 9 types of procedures, although this effect was statistically significant only for knee arthroplasty. For 4 procedures, the odds of exceeding the 75th percentile for duration of surgery were greater when the surgeon volume was low than when the surgeon volume was moderate or high.<br>CONCLUSIONS: Patients operated on by surgeons with a low operation volume seem to have a higher |

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| | | risk of developing an SSI with some procedures, particularly knee arthroplasty. The higher SSI risk for surgeons with a low operation volume is possibly partly mediated by the longer duration of surgery, a well-known risk factor for development of SSI. |
| Hatfield, Ashton et al. (2016)<br>General surgery<br>US<br>Surgeon-specific reports in general surgery: Establishing benchmarks for peer comparison within a single hospital.<br>Journal of the American College of Surgeons, 222(2), 113-121. | BACKGROUND: Methods to assess a surgeon's individual performance based on clinically meaningful outcomes have not been fully developed, due to small numbers of adverse outcomes and wide variation in case volumes.<br>The Achievable Benchmark of Care (ABC) method addresses these issues by identifying benchmark-setting surgeons with high levels of performance and greater case volumes. This method was used to help surgeons compare their surgical practice to that of their peers by using merged National Surgical Quality Improvement Program (NSQIP) and Metabolic and Bariatric Surgery Accreditation and Quality Improvement Program (MBSAQIP) data to generate surgeon-specific reports. | STUDY DESIGN: A retrospective cohort study at a single institution's department of surgery was conducted involving 107 surgeons (8,660 cases) over 5.5 years. Stratification of more than 32,000 CPT codes into 16 CPT clusters served as the risk adjustment. Thirty-day outcomes of interest included surgical site infection (SSI), acute kidney injury (AKI), and mortality. Performance characteristics of the ABC method were explored by examining how many surgeons were identified as benchmark-setters in view of volume and outcome rates within CPT clusters.<br>RESULTS: For the data captured, most surgeons performed cases spanning a median of 5 CPT clusters (range 1 to 15 clusters), with a median of 26 cases (range 1 to 776 cases) and a median of 2.8 years (range 0 to 5.5 years). The highest volume surgeon for that CPT cluster set the benchmark for 6 of 16 CPT clusters for SSIs, 8 of 16 CPT clusters for AKIs, and 9 of 16 CPT clusters for mortality.<br>CONCLUSIONS: The ABC method appears to be a sound and useful approach to identifying benchmark-setting surgeons within a single institution. Such surgeons may be able to help their peers improve their performance. |
| Guidry, Newhook et al. (2016)<br>General surgery<br>US<br>Observations on surgeons' case selection, morbidity, and mortality following board certification. Annals of Surgery, 263(3), 487-492. | OBJECTIVE: The purpose of this study is to determine if patient selection varies based on years of surgical practice.<br>BACKGROUND: The impact of hospital and surgeon volume as a marker of experience has demonstrated an inverse association with surgical outcomes.<br>However, temporal measures of experience often demonstrate no effect. Additionally, a self-reporting survey demonstrated decreasing case complexity over time, suggesting that changes in patient selection may account for some of these observed discrepancies. | METHODS: General surgery cases at a single tertiary care center reported to the American College of Surgeons National Surgical Quality Improvement Program over a 10-year period were identified. Additionally general surgery cases from the ACS NSQIP 2008 PUF data were used to create risk models for any complications, 30-day mortality, or a composite complication or mortality outcome. These models then estimated risk for our local data. Years of experience after American Board of Surgery certification were calculated for each surgeon for each case. Multivariate linear regression, controlling for surgeon clustering, was used to determine the association between years of surgical experience and preoperative risk of complications and mortality.<br>RESULTS: Eighteen thousand six hundred and eightyeight cases were identified from our institution. Surgeons selected patients of increasing operative risk until 15 years of practice before selecting lower risk patients throughout the rest of their career. After adjusting for risk, no association was observed between years from board certification and mortality. However, there was a trend toward decreasing complication rates with increasing experience.<br>CONCLUSIONS: Surgical experience significantly impacts patient selection. Surgeons with over 25 years of experience had lower complication rates. Experience had no impact on mortality. |
| Aquina et al. (2015)<br>Open inguinal hernia repair<br>US | Background: There is currently little information regarding the impact of procedure volume on outcomes after open inguinal | Methods The database of the Statewide Planning and Research Cooperative System was queried for elective open initial inguinal hernia repairs performed in New York State from 2001 to 2008 via the use of International Classification of Diseases, 9th Revision |

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| The pitfalls of inguinal herniorrhaphy: Surgeon volume matters.<br>Surgery (United States), 158(3), 736-746. | hernia repair in the United States.<br>Our hypothesis was that increasing procedure volume is associated with lesser rates of reoperation and resource use. | and Current Procedural Terminology codes. Surgeon and hospital procedure volumes were grouped into tertiles based on the number of open inguinal hernia repairs performed per year. Bivariate, hierarchical mixed effects Cox proportional-hazards, and negative binomial regression analyses were performed assessing for factors associated with reoperation for recurrence, procedure time, and downstream total charges.<br>Results: Among 151,322 patients who underwent open inguinal hernia repair, the overall rate of reoperation for recurrence within 5 years was 1.7% with a median time to reoperation of 1.9 years. An inverse relationship was seen between surgeon volume and reoperation rate, procedure time, and health care costs (P 25 repairs/year).<br>Conclusion: Surgeon volume 25 inguinal hernia repairs per year should be considered to decrease reoperation rates and resource use. |
| Cahill et al. 2014<br>Idiopathic scoliosis<br>US<br>The effect of surgeon experience on outcomes of surgery for adolescent idiopathic scoliosis<br>The Journal of bone and joint surgery. American volume, 20 August 2014, Vol.96(16), pp.1333-9 | Single-surgeon series investigating the learning curve involved in surgery for spinal deformity may be confounded by changes in technology and techniques.<br>Our objective with this multicenter, prospective study was to present a cross-sectional analysis of the impact of surgeon experience on surgery for adolescent idiopathic scoliosis. | All posterior-only surgical procedures for adolescent idiopathic scoliosis performed in the 2007 to 2008 academic year, with a minimum of two years of patient follow-up, were included. Two groups were created on the basis of surgeon experience: a young surgeons' group, which included patients of surgeons with less than five years of experience, and an experienced surgeons' group, which included patients of surgeons with five or more years of experience. Nine surgeons (four young and five experienced) operated on a total of one hundred and sixty-five patients with adolescent idiopathic scoliosis. The surgeons' experience ranged from less than one year to thirty-six years in practice. The two groups had similar preoperative curve-magnitude measurements, SRS-22 (Scoliosis Research Society-22) scores, and distribution by Lenke curve type. There were significant operative and postoperative differences. The young surgeons fused an average of 1.2 levels more than the experienced surgeons ($p = 0.045$). The mean intraoperative estimated blood loss (EBL) of the young surgeons' group was more than twice that of the experienced surgeons' group (2042 mL compared with 1013 mL; $p < 0.001$).<br>The duration of surgery was 458 minutes for the young surgeons compared with 265 minutes for the experienced surgeons ($p < 0.001$). The overall SRS-22 scores were significantly worse in the young surgeons' group (a mean of 4.1 compared with 4.5; $p = 0.001$). The difference between groups was also significant for the domains of pain ($p = 0.016$), self-image ($p = 0.008$), and function ($p < 0.001$). Complication rates did not differ significantly between the groups. Operative results and health-related quality of life following surgery for adolescent idiopathic scoliosis were significantly and positively correlated with surgeon experience. |
| Margulies, Cryer et al. (2001).<br>Trauma surgery<br>US<br>Patient volume per surgeon does not predict survival in adult level I trauma centers. *The Journal of Trauma, 50*(4), 597-601; discussion 601-3 | BACKGROUND: The 1999 American College of Surgeons resources for optimal care document added the requirement that Level I trauma centers admit over 240 patients with Injury Severity Score (ISS) > 15 per year or that trauma surgeons care for at least 35 patients per year. | METHODS: Data were obtained from the trauma registry of the five American College of Surgeons-verified adult Level I trauma centers in our mature trauma system between January 1, 1998, and March 31, 1999. Data abstracted included age, sex, Glasgow Coma Scale (GCS) score, intensive care unit length of stay, hospital length of stay, probability of survival (Ps), mechanism of injury, number of patients per each trauma surgeon and institution, and mortality. Multiple logistic regression was performed to select independent variables for modeling of survival. |

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| | The purpose of this study was to test the hypothesis that high volume of patients with ISS > 15 per individual trauma surgeon is associated with improved outcome. | RESULTS: From the five Level I centers there were 11,932 trauma patients in this time interval; of these, 1,754 patients (14.7%) with ISS > 15 were identified and used for analysis. Patients with ISS > 15 varied from 173 to 625 per institution; trauma surgeons varied from 8 to 25 per institution; per-surgeon patient volume varied from 0.8 to 96 per year. Logistic regression analysis revealed that the best independent predictors of survival were Ps, GCS score, age, mechanism of injury, and institutional volume ($p < 0.01$). Age and institutional volume correlated negatively with survival. Analysis of per-surgeon patient caseload added no additional predictive value ($p = 0.44$).<br>CONCLUSION: The significant independent predictors of survival in severely injured trauma patients are Ps, GCS score, age, mechanism of injury, and institutional volume. We found no statistically meaningful contribution to the prediction of survival on the basis of per-surgeon patient volume. Since this volume criterion for surgeon enpanelment and trauma center designation would not be expected to improve outcome, such a requirement should be justified by other measures or abandoned. |
| Haut, Chang, Efron et al. (2006)<br>Trauma surgery<br>US<br>Injured patients have lower mortality when treated by "full-time" trauma surgeons vs. surgeons who cover trauma "part-time".<br>The Journal of Trauma, 61(2), 272-8; discussion 278-9. | BACKGROUND: Studies examining the effect of trauma surgeon volume on patient outcomes have had disparate results. We hypothesize that "full-time" trauma surgeons would have lower patient mortality rates than surgeons covering trauma "part-time." | METHODS: Retrospective review of 14,171 patients during a span of 6.5 years (January 1998 to June 2004) from the trauma registry at an urban, university-based Level I trauma center. "Full-time" surgeons practiced primarily trauma, emergency surgery, and critical care. "Part-time" surgeons took trauma call, but mainly practiced another type of surgery (e.g., pancreatic, hepatobiliary, vascular, transplant). Chi square and multiple logistic regression compared mortality between groups.<br>RESULTS: There were no differences in patient demographics or admission injury patterns between the two groups. On bivariate analysis, the subgroup of patients with severe head injury had lower mortality when treated by "full-time" surgeons. With ED deaths excluded, more severely injured patients (Injury Severity Score [ISS] >15) had a survival benefit in the "full-time" group. Multiple logistic regression showed a 50% increase in mortality for patients treated by "part-time" trauma surgeons when adjusting for age, sex, ISS >15, severe head injury, hypotension, nighttime admission, day of the week, and penetrating mechanism (odds ratio of death 1.45, 95% CI 1.04-2.02). Similar results are seen in only patients surviving to emergency room discharge (odds ratio of death 1.50, 95% CI 1.01-2.22). Z and W scores showed higher than expected survival for all patients with the "full-time" cohort showing a larger benefit.<br>CONCLUSIONS: Even within an established trauma program treating many injured patients, mortality is significantly lower in patients initially treated by "full-time" trauma surgeons. |
| Chukmaitov et al. (2008)<br>Outpatient colonoscopy, cataract removal, and upper gastrointestinal endoscopy.<br>US<br>Is there a relationship between physician and facility volumes of ambulatory procedures and patient outcomes? | This study explores associations between patient outcomes (7- and 30-day hospitalization and mortality) and healthcare provider (physician and facility) volumes of outpatient colonoscopy, cataract removal, and upper gastrointestinal endoscopy performed in outpatient surgical settings in Florida. | Findings indicate that patients treated by high-volume physicians or facilities had lower adjusted odds ratios for hospitalizations and mortality. When physician and facility volume were assessed simultaneously, physician volume accounted for larger effects than facility volume in hospitalization models. When assessing both physician and facility volume together for mortality, facility volume was a stronger predictor of mortality outcomes at 30 days.<br>Further examinations of associations of outpatient physician and facility volumes and patient outcomes are suggested. |

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| The Journal of Ambulatory Care Management, 31(4), 354-369. | | |
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| Conway, O'Riordan & Silke (2013)<br>Emergency medicine<br>US<br>Consultant volume, as an outcome determinant, in emergency medical admissions.<br>QJM: Monthly Journal of the Association of Physicians, 106(9), 831-837. | BACKGROUND: Increasing hospital or specialist volumes has been shown to improve outcomes; there are little data on volumes and outcomes in emergency medical admissions.<br>We have examined the hospital length of stay (LOS) and 30-day mortality for patients admitted under a consultant 'of the day' having high- or low-admission volumes. | METHODS: An analysis was performed on all emergency medical patients admitted between 1 January 2002 and 31 December 2011, using anonymous patient data. We calculated the numbers of unique patients admitted to each 'on call' consultant and allocated the latter to a high- (70th centile with 8/22 consultants) or low-volume (14/22 consultants) category. We examined outcomes (LOS and in-hospital 30-day mortality), by these cut-offs employing logistic regression to calculate unadjusted and adjusted odds ratios (ORs) and 95% confidence intervals (CIs).<br>RESULTS: The hospital LOS was shorter (P < 0.001) for high [median 4.2, inter-quartile range (IQR) 1.7, 8.7] compared with the lower volume group (median 4.8, IQR 1.9, 9.7). There was a reduced 30-day in hospital mortality for high-volume (8.2%) compared with low-volume consultants (9.6%: P < 0.01). An admission under a high-volume consultant was independently predictive of survival, after adjustment for other outcome predictors including co-morbidity; the relative risk reduction was 25% [OR 0.75 (95% CI 0.68-0.82): P < 0.001].<br>CONCLUSION: In an era of increasing specialization, these data provide support for the concept that the frequency of being 'on-call' contributes to maintaining competence with an associated improvement in patient outcomes. |
| David, G., & Brachet, T. (2009).<br>Emergency medical services<br>US<br>Retention, learning by doing, and performance in emergency medical services. Health Services Research, 44(3), 902-925. | OBJECTIVES: To examine the strength of the volume-outcome relationship among paramedics, a group of providers that has not been previously studied in this context. By identifying the effects of individual learning on performance, we also assess the value of paramedics' retention. The prehospital emergency medical services (EMS) setting allows us to interpret any volume-outcome relationship as learning by doing, uncontaminated by reputation-based referrals because ambulance units are dispatched based on proximity. | DATA SOURCES: Incident-level EMS data spanning 1991 to 2005 from the Mississippi Emergency Medical Services Information System collected by the Mississippi Department of Health.<br>RESEARCH DESIGN: Using linear and quantile methods with and without provider fixed effects, we estimate the relationship between experience accumulation and performance using the universe of trauma incidents involving injured patients (including motor vehicle crashes, falls, stabbings, and shootings). PRINCIPAL<br>FINDINGS: We find that greater individual volume is robustly related to improved performance. In addition, we find that the benefit of learning operates through both recent and past experiences, accrues differentially across tenure groups, and operates on both mean performance and the upper quantiles of the performance distribution.<br>CONCLUSIONS: Persistent past and current volume effects suggest that policy and managerial implications in EMS should be directed at retention efforts to take advantage of individual learning by paramedics. |
| Conway, O'Riordan et al. (2013).<br>Emergency medical admissions<br>US<br>Consultant volume, as an outcome determinant, in emergency medical admissions.<br>QJM: Monthly Journal of the Association of Physicians, 106(9), 831-837. | BACKGROUND: Increasing hospital or specialist volumes has been shown to improve outcomes; there are little data on volumes and outcomes in emergency medical admissions. We have examined the hospital length of stay (LOS) and 30-day mortality for patients admitted under a consultant 'of the day' having high- or low-admission volumes. | METHODS: An analysis was performed on all emergency medical patients admitted between 1 January 2002 and 31 December 2011, using anonymous patient data. We calculated the numbers of unique patients admitted to each 'on call' consultant and allocated the latter to a high- (70th centile with 8/22 consultants) or low-volume (14/22 consultants) category. We examined outcomes (LOS and in-hospital 30-day mortality), by these cut-offs employing logistic regression to calculate unadjusted and adjusted odds ratios (ORs) and 95% confidence intervals (CIs).<br>RESULTS: The hospital LOS was shorter (P < 0.001) for high [median 4.2, inter-quartile range (IQR) 1.7, 8.7] compared with the lower volume group (median |

| Author(s) & clinical area | Objectives & studied factors | Results and comments |
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| | | 4.8, IQR 1.9, 9.7). There was a reduced 30-day in hospital mortality for high-volume (8.2%) compared with low-volume consultants (9.6%: P < 0.01). An admission under a high-volume consultant was independently predictive of survival, after adjustment for other outcome predictors including co-morbidity; the relative risk reduction was 25% [OR 0.75 (95% CI 0.68-0.82): P < 0.001].<br>CONCLUSION: In an era of increasing specialization, these data provide support for the concept that the frequency of being 'on-call' contributes to maintaining competence with an associated improvement in patient outcomes. |
| LeFevre (1992).<br>Perinatal & neonatal<br>US<br>Physician volume and obstetric outcome.<br>Medical Care, 30(9), 866-871. | Although much has been written regarding regionalization of obstetric services and inferences made about centralization of labor and delivery, little data exist that specifically address the volume-outcome relationship for obstetrics. The purpose of this study was to determine the relationship between physician volume and perinatal outcome as measured by neonatal and perinatal mortality. | A sample of 210,547 births to Missouri residents from 1984 to 1987 was studied using multivariate logistic regression with perinatal death and neonatal death as outcomes.<br>No relationship was found between physician volume and outcome. |
| ChinYee et al. (2013)<br>Breast cancer<br>Canada<br>Impact of center case volume on cardiotoxicity during adjuvant trastuzumab in breast cancer.<br>Journal of Clinical Oncology, 31 (15 SUPPL. 1) (no pagination). | Background: A recent study suggested that cardiotoxicity from trastuzumab (T) was associated with regional variation and insufficient cardiac monitoring (Ng et al.SABCS 2012).<br>Few studies have examined the impact of centre or physician (MD) case volume (vol) on outcomes in systemic therapy. | Methods: All breast cancer patients who were diagnosed in 2003-2009 in Ontario and treated with adjuvant T were identified through a provincial drug funding program, and linked to administrative databases to ascertain patient demographics, hospitalizations, cardiac risk factors, cardiac imaging, comorbidities, and treating centre and MD. For each year, we calculated case vol as the number of patients treated with adjuvant T by each MD and by each centre. Cardiotoxicity was defined as receiving less than 16 out of 18 doses of T because of heart failure (HF) admission, HF diagnosis by physician claims, or discontinuation after cardiac imaging. Insufficient cardiac monitoring was defined as per recent guideline and per Ng et al. Logistic regression and mixed models were constructed to examine factors associated with cardiotoxicity.<br>Results: Our cohort consisted of 3,777 patients, 214 MDs and 68 centres. For patients, 16.5% were over age 65; 30.3%, 9.4%, and 1.2% had previous diagnoses of hypertension, diabetes, and HF, respectively; 16.9% had cardiotoxicity. Univariate analyses found that high centre vol, but not MD vol, was associated with lower cardiotoxicity. Cardiotoxicity rates by centre vol quintiles (Q) were 23.4% (Q1-3), 18.2% (Q4), and 15.2% (Q5). Multivariable analyses found that lower cardiotoxicity was associated with higher centre vol (OR=0.85 per Q, p=0.02) and diagnosis in recent years (2008-2009 vs. before 2008; OR=0.50, p<0.001), after adjusting for age, previous HF, comorbidities, regional variation, and cardiac monitoring. Accounting for clustering within centres, there remained a strong trend of lower cardiotoxicity with higher centre vol (OR=0.77 per Q, p=0.06) and recent diagnosis (OR=0.50, p<0.001).<br>Conclusions: Our findings suggest a reduction in cardiotoxicity with experience and over time, and support the notion of centralization of systemic therapy in high vol centres to optimize outcomes. |

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| Kumachev, ChinYee et al. (2013).<br>Breast cancer<br>Canada<br>Impact of physician and center case volume on the adequacy of cardiac monitoring during adjuvant trastuzumab in breast cancer.<br>Journal of Clinical Oncology, 31 (26 SUPPL. 1) (no pagination) | Background: A recent study suggests that cardiotoxicity from adjuvant trastuzumab (T-mab) is associated with inadequate cardiac monitoring (Ng et al.SABCS 2012).<br>Few studies have examined the impact of centre or physician (MD) case volume (vol) on the quality of care in systemic therapy, including the adequacy of cardiac monitoring during T-mab treatment. | Methods: All breast cancer patients treated with adjuvant T-mab in Ontario between 2003-2009 were identified through a provincial drug funding program. Patient demographics, hospitalizations, cardiac risk factors, cardiac imaging, comorbidities, treatment centres and MDs were ascertained. Annual case vol was calculated as the number of patients treated per year with adjuvant T-mab by each MD and centre. Cumulative case vol was calculated as the total number of patients treated with adjuvant T-mab. Centre and MD vol were divided into terciles (T1, T2 and T3) by the year of diagnosis. Inadequate cardiac monitoring was defined as per recent guidelines and per Ng et al. Hierarchical multivariable logistic regression models were constructed to examine factors associated with inadequate cardiac monitoring.<br>Results: Our cohort consisted of 3,777 patients, 214 MDs and 68 centres. Of the total patients, 16.5% were over age 65; 30.3%, 9.4%, and 1.2% had previous diagnoses of hypertension, diabetes, and heart failure (HF), respectively; 24.3% did not receive adequate cardiac monitoring. Inadequate cardiac monitoring was associated with lower cumulative MD vol (T1: 27.9%, T2: 23.3%, T3: 20.8%, $p < 0.0001$) and lower annual centre vol (T1: 32.5%, T2: 19.7%, T3: 20.7%, $p < 0.0001$) in univariate analyses, and remained significant after adjusting for age, comorbidities, previous HF, socioeconomic status based on income, rural residence and calendar period. After adjusting for patient clustering at the MD, centre, and regional levels, lower cumulative MD vol ($p=0.012$), but not annual centre vol, remained a significant predictor for inadequate cardiac monitoring.<br>Conclusions: Our findings suggest improved cardiac monitoring with greater MD experience, supporting the notion of centralization of systemic therapy to high vol MDs to optimize outcomes. |
| Lindenauer et al. (2006)<br>Pneumonia<br>US<br>Volume, quality of care, and outcome in pneumonia.<br>Annals of Internal Medicine, 144(4), 262-269. | BACKGROUND: The establishment of minimum volume thresholds has been proposed as a means of improving outcomes for patients with various medical and surgical conditions.<br>OBJECTIVE: To determine whether volume is associated with either quality of care or outcome in the treatment of pneumonia. | DESIGN: Retrospective cohort study. SETTING: 3243 hospitals participating in the National Pneumonia Quality Improvement Project in 1998 and 1999. PATIENTS: 13,480 patients with pneumonia cared for by 9741 physicians. MEASUREMENTS: The association between the annual pneumonia caseload of physicians and hospitals and adherence to quality-of-care measures and severity-adjusted in-hospital and 30-day mortality rates.<br>RESULTS: Physician volume was unrelated to the timeliness of administration of antibiotics and the obtainment of blood cultures; however, physicians in the highest-volume quartile had lower rates of screening for and administration of influenza (21%, 19%, 20%, and 12% for quartiles 1 through 4, respectively; $P < 0.01$) and pneumococcal (16%, 13%, 13%, and 9% for quartiles 1 through 4, respectively; $P < 0.01$) vaccines. Among hospitals, the percentage of patients who received antibiotics within 4 hours of hospital arrival was inversely related to pneumonia volume (72%, 64%, 60%, and 56% for quartiles 1 through 4, respectively; $P < 0.01$), while selection of antibiotic, obtainment of blood cultures, and rates of immunization were similar. Physician volume was not associated with in-hospital or 30-day mortality rates. Odds ratios for in-hospital mortality rates rose with increasing hospital volume (1.14 95% CI, 0.87 to 1.49], 1.34 CI, 1.03 to 1.75], and 1.32 CI, 0.97 to 1.80] for quartiles 2 to 4, respectively); however, odds ratios for 30-day mortality rates were similar. LIMITATIONS: This study was limited to Medicare beneficiaries 65 years of age and older. Ascertainment of some measures of |

| Author(s) & clinical area | Objectives & studied factors | Results and comments |
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| | | the quality of care and severity of illness depended on the documentation practices of the physician.<br>CONCLUSION: Among both physicians and hospitals, higher pneumonia volume is associated with reduced adherence to selected guideline recommendations and no measurable improvement in patient outcomes. |
| Gidengil, Linder et al. (2015).<br>Acute respiratory infections<br>US<br>The volume-quality relationship in antibiotic prescribing: When more isn't better.<br>Inquiry : A Journal of Medical Care Organization, Provision and Financing, 52, 1. | For many surgeries and high-risk medical conditions, higher volume providers provide higher quality care.<br>The impact of volume on more common medical conditions such as acute respiratory infections (ARIs) has not been examined. | Using electronic health record data for adult ambulatory ARI visits, we divided primary care physicians into ARI volume quintiles. We fitted a linear regression model of antibiotic prescribing rates across quintiles to assess for a significant difference in trend.<br>Higher ARI volume physicians had lower quality across a number of domains, including higher antibiotic prescribing rates, higher broad-spectrum antibiotic prescribing, and lower guideline concordance. Physicians with a higher volume of cases manage ARI very differently and are more likely to prescribe antibiotics. When they prescribe an antibiotic for a diagnosis for which an antibiotic may be indicated, they are less likely to prescribe guideline-concordant antibiotics. Given that high-volume physicians account for the bulk of ARI visits, efforts targeting this group are likely to yield important population effects in improving quality. |

# Bilag 3 Teams som faktor

**Bilagstabel 3.1** Tværfaglige teams som medierende faktor

| Author(s) & clinical area | Objectives & studied factors | Results and comments |
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| Brännström et al. (2015)<br>Rectal cancer<br>Sweden<br>Multidisciplinary team conferences promote treatment according to guidelines in rectal cancer.<br>Acta Oncologica, 54(4), 447-453. | Multidisciplinary team (MDT) conferences have been introduced into standard cancer care, though evidence that it benefits the patient is weak.<br>We used the national Swedish Rectal Cancer Register to evaluate predictors for case discussion at a MDT conference and its impact on treatment. | MATERIAL AND METHODS: Of the 6760 patients diagnosed with rectal cancer in Sweden between 2007 and 2010, 78% were evaluated at a MDT. Factors that influenced whether a patient was discussed at a preoperative MDT conference were evaluated in 4883 patients, and the impact of MDT evaluation on the implementation of preoperative radiotherapy was evaluated in 1043 patients with pT3c-pT4 M0 tumours, and in 1991 patients with pN+ M0 tumours.<br>RESULTS: Hospital volume, i.e. the number of rectal cancer surgical procedures performed per year, was the major predictor for MDT evaluation. Patients treated at hospitals with < 29 procedures per year had an odds ratio (OR) for MDT evaluation of 0.15. Age and tumour stage also influenced the chance of MDT evaluation. MDT evaluation significantly predicted the likelihood of being treated with preoperative radiotherapy in patients with pT3c-pT4 M0 tumours (OR 5.06, 95% CI 3.08-8.34), and pN+ M0 (OR 3.55, 95% CI 2.60-4.85), even when corrected for co-morbidity and age.<br>CONCLUSIONS: Patients with rectal cancer treated at high-volume hospitals are more likely to be discussed at a Multidisciplinary team conference, and that is an independent predictor of the use of adjuvant radiotherapy.<br>These results indirectly support the introduction into clinical practice of discussing all rectal cancer patients at MDT conferences, not least those being treated at low-volume hospitals. |

# Bilag 4 Afledte negative konsekvenser

**Bilagstabel 4.1** Afledte negative konsekvenser

| Author(s) & clinical area | Objectives & studied factors | Results and comments |
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| Rasmussen & Bratlid (2007)<br>38 højt specialiserede funktioner<br>Norge<br>Quality or equality? The Norwegian experience with medical monopolies.<br>BMC Health Services Research, 7(20). | PURPOSE: The review was designed to answer the question if this centralized system, in addition to securing services of adequate quality, also was equally accessible for patients throughout the country. | PATIENTS AND METHODS: The review included the identification of the counties of residence for each of the 2 711 patients admitted and treated for the first time that year.For analysis of distribution of services the patient volume from the three northernmost counties (population 464 000) are compared with the remaining 16 counties (population 4 058 000). Furthermore, the combined three northernmost counties and the four counties in the central and west part of the country ("District Norway", population 1 208 000) are compared with the remaining 12 southern counties (population 3 314 000).<br>RESULTS: the general tendency is that people living in the north and in "district Norway" have a substantially reduced chance of being admitted to these highly specialized services. When only the 31 monopoly functions are analyzed the odds ratios are somewhat smaller than for the all services combined. For non-renal organ transplantation the chances of having access to treatment for a resident in the north is about 1/3 as for residents in the rest of the country. All the differences are statistically highly significant with p-levels below 0.001, except for the comparison of the northern counties versus the rest with regard to organ transplantations, which has a p-level of 0.007.<br>CONCLUSION: Despite the fact that the performance of these services has been monitored, highly significant differences in access to the services for patients from different parts of the country has been disclosed. This inequality of access is particularly disturbing since the medical conditions and treatments covered, such as organ transplantation, are among the most severe and critical in relation to life or death, and are services defined as having a high medical and political priority in the Norwegian National Health Service. It seems unlikely that the findings can be explained by a lower true demand in the northern and peripheral parts of the country. Most health statistics point in the opposite directions regarding all main disease groups, particularly in the northernmost counties. |
| Stitzenberg et al. (2009)<br>Cancer surgery<br>US<br>Centralization of cancer surgery: implications for patient access to optimal care.<br>Journal of Clinical Oncology, 27(28):4671-8. | PURPOSE: The volume-outcomes relationship has led many to advocate centralization of cancer procedures at high volume hospitals (HVH). We hypothesized that in response cancer surgery has become increasingly centralized and that this centralization has resulted in increased travel burden for patients. | PATIENTS AND METHODS: Using 1996 to 2006 discharge data from NY, NJ, PA, all patients > or = 18 years old treated with extirpative surgery for colorectal, esophageal, or pancreatic cancer were examined. Patients and hospitals were geocoded. Annual hospital procedure volume for each tumor site was examined, and multiple quantile and logistic regressions were used to compare changes in centralization and distance traveled.<br>RESULTS: Five thousand two hundred seventy-three esophageal, 13,472 pancreatic, 202,879 colon, and 51,262 rectal procedures were included. A shift to HVH occurred to varying degrees for all tumor types. The odds of surgery at a low volume hospital decreased for esophagus, pancreas and colon: per year odds ratios (ORs) were 0.87 (95% CI, 0.85 to 0.90), 0.85 (95% CI, 0.84 to 0.87), and 0.97 (95% CI, 0.97 to 0.98). Median travel distance increased for all sites: esophagus 72%, pancreas 40%, colon 17%, and rectum 28% (P < .0001). Travel distance was proportional to procedure volume (P < .0001). The majority of the increase in distance was attributable to centralization.<br>CONCLUSION: There has been extensive centralization of complex cancer surgery over the past decade. While this process should result in population-level improvements in cancer outcomes, centralization is increasing patient travel. For some subsets of the population, increasing travel requirements may pose a significant barrier to access to quality cancer care. |

| Author(s) & clinical area | Objectives & studied factors | Results and comments |
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| Gunderson et al. (2013)<br>US<br>Primary uterine cancer in maryland: Impact of distance on access to surgical care at high-volume hospitals.<br>International Journal of Gynecological Cancer: Official Journal of the International Gynecological Cancer Society, 23(7), 1244-1251. | OBJECTIVE: To evaluate the influence of distance on access to high-volume surgical treatment for patients with uterine cancer in Maryland. | METHODS: The Maryland Health Services Cost Review Commission database was retrospectively searched to identify primary uterine cancer surgical cases from 1994 to 2010. Race, type of insurance, year of surgery, community setting, and both surgeon and hospital volume were collected. Geographical coordinates of hospital and patient's zip code were used to calculate primary independent outcomes of distance traveled and distance from nearest high-volume hospital (HVH). Logistic regression was used to calculate odds ratios and confidence intervals.<br>RESULTS: From 1994 to 2010, 8529 women underwent primary surgical management of uterine cancer in Maryland. Multivariable analysis demonstrated white race, rural residence, surgery by a high-volume surgeon and surgery from 2003 to 2010 to be associated with both travel 50 miles or more to the treating hospital and residence 50 miles or more from the nearest HVH (all P /=50 miles from a HVH, are less likely to have their surgery at an HVH. (odds ratio, 0.37; 95% confidence interval, 0.32-0.42).<br>CONCLUSION: In Maryland, 50 miles or more from residence to the nearest HVH is a barrier to high-volume care. However, patients who travel 50 miles or more seem to do so to receive care by a high-volume surgeon at an HVH. In Maryland, Nonwhites are more likely to live closer to an HVH and more likely to use these services. |
| Riall, Eschbach et al. (2007).<br>Pancreatic resection<br>US<br>Trends and disparities in regionalization of pancreatic resection. Journal of Gastrointestinal Surgery: Official Journal of the Society for Surgery of the Alimentary Tract, 11(10), 1242-51; discussion 1251-2. | BACKGROUND: The current recommendation is that pancreatic resections be performed at hospitals doing >10 pancreatic resections annually.<br>OBJECTIVE: To evaluate the extent of regionalization of pancreatic resection and the factors predicting resection at high-volume centers (>10 cases/year) in Texas. | METHODS: Using the Texas Hospital Inpatient Discharge Public Use Data File, we evaluated trends in the percentage of patients undergoing pancreatic resection at high-volume centers (>10 cases/year) from 1999 to 2004 and determined the factors that independently predicted resection at high-volume centers.<br>RESULTS: A total of 3,189 pancreatic resections were performed in the state of Texas. The unadjusted in-hospital mortality was higher at low-volume centers (7.4%) compared to high-volume centers (3.0%). Patients resected at high-volume centers increased from 54.5% in 1999 to 63.3% in 2004 (P = 0.0004). This was the result of a decrease in resections performed at centers doing less than five resections/year (35.5% to 26.0%). In a multivariate analysis, patients who were >75 (OR = 0.51), female (OR = 0.86), Hispanic (OR = 0.58), having emergent surgery (OR = 0.39), diagnosed with periampullary cancer (OR = 0.68), and living >75 mi from a high-volume center (OR = 0.93 per 10-mi increase in distance, P < 0.05 for all OR) were less likely to be resected at high-volume centers. The odds of being resected at a high-volume center increased 6% per year.<br>CONCLUSIONS: Whereas regionalization of pancreatic resection at high-volume centers in the state of Texas has improved slightly over time, 37% of patients continue to undergo pancreatic resection at low-volume centers, with more than 25% occurring at centers doing less than five per year. There are obvious demographic disparities in the regionalization of care, but additional unmeasured barriers need to be identified. |
| McDade, Smith et al. (2012).<br>Pancreatic resection<br>US<br>Inequal benefits from regionalization of cancer care: The pancreatic cancer surgery paradigm. Journal of Clinical Oncology, 30 (15 SUPPL. 1) (no pagination | Background: Regionalization has been proposed for high-level care, including multidisciplinary cancer treatment and complex procedures. Pancreatic resections can serve as a marker for both.<br>Using Massachusetts Division of Health Care Finance and Policy (DHCFP) data, we investigated regionalization of surgery for pancreatic cancer (PCa), its potential effect on perioperative outcomes, and disparities in access to high- | Methods: Using MA DHCFP Hospital Inpatient Discharge Data, 2005-2009, 10,524 discharges for PCa were identified, of which 746 were associated with pancreatic resection. Discharges with missing or out-of-state residence were excluded (n=704). Using geodetic methods and ZIP codes, center-to-center distances were calculated between patient (pt) and treating hospital. Median ZIP income was estimated from 2009 census data. High volume hospitals (4 of 25 performing pancreatic resections in MA) were defined using Leapfrog Criteria (> 11 per year (87th percentile for MA). Chi-square and logistic regression analyses were performed using SAS software.<br>Results: Median age was 65. Pts were predominantly White (87.2%), with median ZIP income of $54,677. Pts travelled in-state up to 112 miles (median 15.4), with the majority resected at high volume hospitals (76%). Median length of stay (LOS) was 8.0 days, with LOS>1 week associated with low volume hospitals (p=0.0002). Of 14 in-hospital deaths, 7 were at low volume hospitals (4.14% of 169 pts) compared to 7 at high volume hospitals |

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| | volume PCa surgery centers. | (1.31% of 535 pts) (p=0.0214). Predictors of shorter travel distance were: Black race (OR 4.45 (95% CI 1.66-11.93)), operation at low volume hospital (OR 2.62 (95% CI 1.81-3.77), and increased age (per year) (OR 1.02 (95% CI 1.00-1.03), but not sex or median income.<br>Conclusions: Using MA statewide discharge data, regionalization of pancreatic cancer surgery to high-volume, better-outcome centers is seen to be occurring. However, it is not uniform, and disparities exist between groups of cancer pts that do and do not travel for their care. In the current era of scrutiny on cost, quality, and access to cancer care, further study into predictors of pts receiving optimal care is warranted. |
| Bliss et al. (2014).<br>Pancreatic surgery<br>US<br>Patient selection and the volume effect in pancreatic surgery: Unequal benefits?<br>HPB: The Official Journal of the International Hepato Pancreato Biliary Association, 16(10), 899-906. | BACKGROUND: The volume effect in pancreatic surgery is well established. Regionalization to high-volume centres has been proposed. The effect of this proposal on practice patterns is unknown. | METHODS: Retrospective review of pancreatectomy patients in the Nationwide Inpatient Sample 2004-2011. Inpatient mortality and complication rates were calculated. Patients were stratified by annual centre pancreatic resection volume (low 18). Multivariable regression model evaluated predictors of resection at a high-volume centre.<br>RESULTS: In total, 129,609 patients underwent a pancreatectomy. The crude inpatient mortality rate was 4.3%. 36.0% experienced complications. 66.5% underwent a resection at high-volume centres. In 2004, low-, medium- and high-volume centres resected 16.3%, 24.5% and 59.2% of patients, compared with 7.6%, 19.3% and 73.1% in 2011. High-volume centres had lower mortality (P < 0.001), fewer complications (P < 0.001) and a shorter median length of stay (P < 0.001). Patients at non-high-volume centres had more comorbidities (P = 0.001), lower rates of private insurance (P < 0.001) and more non-elective admissions (P < 0.001).<br>DISCUSSION: In spite of a shift to high-volume hospitals, a substantial cohort still receives a resection outside of these centres. Patients receiving non-high-volume care demonstrate less favourable comorbidities, insurance and urgency of operation. The implications are twofold: already disadvantaged patients may not benefit from the high-volume effect; and patients predisposed to do well may contribute to observed superior outcomes at high-volume centres. |
| Rococo et al. (2016).<br>Breast cancer surgery<br>France<br>Variation in rates of breast cancer surgery: A national analysis based on french hospital episode statistics.<br>European Journal of Surgical Oncology: The Journal of the European Society of Surgical Oncology and the British Association of Surgical Oncology, 42(1), 51-58. | AIMS: Minimum volume thresholds were introduced in France in 2008 to improve the quality of cancer care. We investigated whether/how the quality of treatment decisions in breast cancer surgery had evolved before and after this policy was implemented. | METHODS: We used Hospital Episode Statistics for all women having undergone breast conserving surgery (BCS) or mastectomy in France in 2005 and 2012. Three surgical procedures considered as better treatment options were analyzed: BCS, immediate breast reconstruction (IBR) and sentinel lymph node biopsy (SLNB). We studied the mean rates and variation according to the hospital profile and volume.<br>RESULTS: Between 2005 and 2012, the volume of breast cancer surgery increased by 11% whereas one third of the hospitals no longer performed this type of surgery. In 2012, the mean rate of BCS was 74% and similar in all hospitals whatever the volume. Conversely, IBR and SLNB rates were much higher in cancer centers (CC) and regional teaching hospitals (RTH) [IBR: 19% and 14% versus 8% on average; SLNB: 61% and 47% versus 39% on average]; the greater the hospital volume, the higher the IBR and SLNB rates (p < 0.0001). Overall, whatever the surgical procedure considered, inter-hospital variation in rates declined substantially in CC and RTH.<br>CONCLUSIONS: We identified considerable variation in IBR and SLNB rates between French hospitals. Although more complex and less standardized than BCS, most clinical guidelines recommended these procedures. This apparent heterogeneity suggests unequal access to high-quality procedures for women with breast cancer. |
| Liu et al. (2016.)<br>Complex cancer surgery<br>Why do patients still go to low-volume hospitals | Background: While a strong volume-outcome relationship exists for many cancer operations, | Methods: Patients were identified from the National Cancer Data Base (NCDB) from 2010-2014 who underwent resection for bladder, breast, esophagus, stomach, pancreas, lung and rectal malignancies from 1,406 hospitals. Low-volume hospitals were defined as those in the bottom quartile by surgical volume for each |

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| for complex cancer surgery?<br>US | patients continue to undergo these operations at low-volume centers. | operation separately. Regression models were developed to assess patient-level factors associated with undergoing surgery at a low-volume hospital for their malignancy.<br>Results: Of 633,853 patients identified, 49,926 (7.9%) underwent cancer surgery at a low-volume hospital. The low-volume threshold was 1 case/year for bladder, 34 for breast, 1 for esophagus, 1 for stomach, 1 for pancreas, 5 for lung, and 2 for rectal cancers.<br>For all the cancer surgeries examined, patients were more likely to undergo surgery at a low-volume hospital if they lived in a rural area or if they already had to drive a long distance just to reach the low-volume hospital. Patient demographics, socioeconomic factors, insurance type, comorbidities, and stage of disease were not consistently associated with undergoing surgery at a low-volume hospital across all malignancies. Although breast cancer is a common cancer with a less established volume-outcome relationship, the factors associated with undergoing surgery at a low-volume hospital were similar to those of the more complex cancer operations.<br>Conclusions: Patients continue to undergo surgery at low-volume hospitals due to where they live and how far they have to travel. Regionalization policy initiatives will remain challenging in this population. Efforts should therefore continue to emphasize quality improvement locally at each facility caring for patients with cancer. |
| Al-Refaie et al. (2012)<br>Who receives their complex cancer surgery at low-volume hospitals?<br>Journal of the American College of Surgeons, 214(1), 81-87. | Previous literature has consistently shown worse operative outcomes at low-volume hospitals (LVH) after complex cancer surgery. Whether patient-related factors impact this association remains unknown.<br>We hypothesize that patient-related factors contribute to receipt of complex cancer surgery at LVH. | Using the 20032008 National Inpatient Sample, we identified 59,841 patients who underwent cancer operations for lung, esophagus, and pancreas tumors. Logistic regression models were used to examine the impact of sociodemographic factors on receipt of complex cancer surgery at LVH. Overall, 38.4% received their cancer surgery at LVH. A higher proportion of esophagectomies were performed at LVH (70.3%), followed by pancreatectomy (38.2%) and lung resection (33.8%). Patients who were non-white, with non-private insurance, and had more comorbidities were all more likely to receive their cancer surgery at LVH (for all, $p < 0.05$). Multivariate analyses continued to demonstrate that nonwhite race, insurance status, increased comorbidities, region, and nonelective admission predicted receipt of cancer surgery at LVH across all 3 procedures. In this large national study, nonwhite race and increased comorbidities contributed to receipt of cancer surgery at LVH. Patient selection and access to high-volume hospitals are likely reasons worthy of additional investigation.<br>This study provides additional insight into the volumeoutcomes relationship. Given the demonstrated outcomes disparity between high-volume hospitals and LVH, future policy and research should encourage mechanisms for referral of patients with cancer to high-volume hospitals for their surgical care. |
| Gani et al. (2016)<br>Liver resection<br>Evaluating trends in the volume-outcomes relationship following liver surgery: Does regionalization benefit all patients the same? | Data evaluating trends in hospital volume are lacking. The current study sought to examine trends in outcomes relative to hospital volume following liver surgery. | Over time, the proportion of patients undergoing a LR at a high-volume hospital (HVH) increased from 24.4 to 45.0 %, while the proportion of patients undergoing a LR at a low-volume hospital (LVH) decreased from 40.4 to 22.7 %. On multivariable analysis, patients undergoing a LR at high-volume hospitals demonstrated a 29 % lower odds of mortality compared with patients undergoing a LR at a LVH. The rate of regionalization, however, was not equal among all patients as older patients, patients belonging to a racial minority, and those presenting with substantial comorbidity were less likely to undergo a LR at a HVH.<br>An increase in the regionalization of liver surgery was observed over time. Trends in regionalization were, however, associated with discrepancies in access to HVH among specific patient populations. |
| Gentil et al. (2012)<br>Breast cancer<br>For patients with breast cancer, geographic and | BACKGROUND: It has been shown in several studies that survival in cancer patients who were operated on by a high-volume surgeon | METHODS: All cases of primary invasive breast cancer diagnosed in the Cote d'Or from 1998 to 2008 were included. Individual clinical data and distance to the nearest reference care centre were collected. The Townsend Index of each residence area was calculated. A Log Rank test and a Cox model were used for survival analysis, and a multilevel logistic regression model was used |

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| social disparities are independent determinants of access to specialized surgeons. A eleven-year population-based multilevel analysis.<br>BMC Cancer, 12, 351-2407-12-351. | was better. Why then do all patients not benefit from treatment by these experienced surgeons? The aim of our work was to study the hypothesis that in breast cancer, geographical isolation and the socio-economic level have an impact on the likelihood of being treated by a specialized breast-cancer surgeon | to determine predictive factors of being treated or not by a specialized breast cancer surgeon. RESULTS: Among our 3928 patients, the ten-year survival of the 2931 (74.6 %) patients operated on by a high-volume breast cancer surgeon was significantly better (LogRank p < 0.001), independently of age at diagnosis, the presence of at least one comorbidity, circumstances of diagnosis (screening or not) and TNM status (Cox HR = 0.81 [0.67-0.98]; p = 0.027). In multivariate logistic regression analysis, patients who lived 20 to 35 minutes, and more than 35 minutes away from the nearest reference care centre were less likely to be operated on by a specialized surgeon than were patients living less than 10 minutes away (OR = 0.56 [0.43; 0.73] and 0.38 [0.29; 0.50], respectively). This was also the case for patients living in rural areas compared with those living in urban areas (OR = 0.68 [0.53; 0.87]), and for patients living in the two most deprived areas (OR = 0.69 [0.48; 0.97] and 0.61 [0.44; 0.85] respectively) compared with those who lived in the most affluent area.<br>CONCLUSIONS: A disadvantageous socio-economic environment, a rural lifestyle and living far from large specialized treatment centres were significant independent predictors of not gaining access to surgeons specialized in breast cancer. Not being treated by a specialist surgeon implies a less favourable outcome in terms of survival. |
| Hollenbeck et al. (2005).<br>Radical cystectomy<br>US<br>The regionalization of radical cystectomy to specific medical centers.<br>The Journal of Urology, 174(4 Pt 1), 1385-9; discussion 1389. | PURPOSE: Regionalization of high risk surgical procedures to larger teaching hospitals has been suggested as a means to improve the quality of care.<br>We established a novel framework for characterizing regionalization, implemented it to determine the extent to which regionalization of radical cystectomy has occurred and delineated whether specific patient characteristics are associated with this phenomenon. | MATERIALS AND METHODS: We used the Nationwide Inpatient Sample to identify 22,088 patients who underwent radical cystectomy for bladder cancer from 1988 to 2000. Regionalization was assessed using 5 structural hospital measures, including teaching status, urban location, discharge volume, cystectomy volume and bed capacity. Adjusted models were developed to identify the significance of temporal trends and assess the association of demographic factors with structural qualities.<br>RESULTS: Compared with 1988 to 1990 subjects were more likely to undergo cystectomy at teaching hospitals (OR 1.8), high cystectomy volume hospitals (OR 1.2), high discharge volume hospitals (OR 1.7) and large bed capacity medical centers (OR 1.4) in 1998 to 2000. The concentration of cystectomy to urban medical centers during the study years was 90% to 92%. The proportion of subjects undergoing partial cystectomy decreased from 23.9% to 16.6% as regionalization occurred. Older subjects were less likely to be treated at these regionalized centers.<br>CONCLUSIONS: Without broad legislation from health care payers radical cystectomy has increasingly regionalized to specific medical centers. Despite this regionalization disparities in its use exist among specific, vulnerable patients. Addressing this may facilitate further concentration of this procedure. |
| Simhan et al. (2011).<br>Adrenalectomy<br>US<br>Trends in regionalization of adrenalectomy to higher volume surgical centers.<br>Journal of the American College of Surgeons. Conference Publication: (Var.Pagings), 213(3 SUPPL. 1), S146. | INTRODUCTION: Although centralization of surgical procedures to high volume centers has been described previously, patterns of care for adrenal surgery are unknown.<br>We investigated trends in regionalization of care for patients undergoing adrenalectomy using hospital discharge data from 3 Northeastern states. | METHODS: Using 1996-2009 hospital discharge data from NY, NJ and PA, all patients 55 years (OR 0.91 [CI 0.86-0.96]), insured through Medicaid (OR 0.58 [CI 0.41-0.83]), or be uninsured (OR 0.29 [CI 0.20-0.44]). Controlling for year treated, patients were less likely to die in the hospital if treated at a VHVH (OR 0.38 [CI 0.19-0.75]).<br>CONCLUSIONS: These data demonstrates centralization of adrenalectomy to VHVHs since 1996 with improved clinical outcomes. Inequities in access to care to higher volume centers appear to exist and require further investigation. |
| Greenberg et al. (1988)<br>Lung Cancer<br>US<br>Referral of lung cancer patients to university hospital cancer centers. | To determine whether the referral of lung cancer patients to university cancer centers was related to nonclinical factors. | Medical charts were reviewed for almost all lung cancer patients diagnosed during the period of 1973–1976 in New Hampshire and Vermont. Greater distance from a cancer center, lower functional status, and age over 75 years were all inversely related to the use of university cancer centers both for diagnosis and for referral for treatment. Tumor cell type, patient marital status, and private medical insurance coverage were not related to the likelihood of |

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| A population-based study in two rural states.<br>Cancer, 62: 1647–1652. | | being diagnosed in or referred to a university cancer center. In rural areas distance from a specialized medical center may be the dominant factor in determining whether patients are referred, especially for a disease such as lung cancer in which referral does not offer substantial survival advantages. |
| Brookfield et al. (2009).<br>Gynecologic cancer care<br>US<br>Will patients benefit from regionalization of gynecologic cancer care? PloS One, 4(1), e4049. | OBJECTIVE: Patient chances for cure and palliation for a variety of malignancies may be greatly affected by the care provided by a treating hospital. We sought to determine the effect of volume and teaching status on patient outcomes for five gynecologic malignancies: endometrial, cervical, ovarian and vulvar carcinoma and uterine sarcoma. | METHODS: The Florida Cancer Data System dataset was queried for all patients undergoing treatment for gynecologic cancers from 1990-2000.<br>RESULTS: Overall, 48,981 patients with gynecologic malignancies were identified. Endometrial tumors were the most common, representing 43.2% of the entire cohort, followed by ovarian cancer (30.9%), cervical cancer (20.8%), vulvar cancer (4.6%), and uterine sarcoma (0.5%). By univariate analysis, although patients treated at high volume centers (HVC) were significantly younger, they benefited from an improved short-term (30-day and/or 90-day) survival for cervical, ovarian and endometrial cancers. Multivariate analysis (MVA), however, failed to demonstrate significant survival benefit for gynecologic cancer patients treated at teaching facilities (TF) or HVC. Significant prognostic factors at presentation by MVA were age over 65 (HR = 2.6, p<0.01), African-American race (HR = 1.36, p<0.01), and advanced stage (regional HR = 2.08, p<0.01; advanced HR = 3.82, p<0.01, respectively). Surgery and use of chemotherapy were each significantly associated with improved survival.<br>CONCLUSION: No difference in patient survival was observed for any gynecologic malignancy based upon treating hospital teaching or volume status. Although instances of improved outcomes may occur, overall further regionalization would not appear to significantly improve patient survival. |
| Kuo et al. (2015).<br>Bariatric surgery<br>US<br>Bariatric centers of excellence: Effect of centralization on access to care.<br>*Journal of the American College of Surgeons, 221*(5), 914-922. | BACKGROUND: In 2006, the Centers for Medicare and Medicaid Services restricted coverage for bariatric procedures to designated high-volume Centers of Excellence.<br>The effect of centralization of elective surgical procedures on the ability of patients to access surgery has not been studied previously. | STUDY DESIGN: Inpatient claims data from 2008 to 2011 from 2 high-volume surgical states were used. All patients older than 18 years undergoing a bariatric surgical procedure were included. The number of bariatric procedures and characteristics of patients undergoing bariatric surgery were examined in each year. Nonparametric tests for trend were performed to analyze time trends. Difference-in-difference analyses were performed to assess the rate of bariatric surgery in underserved Medicare patients compared with underserved patients with other payers.<br>RESULTS: The percentage of procedures performed at Centers of Excellence increased from 60.5% in 2008 to 73.1% in 2011 (p < 0.01). The proportion of Medicare patients receiving surgery at a Center of Excellence increased from 77.7% in 2008 to 88.1% in 2011 (p < 0.01). The proportion of bariatric surgery patients from underserved groups increased over time except among those residing in rural areas, for whom there was no change. Among patients from underserved populations, only black Medicare patients experienced an increase in bariatric surgery use when compared with non-Medicare patients. The travel distance for Medicare patients consistently exceeded travel distance for non-Medicare patients. However, travel distance for Medicare patients decreased slightly during the study period.<br>CONCLUSIONS: Despite the longer travel distance required for Medicare patients, centralization of bariatric surgery to Centers of Excellence did not result in impaired access to care. In fact, in this study, an improvement in access to bariatric surgery was seen and persisted among some underserved populations. |
| Dy, Marx et al. (2015).<br>Elective total joint arthroplasty<br>The potential influence of regionalization strategies on delivery of care for elective total joint arthroplasty. | Regionalization of total joint arthroplasty (TJA) to high volume hospitals (HVHs) may affect access to care and complication risk. | Using administrative data, 2,560,314 patients who underwent primary total hip or knee arthroplasty from 1991 to 2006 were categorized by whether an HVH (>200 annual TJAs) was available locally. Associations among patient characteristics, hospital utilization, and in-hospital complications were estimated using regression modeling.<br>The complication risk was higher (Odds Ratio 1.18 [95% CI: 1.16, 1.20]) if patients went to a local low volume hospital. Black and Medicaid patients were more likely to utilize the local low volume hospital than a local HVH. Utilizing a local HVH is associated with |

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| The Journal of Arthroplasty, 30(1), 1-6. | | lower complication risks. However, patients from vulnerable groups were less likely to utilize these patterns. |
| Catanzano et al. (2016).<br>Total joint arthroplasty<br>US<br>The relationship between hospital payer mix and volume growth in total joint arthroplasty: A 12-year analysis. The Journal of Arthroplasty, 31(8), 1641-1644. | BACKGROUND: Hospital reimbursement for Medicare/Medicaid/self-pay patients has not kept pace with rising expenses, and even well run efficient organizations struggle to maintain a positive margin on these cases. Therefore, hospitals rely on commercially insured patients to remain economically viable. However, hospitals located in areas with a high Medicare/Medicaid/uninsured population cannot depend on a favorable payer mix for financial sustainability. | METHODS: Using the Statewide Planning and Research Cooperative System database, total joint arthroplasties (TJAs) in New York from 2000 to 2012 were identified. Hospitals were divided into quartiles by volume, with quartile 1 representing the lowest volume hospitals. TJA cases were stratified by primary payer type, and the percentage of each primary payer type was calculated and compared among quartiles.<br>RESULTS: The highest number of hospitals performing TJAs was 207 in 2000, and the least number of hospitals was in 2012, with only 178 hospitals performing TJA. Despite the decrease in the number of hospitals, the total number of joint arthroplasties increased from 33,036 in 2000 to 62,104 in 2012.<br>CONCLUSIONS: Our study demonstrates that higher volume hospitals tended to have a more favorable payer mix (less Medicare/Medicaid/self-pay patients). This inequity widened over the 12-year study period. This trend has ethical implications for lower socioeconomic status patients as high-volume centers tend to have superior outcomes compared with low-volume centers. In addition, the lower volume high Medicare/Medicaid/self-pay hospitals are more susceptible to the Center for Medicare and Medicaid Services quality penalties making their economic viability even more tenuous potentially leading to access of care problems for these patients. |
| Diggs et al. (2008)<br>Trauma care<br>US<br>Proportion of seriously injured patients admitted to hospitals in the US with a high annual injured patient volume: A metric of regionalized trauma care.<br>Journal of the American College of Surgeons, 206(2), 212-219. | BACKGROUND: Multiple regional trauma systems have been implemented over the past 3 decades to achieve the goal of regionalized care for injured patients. The American College of Surgeons Committee on Trauma (ACS-COT) advocates that seriously injured patients should be treated in designated Level I trauma centers that meet criteria including admitting more than 1,200 injured patients annually. Reliable measures are needed to evaluate the implementation of regionalized care nationally. The goal of this study was to measure the proportion of seriously injured patients treated at high injury-volume hospitals. | STUDY DESIGN: We performed a retrospective observational study of injured patients hospitalized in the US during the years 1995 to 2003, drawn from the Nationwide Inpatient Sample. Hospitals were ranked in order of annual volume of injured patient admissions. A patient's severity of injury was calculated using ICD-9-based Injury Severity Score (ICISS). The principal measure was the proportion of seriously injured patients (ICISS<or=0.90) admitted to high-volume hospitals.<br>RESULTS: Nine hundred fifteeen injured patients admitted per year is the empiric threshold for hospitals with a high injury volume. Only 7% of hospitals in the US meet this volume threshold. Sixty percent of seriously injured patients are treated in these high-volume hospitals; within the elder (age 65 years or older) subset, this percentage is lower.<br>CONCLUSIONS: The proportion of seriously injured patients in high-volume hospitals is a functional metric that provides a practicable and comprehensive measure of regionalized trauma care in the US. Injured elder Americans have less access to experienced trauma hospitals. |
| Hinson et al. (2016).<br>Parathyroid surgery<br>U.S.<br>Domestic travel and regional migration for parathyroid surgery among patients receiving care at academic medical centers in the united states, 2012-2014.<br>JAMA Otolaryngology Head & Neck Surgery, 2016, Vol.142(7), p.641(7). | To assess how race/ethnicity and insurance status influence domestic travel patterns and selection of high- vs low-volume hospitals in different regions of the United States for parathyroid surgery. | DESIGN, SETTING, AND PARTICIPANTS: A retrospective study was conducted of 36 750 inpatients and outpatients discharged after undergoing parathyroidectomy identified in the University HealthSystem Consortium database from January 1, 2012, to December 31, 2014 (12 quarters total). Each US region (Northeast, Mid-Atlantic, Great Lakes, Central Plains, Southeast, Gulf Coast, and West) contained 20 or more low-volume hospitals (1-49 cases annually), 5 or more mid-volume hospitals (50-99 cases annually), and multiple high-volume hospitals (≥100 cases annually). Domestic medical travelers were defined as patients who underwent parathyroidectomy at a hospital in a different US region from which they resided and traveled more than 150 miles to the hospital.<br>MAIN OUTCOMES AND MEASURES: Distance traveled, regional destination, and relative use of high- vs low-volume hospitals. RESULTS: A total of 23 268 of the 36 750 patients (63.3%) |

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| | | had parathyroidectomy performed at high-volume hospitals. The mean (SD) age of the study cohort was 71.5 (16.2) years (95% CI, 71.4-71.7 years). The female to male ratio was 3:1. Throughout the study period, mean (SD) distance traveled was directly proportional to hospital volume (high-volume hospitals, 208.4 [455.1] miles; medium-volume hospitals, 50.5 [168.4] miles; low-volume hospitals, 27.7 [89.5] miles; P < .001). From 2012 to 2014, the annual volume of domestic medical travelers increased by 15.0% (from 961 to 1105), while overall volume increased by 4.9% (from 11 681 to 12 252; P = .03). Nearly all (2982 of 3113 [95.8%]) domestic medical travelers had surgery at high-volume hospitals, and most of these patients (2595 of 3113 [83.4%]) migrated to hospitals in the Southeast. Domestic medical travelers were significantly more likely to be white (2888 of 3113 [92.8%]; P < .001) and have private insurance (1934 of 3113 [62.1%]; P < .001). Most patients with private insurance (12 137 of 17 822 [68.1%]) and Medicare (9433 of 15 121 [62.4%]) had surgery at high-volume hospitals, while the largest proportion of patients with Medicaid and those who were uninsured had surgery at low-volume hospitals (1059 of 2715 [39.0%]).<br>Centralization of parathyroid surgery is a reality in the United States. Significant disparities based on race and insurance coverage exist and may hamper access to the highest-volume surgeons and hospitals. Academic medical centers with dedicated endocrine surgery programs should consider strategic initiatives to reduce disparities within their respective regions. |
| Gray et al. (2009).<br>US<br>Racial and ethnic disparities in the use of high-volume hospitals. Inquiry, 46(3), 322-338. | Differences in the source of care could contribute to racial and ethnic disparities in health status.<br>This study looks at a major metropolitan area and examines racial and ethnic differences in the use of high-volume hospitals for 17 services for which there is a documented positive volume-outcome relationship. | Focusing on the hospitalizations of New York City area residents in the periods 1995-1996 and 2001-2002, we found, after controlling for socioeconomic characteristics, insurance coverage, proximity of residence to a high-volume hospital, and paths to hospitalization, that minority patients were significantly less likely than whites to be treated at high-volume hospitals for most volume-sensitive services. The largest disparities were between blacks and whites for cancer surgeries and cardiovascular procedures. |
| Liu, et al. (2006).<br>Complex surgery<br>(Elective abdominal aortic aneurysm repair, coronary artery bypass grafting, carotid endarterectomy, esophageal cancer resection, hip fracture repair, lung cancer resection, cardiac valve replacement, coronary angioplasty, pancreatic cancer resection, and total knee replacement.)<br>U.S.<br>Disparities in the utilization of high-volume hospitals for complex surgery.<br>JAMA, 25 October 2006, Vol.296(16), pp.1973-80 | To identify patient characteristics associated with the use of high-volume hospitals using California's Office of Statewide Health Planning and Development patient discharge database.<br><br>Retrospective study of Californians receiving the following inpatient operations from 2000 through 2004: elective abdominal aortic aneurysm repair, coronary artery bypass grafting, carotid endarterectomy, esophageal cancer resection, hip fracture repair, lung cancer resection, cardiac valve replacement, coronary angioplasty, pancreatic cancer resection, and total knee replacement. Patient race/ethnicity and insurance status in high-volume (highest 20% of | Overall, nonwhites, Medicaid patients, and uninsured patients were less likely to receive care at high-volume hospitals and more likely to receive care at low-volume hospitals when controlling for other patient-level characteristics.<br>There are substantial disparities in the characteristics of patients receiving care at high-volume hospitals. The interest in selective referral to high-volume hospitals should include explicit efforts to identify the patient and system factors required to reduce current inequities regarding their use. |

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| | patients by mean annual volume) and in low-volume (lowest 20%) hospitals. A total of 719,608 patients received 1 of the 10 operations. | |
| Cooperberg et al. (2007)<br>Urological malignancies<br>US<br>Trends in regionalization of inpatient care for urological malignancies, 1988 to 2002.<br>The Journal of Urology, 178(5), 2103-8; discussion 2108. | Higher hospital and clinician volumes may be associated with improved patient outcomes for complex surgical and medical care, although the strength and consistency of this association varies markedly across specific conditions and procedures.<br>Pressures from payors and policymakers exist to move complex care to high volume hospitals. The net effect of these pressures may be the regionalization of care.<br>We quantified trends in the regionalization of inpatient care for urological oncology in a national administrative database. | High volume hospital discharges increased significantly as a proportion of all discharges for bladder (67% to 70%) and renal (67% to 73%) cancer surgery, and they were essentially constant for prostate surgery (76%). Trends were similar for Medicare and Medicaid patients except high volume hospital discharges for prostate cancer decreased during the study period. Significant regional variation was observed for the regionalization of surgical and nonsurgical care.<br>Nationwide Inpatient Sample data demonstrate the ongoing regionalization of urological oncology care. The policy implications of this trend are complex with potentially important benefits and risks in terms of access to and quality of care. |
| Johnston et al. (2013)<br>Endovascular repair to treat thoracic aortic diseases<br>US<br>“Association of race and socioeconomic status with the use of endovascular repair to treat thoracic aortic diseases.“ | Descending thoracic aortic diseases may be treated with either open thoracic aortic repair or thoracic endovascular aortic repair (TEVAR).<br>Previous studies have demonstrated that race and socioeconomic status (SES) affect access to care and treatment allocation in vascular surgery.<br>We hypothesized that racial minorities and lower SES patients have decreased propensity to have their thoracic aortic disease treated with TEVAR. | Contrary to our initial hypothesis, racial minorities (Black, Hispanic, and Native American) and patients with lower median household incomes have a greater association with the performance for TEVAR after accounting for patient comorbid disease, indication for treatment, payer status, and hospital volume.<br>These results indicate that traditional racial disparities do not persist in TEVAR allocation. |
| Birkmeyer et al. (2003b).<br>High-risk surgery (esophagectomy and pancreatic resection).<br>Regionalization of high-risk surgery and implications for patient travel times. | To estimate how minimum volume standards for esophagectomy and pancreatic resection would affect how long patients must travel for these procedures. | Most patients would need to travel less than 30 additional minutes (74% pancreatectomy; 76% esophagectomy). Many patients already lived closer to a higher-volume hospital (25% pancreatectomy; 26% esophagectomy). Conversely, with very high-volume standards (>16/year for pancreatectomy; >19/year for esophagectomy), approximately 80% of patients would change to higher-volume centers. More than 50% of these patients would increase their travel time by more than 60 minutes. Travel times would increase most for patients living in rural areas.<br>Many patients travel past a higher-volume center to undergo surgery at a low-volume hospital. If not set too high, hospital volume standards could be implemented for selected operations without imposing unreasonable travel burdens on patients. |
| Grumbach et al. (1995)<br>Coronary artery bypass surgery (CABS) | To determine how regionalization of facilities for coronary artery by- | DESIGN: Computerized hospital discharge records were used to measure hospital CABS volume and in-hospital post-CABS mortality rates. Relationships between surgical volume and age- and sex-adjusted mortality rates were compared using chi 2 tests. |

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| US & Canada<br>Regionalization of cardiac surgery in the United States and Canada. Geographic access, choice, and outcomes.<br>JAMA. 1995 Oct 25;274(16):1282-8. | pass surgery (CABS) affects geographic access to CABS and surgical outcomes. | Small-area analysis of the association between CABS rates and distances to nearest CABS hospital was performed using multivariate linear regression methods. SETTING: All nonfederal hospitals in New York, California, Ontario, Manitoba, and British Columbia. PATIENTS: All adult residents of the five jurisdictions who underwent CABS in a hospital in their jurisdiction from 1987 through 1989.<br>RESULTS: In New York and Canada, approximately 60% of all CABS operations took place in hospitals performing 500 or more CABS operations per year, compared with only 26% in California. The highest mortality rates were found among California hospitals performing fewer than 100 CABS operations per year (adjusted 14-day in-hospital mortality was 4.7% compared with 2.4% in high-volume California hospitals, P < .001). The percentage of the population residing within 25 miles of a CABS hospital was 91% in California, 82% in New York, and less than 60% in Canada. Eliminating very low-volume (< 100 cases per year) CABS hospitals in California would increase travel distances to a CABS hospital only slightly for a small number of residents. The Canadian degree of regionalization was not associated with lower CABS rates within provinces for populations living at more remote distances from the nearest CABS hospital.<br>CONCLUSION: Regionalization of CABS facilities in New York and Canada largely avoids the problem of low-volume outlier hospitals with high postoperative mortality rates found in California. New York has avoided the redundancy of facilities that exists in California while still providing residents a geographically convenient selection of CABS hospitals. Stricter regionalization in Canada may leave residents with a more narrow choice of facilities, but does not disproportionately affect access to surgery for populations living at remote distances from CABS facilities. |
| Rousseau et al. 1994<br>Literature review<br>UK<br>Primary health care in rural areas: Issues of equity and resource management – a literature review.<br>(Report no. 66). Centre for Health Services Research, University of Newcastle upon Tyne. | | The trend towards centralization of trauma services pays too much attention to the advantage of centralization and not enough to the extent to which delays in reaching hospital care contribute to preventable deaths. |
| **Kapacitet og adgang** | | |
| Beecher et al. (2015).<br>Increased risk environment for emergency general surgery in the context of regionalization and specialization.<br>International Journal of Surgery (London, England), 21, 112-114. | BACKGROUND: The pressures on tertiary hospitals with increased volume and complexity related to regionalization and specialization has impacted upon availability of operating theatres with consequent displacement of emergencies to high risk out of hours settings. | METHODS: A retrospective review of an electronic emergency theatre list prospectively maintained database was performed over a two year period. Data gathered included type of operation performed, Time to Theatre (TTT), operation start time and length of stay (LOS).<br>RESULTS: Of 7041 emergency operations 25% were performed out of hours. 2949 patient had general surgical emergency procedures with 910 (30%) performed out of hours. 53% of all emergency laparotomies and 54% of appendicectomies were out of hours. 57% of cases operated on out of hours had been awaiting surgery during the day. Mean TTT was shorter for those admitted at the weekend compared to those admitted during the week (15.6 vs 24.9 h) (p < 0.0001).<br>CONCLUSION: The majority of major emergency surgery is performed out of hours in a way unfavorable to good clinical outcomes. It is of concern that more than half of the most life threating procedures involving laparotomy, take place out of hours. Regionalization needs to be accompanied by infrastructure planning to accommodate emergency surgery. |
| Morris et al. (2006). | PURPOSE: The regionalization of procedures to | MATERIALS AND METHODS: We used the Nationwide Inpatient Sample to identify 12,948 patients who underwent percutaneous |

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| Regionalization of percutaneous nephrolithotomy: Evidence for the increasing burden of care on tertiary centers.<br>The Journal of Urology, 176(1), 242-6; discussion 246. | specialized medical centers has been suggested as a means to improve the quality of care for select high risk procedures.<br>Prior work has demonstrated the spontaneous regionalization of high risk procedures to tertiary centers. Similar concentration of complex, low risk procedures (e.g. percutaneous nephrolithotomy) to these centers would underscore the increasing burden of care placed on these hospitals. | nephrolithotomy for stones between 1988 and 2002. Regionalization was measured based on the 6 structural hospital qualities of teaching status, urban location, bed capacity, hospital throughput (all diagnoses), annual percutaneous nephrolithotomy volume and for-profit status. Logistic regression was used to determine the propensity of percutaneous nephrolithotomy to concentrate to these medical centers.<br>RESULTS: Compared to procedures performed between 1988 and 1990, patients were more likely to undergo percutaneous nephrolithotomy at teaching (OR 1.6, 95% CI 1.3-1.9), high percutaneous nephrolithotomy volume (OR 1.7, 95% CI 1.6-1.9), large bed capacity (OR 1.2, 95% CI 1.1-1.3) and high throughput hospitals (OR 1.4, 95% CI 1.3-1.4) in the years 2000 to 2002.<br>CONCLUSIONS: Percutaneous nephrolithotomy, a technically complex but low risk procedure, has spontaneously regionalized to tertiary centers, suggesting the migration of complex surgical care to these centers. The impact of this increasing burden of care on tertiary centers is unclear but may be problematic in the current reimbursement environment. |
| Metcalfe et al. (2014).<br>Trauma<br>Effect of regional trauma centralization on volume, injury severity and outcomes of injured patients admitted to trauma centres.<br>*The British Journal of Surgery, 101*(8), 959-964 | BACKGROUND: Centralization of complex healthcare services into specialist high-volume centres is believed to improve outcomes. For injured patients, few studies have evaluated the centralization of major trauma services.<br>The aim of this study was to evaluate how a regional trauma network affected trends in admissions, case mix, and outcomes of injured patients. | METHODS: A retrospective before-after study was undertaken of severely injured patients attending four hospitals that became major trauma centres (MTCs) in March 2012. Consecutive patients with major trauma were identified from a national registry and divided into two groups according to injury before or after the launch of a new trauma network. The two cohorts were compared for differences in case mix, demand on hospital resources, and outcomes.<br>RESULTS: Patient volume increased from 442 to 1326 (200 per cent), operations from 349 to 1231 (253 per cent), critical care bed-days from 1100 to 3704 (237 per cent), and total hospital bed-days from 7910 to 22,772 (188 per cent). Patient age increased on MTC designation from 45.0 years before March 2012 to 48.2 years afterwards (P = 0.021), as did the proportion of penetrating injuries (1.8 versus 4.1 per cent; P = 0.025). Injury severity fell as measured by median Injury Severity Score (16 versus 14) and Revised Trauma Score (4.1 versus 7.8). Fewer patients required secondary transfer to a MTC from peripheral hospitals (19.9 versus 16.1 per cent; P = 0.100). There were no significant differences in total duration of hospital stay, critical care requirements or mortality. However, there was a significant increase, from 55.5 to 62.3 per cent (P < 0.001), in the proportion of patients coded as having a 'good recovery' at discharge after institution of the trauma network.<br>CONCLUSION: MTC designation leads to an increased case volume with considerable implications for operating theatre capacity and bed occupancy. Although no mortality benefit was demonstrated within 6 months of establishing this trauma network, early detectable advantages included improved functional outcome at discharge. |
| **Det hele patientforløb og brugerinddragelse** | | |
| Svederud et al. (2015)<br>Highly specialised procedures<br>Sweden<br>Patient perspectives on centralisation of low volume, highly specialised procedures in sweden.<br>Health Policy, 119, 1068-1075. | This study explores important considerations from a patient perspective in decisions regarding centralisation of specialised health care services.<br>The analysis is performed in the framework of the Swedish National Board of Health and Welfare's ongoing work to evaluate and, if appropriate, centralise low volume, highly specialised, health services defined | In addition to a literature review, a survey directed to members of patient associations and semi-structured interviews with patient association representatives and health care decision makers were conducted.<br>The results showed that from a patient perspective, quality of care in terms of treatment outcomes is the most important factor in decisions regarding centralisation of low volume, highly specialised health care. The study also indicates that additional factors such as continuity of treatment and a well-functioning care pathway are highly important for patients.<br>However, some of these factors may be dependent on the implementation process and predicting how they will evolve in case of centralisation will be difficult. Patient engagement and patient association involvement in the centralisation process is likely to be a key component in attaining patient focused care and ensuring patient satisfaction with the centralisation decisions. |

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| | as National Specialised Medical Care. | |
| Moscelli et al. (2016)<br>Hip replacement<br>England<br>Location, quality and choice of hospital: Evidence from England 2002-2013.<br>Regional Science and Urban Economics, 60, 112-124. | We investigate (a) how patient choice of hospital for elective hip replacement is influenced by distance, quality and waiting times, (b) differences in choices between patients in urban and rural locations, (c) the relationship between hospitals' elasticities of demand to quality and the number of local rivals, and how these changed after relaxation of constraints on hospital choice in England in 2006. | Using a data set on over 500,000 elective hip replacement patients over the period 2002 to 2013 we find that patients became more likely to travel to a provider with higher quality or lower waiting times, the proportion of patients bypassing their nearest provider increased from 25% to almost 50%, and hospital elasticity of demand with respect to own quality increased. By 2013 average hospital demand elasticity with respect to readmission rates and waiting times were −0.2 and −0.04. Providers facing more rivals had demand that was more elastic with respect to quality and waiting times. Patients from rural areas have smaller disutility from distance.<br>As with previous studies,we find distance to be a strong predictor of choice,with patients preferring hospitals close from home. |
| Clark (2012)<br>25 major diagnostic categories<br>U.S. general hospitals<br>Comorbidity and the limitations of volume and focus as organizing principles.<br>Medical Care Research and Review, 69(1), 83-102. | To examine the extent to which patient comorbidity moderates the efficiency benefits of hospital volume and hospital focus. | Patient comorbidities moderate the cost advantages of volume and focus.<br>The narrow scope of the specialized silos and the thick boundaries between them may generate inefficiencies with respect to care for patients with multiple conditions. |
| Finlayson et al. (1999)<br>Elective surgery<br>US<br>Patient preferences for location of care: implications for regionalization.<br>Medical Care, 37(2), 204-209. | To determine the strength of patient preferences for local care.<br>For patients travel to regional centers may be undesirable despite the expected mortality benefit. | DESIGN: Using a scenario of potentially resectable pancreatic cancer and a modification of the standard gamble utility assessment technique, we determined the level of additional operative mortality risk patients would accept to undergo surgery at a local rather than at a distant regional hospital in which operative mortality was assumed to be 3%. We used multiple logistic regression to identify predictors of willingness to accept additional risk. SUBJECTS: One hundred consecutive patients (95% male, median age 65) awaiting elective surgery at the Veterans Affairs Medical Center in White River Jct., VT.<br>RESULTS: All patients preferred local surgery if the operative mortality risk at the local hospital were the same as the regional hospital (3%). If local operative mortality risk were 6%, which is twice the regional risk, 45 of 100 patients would still prefer local surgery. If local risk were 12%, 23 of 100 patients would prefer local surgery. If local risk were 18%, 18 of 100 patients would prefer local surgery. Further increases in local risk did not result in large changes in the proportion of patients preferring local care.<br>Many patients prefer to undergo surgery locally even when travel to a regional center would result in lower operative mortality risk.<br>Policy makers should consider patient preferences when assessing the expected value of regionalizing major surgery. |
| Chang et al. (2004)<br>Pediatric heart surgery<br>Canada<br>Parental preference regarding hospitals for children undergoing surgery: a trade-off between travel distance | OBJECTIVE: To explore parental preference in the choice between a local and a referral hospital for children undergoing heart surgery. | METHODS: One hundred three parents or adult primary caregivers of children referred to a pediatric cardiology clinic were interviewed. Participants were presented with hypothetical scenarios in which they or their children had a heart condition requiring elective surgery. The surgery could be performed at either a local hospital or a regional referral hospital. The travel time to the referral hospital was initially presented as 2 h, and the mortality rate was set at 3% for both the local and the referral hospitals. The parents were then presented with scenarios that sequentially increased the mortality of the local hospital and the distance to the |

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| and potential outcome improvement.<br>The Canadian Journal of Cardiology, 20(9):877-882. | | referral hospital, and were asked to choose between the local and regional referral hospitals.<br>RESULTS: When the regional referral hospital was 2 h away and the mortality rates for the referral hospital and the local hospital were equal at 3%, 82.5% of participants chose the local hospital for their children. The percentage of participants choosing the local hospital decreased progressively as the mortality rate of the local hospital increased (to 9.7% at 18% mortality). Between 5% and 10% more participants chose the local hospital when the distance to the referral hospital was increased from 2 h to 4 h. There was no difference in age, sex, ethnicity, language, type of insurance, level of education and availability of personal transportation between participants who chose the regional referral hospital and those who chose the local hospital. Participants who lived closer to the hospital at which the survey was conducted were more likely to choose the local hospital.<br>CONCLUSION: The present study defines a relation between potential outcome improvement and increasing travel distance from a patient or parent's perspective. This trade-off is an important consideration when planning for regionalization. |
| Kronebusch (2009b)<br>Quality information and fragmented markets: Patient responses to hospital volume thresholds.<br>Journal of Health Politics, Policy and Law, Vol. 34, No. 5. | Over the last two decades, information dissemination policies to improve patient hospital choice have emerged. But during this same period, policy makers have also generally adopted a market-oriented approach vis-a-vis hospitals, with limited regulation of facility expansion and few restrictions on hospital mergers and ownership changes.<br>These policies may be in tension, and this analysis examines whether there have been changes over time in patient responses to information about the value of high-volume hospitals and the degree to which hospital market changes may have limited these patient responses. | The results indicate modest changes consistent with an increase in quality-seeking behavior for several services for which research indicates a volume-outcome relationship. At the same time, there are services for which trends have been moving in the opposite direction--toward greater local-care seeking--and changes for the remaining services have been fairly small. Even for services with a trend toward greater patient sensitivity to volume as a marker for quality, however, hospital market changes have reduced the change over time in high-volume hospital use. These results highlight some of the limitations of market-oriented strategies for increasing patient use of high-quality hospitals.<br>From the perspective of patients, the quality of hospital care is not the only consideration in their decision calculus. Other characteristics that might matter to a patient include his or her physician's recommendations, the hospital's location and convenience of access, personal familiarity with the hospital, the availability of culturally and linguistically competent staff, the religious affiliation of the hospital and the nature of its ownership, and insurance coverage limitations. All of thesemight counterbalance patient perceptions about the technical quality of medical services and might limit the extent to which patients will choose higher-volume hospitals.<br>The history of certificate-of-need regulation has shown the difficulties of restricting hospitals from entering the market to provide specialized services, especially for services seen as profitable or that may be important to attracting physicians and hospital staff. While the creation of centers of excellence is less controversial, both approaches have the necessary implication that with a relatively fixed number of patients in an area needing any particular service, the concentration of care in particular facilities implies that some low-volume hospitals currently providing these services will eventually need to drop out of the market for these services. |
| Stewart et al. (2006)<br>Complex and infrequently performed operations.<br>Australia<br>"Surgical service centralisation in australia versus choice and quality of life for rural patients." | High patient volume for both hospitals and surgeons is an important determinant of operative mortality and outcome for complex and infrequently performed operations. | The 13% of Australia's population who live in rural and remote areas often choose to have surgery close to home and support networks despite the potentially higher operative mortality and morbidity. Rural patients should be able to make an informed choice about having their surgery locally. Rural and metropolitan surgeons should discuss and reach mutual agreement on where each patient is best treated.<br>A balance must be struck between quality of services that can be provided locally and geographic convenience. |

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| Ændringer i indikationer og øget risici | | |
| Johnson et al. (2012)<br>Liver transplant<br>US<br>Liver transplant center risk tolerance.<br>Clinical Transplantation, 26(3), E269-76. | Recent changes in Center for Medicare & Medicaid Services (CMS) condition for participation, using benchmark volume/outcomes requirements for certification, have been implemented.<br>Consequently, the ability of a transplant center to assess its risk tolerance is important in successful management. An analysis of SRTR data was performed to determine donor/recipient risk factors for graft loss or patient death in the first year. Each transplant performed was then assigned a prospective relative risk (RR) of failure. | The modeling demonstrates that centers with smaller annual volumes must use a more risk taking strategy than larger volume centers to avoid being flagged for CMS volume requirements. The modeling also demonstrates optimal risk taking strategies for centers based upon volume to minimize the probability of being flagged for not meeting volume or outcomes benchmarks. Small volume centers must perform higher risk transplants to meet current CMS requirements and are at risk for adverse action secondary to chance alone. |
| Kraus et al. (2005)<br>Germany<br>Relationships between volume, efficiency, and quality in surgery – A delicate balance from managerial perspectives.<br>World Journal of Surgery, 29(10), 1234-1240. | Volume, efficiency, and quality in hospital care are often mixed in debate. We analyze how these dimensions are interrelated in surgical hospital management, with particular focus on volume effects. | External perception of quality is important to attract patients and gain volumes. There are numerous explicit and implicit notions of surgical quality. The relevance of implicit criteria (functionality, reliability, consistency, customaziability, convenience) can change in the time course of hospital competition.<br>All volumes-based learning within standardized processes will finally lead to a plateauing of quality. Only innovations will then further improve quality. Possessing volume can set the optimal ground for continuous process research, subsequent change, innovation, and optimization, while volume itself appears not to be a quality prerequisite.<br>Escape phenomena, such as change of surgical indication.<br>Rivalry between hospitals and hospital closings.<br>Reduced patient access. |
| **Deskilling, rekruttering og fastholdelse** | | |
| Odetola et al. (2006)<br>Pediatric critical care<br>US<br>Growth, development, and failure to thrive: Factors that underlie the availability of pediatric critical care facilities in the United States.<br>Pediatric Critical Care Medicine, Vol 6(1), 70-73. | The local factors that drive the availability of pediatric intensive care units (PICUs) are unknown.<br>This study was conducted to explore the factors that promote the development, expansion, and closure of PICUs in the United States. | We conducted cross-sectional, indepth telephone interviews of the chief executive officers where PICUs were established, expanded or closed between 1997 and 2001.<br>In six of the eight closure cases, the inability to recruit and retain subspecialists was regarded as a major factor that led to the closure of the PICU. All the PICUs that were closed experienced stiff competition from what they described as larger PICUs with greater availability of materiel and human resources.<br>All respondents believed that the inability to achieve and maintain a high patient census led to job dissatisfaction among physicians and nurses and high personnel turnover.<br>There were concerns that a significant proportion of the patients admitted to the PICUs had illness of low severity, raising concerns about the opportunities that existed for the development and maintenance of the skills and level of competence of the PICU staff.<br>In one of the closure cases, the impact of the closure had the intrainstitutional effect that all inpatient pediatric services ceased altogether. |
| Holm-Petersen (2015)<br>Denmark<br>Specialeplanlægning. Set fra akutsygehusenes perspektiv. | Formålet med undersøgelsen er at undersøge, hvordan akutsygehuse oplever specialeplanen og dens konsekvenser. | Grundlæggende er de lægelige direktører enige i nødvendigheden af at have en specialeplanlægning for at sikre, at de nødvendige kompetencer er til stede i forbindelse med en række behandlinger. Samtidig giver specialeplanens medfølgende samling af funktioner og centralisering ifølge de lægelige direktører en række afledte konsekvenser, der besværliggør mulighederne for at drive |

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| KORA. | Undersøgelsen bygger på interview med 13 lægelige direktører fra akutsygehuse. De 13 medvirkende akutsygehuse er udvalgt af Sundhedsstyrelsen med henblik på at give en bred repræsentation blandt akutsygehuse, der ikke har en entydig profil som specialiseret. Der er inkluderet akutsygehuse med et befolkningsgrundlag på mellem ca. 150.000-400.000. | akutsygehuse. De efterspørger, at der i højere grad kommer fokus på at skabe kvalitet "for alle patienterne". De lægelige direktører peger på, at der er en række indbyggede dilemmaer i specialeplanlægning, når man anskuer effekterne på de samlede sygehusaktiviteter. De lægelige direktører har blandt andet følgende bekymringer:<br>• At specialeplanlægningens fokus på de ca. 10 % af patienterne, som har status af at være specialiserede, sker på bekostning af de ca. 90 %, der ikke har status af at være specialiserede.<br>• At specialeplanlægningen gør det sværere at rekruttere speciallæger til sygehuse og afdelinger, der ikke har specialiserede funktioner.<br>• At udviklingen vil føre til øget centralisering, hvorved mulighederne for at opretholde kompetente akutsygehuse med brede funktioner forværres.<br>Da den lægefaglige identitet er tæt knyttet op på specialisering, har centralisering af det specialiserede en række afledte effekter eksempelvis i relation til at kunne bemande hovedfunktioner med speciallæger. De lægelige direktører ønsker derfor, at der i fremtiden kommer mere fokus på grundlaget for at kunne rekruttere speciallæger. Ikke mindst til de akut-sygehuse, der geografisk ligger i afstand fra de større byer.<br>En række af de dilemmaer, der er blevet afdækket i denne undersøgelse, er isoleret set ikke specialeplanlægningens skyld. Men specialeplanlægningen taler ind i og forstærker en sammenhæng, hvor der er supersygehuse og en lægefaglig identitet, der trækker i retning af centralisering. Der er på denne vis tale om en central styringsmæssig udfordring. For hvordan skal man så sikre, at der kommer nok fokus på de almindelige og udbredte sygdomme, når nu fagprofessionerne ikke nødvendigvis af sig selv kaster deres energi heri? Det synes at være den største udfordring, som specialeplanlægningen er med til at accentuere. |
| Ramnarayan et al. (2003).<br>Pediatric retrieval service<br>Does the use of a specialised paediatric retrieval service result in the loss of vital stabilisation skills among referring hospital staff?<br>Archives of Disease in Childhood, 88(10), 851-854. | AIMS: To compare the proportion of airway and vascular access procedures performed by referring hospital staff on critically ill children in two discrete time periods, before and after widespread use of a specialised paediatric retrieval service. | METHODS: Transport data were obtained from retrieval logs of all children for whom a paediatric retrieval team was launched in each of two time periods (October 1993 to September 1994; and October 2000 to September 2001).<br>RESULTS: The overall intubation rate was similar in the first and second time periods (83.9% v 79.1%). However, 31/51 (61%) retrieved children were intubated by referring hospital staff in 1993-94, compared to 227/269 (84%) in 2000-01. Referring hospital staff gained central venous access in 11% v 18% and arterial access in 22% v 19% of retrieved children in the first and second time periods respectively. This was in spite of a significant reduction in the proportion of children on whom these procedures were performed.<br>CONCLUSION: Referring hospital staff are performing a greater proportion of initial airway and vascular access procedures undertaken in the stabilisation of sick children retrieved by a specialised paediatric retrieval team. The provision of this service has not resulted in the loss of vital skills at the local hospital. |
| **Tab af prestige og ressourcer** | | |
| Geraedts et al. (2008)<br>Germany<br>Implementation and effects of Germany's minimum volume regulations.<br>Deutsche Ärzteblatt International, 105(51-52), 890-6. | Since 2004, Germany has had legal minimum volumes for five surgical interventions (kidney, liver, and stem cell transplantations and complex pancreatic and esophageal interventions). In 2006, minimum volumes for total knee replacement were added.<br>On behalf of the Federal Joint Committee we evaluated the implementation of the minimum volumes | Methods: We analyzed hospital surveys and secondary data from quality reports for 2004, the Institute for the Hospital Remuneration System, and the Federal Agency for Quality Assurance.<br>Results: In 2006, the minimum volume regulations affected about half of all acute-care hospitals and about 146 000 hospital cases. Depending on the intervention, 10% to 60% of the hospitals with 1% to 31% of the patients performed the procedures yet failed to attain the minimum volumes. The number of hospitals providing the services did not change between 2004 and 2006, so nationwide coverage remained virtually unchanged. Regarding outcomes, only data for total knee replacement were available. One of three analyzed indicators of outcome, wound infections, showed the introduction of the minimum volumes to be associated with better results for higher numbers of cases. |

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| | and their effects on health service structure, hospitals, and outcome quality. | Effects in the hospitals According to the results of the hospital surveys, implementation of the minimum volumes has very rarely—with the exception of TKR—been a local issue between hospitals and funding agencies. It is equally uncommon for hospitals to come to arrangements regarding the spectrum of care or for a hospital to inform those who refer patients when it discontinues performance of interventions subject to minimum volumes. Hospitals excluded from performing the minimum volume procedures expect a worsening of their competitiveness and their public image, while nonexcluded hospitals see themselves as stronger in both respects. To date, hospitals have experienced hardly any effects on other areas of performance. In addition, no clear-cut financial differences from fewer or more patients are reported, and no increase in waiting times. Moreover, neither the surveyed hospitals nor the medical associations of the German federal states, which were also asked about effects of the minimum volumes, reported any noticeable effects on advanced medical training.<br><br>The implementation of minimum volumes in German hospitals has been a step-by-step process of adaptation. Above all, the legally recognized exceptions in special cases have enabled allowance to be made for particular local circumstances. In addition, the GBA has not yet introduced any specific sanctions for failure to achieve the minimum volumes. Nevertheless, the survey results showed that statutory health insurance providers are increasingly putting the minimum volumes on the agenda of their annual negotiations with the hospitals, with the implied threat of refusal to assume the costs. These conditions seem appropriate for a change in the organization of patient care, but also explain why no drastic changes have been observed in the first three years since the introduction of minimum volumes—neither the predicted changes in care structures, nor in patient flow, nor again, as far as can be measured, in outcome.<br><br>Discussion: To date, the minimum volumes have affected health care only marginally. Further monitoring of the effects of the minimum volumes requires prospective definition of essential indicators of outcome and access. |
| **Konkurrence og monopoler** | | |
| Diller et al. (2014)<br><br>Choice and competition between adult congenital heart disease centers: Evidence of considerable geographical disparities and association with clinical or academic results. Circulation.<br><br>Cardiovascular Quality and Outcomes, 7(2), 285-291. | BACKGROUND: Although concentrating adult congenital heart disease services at high-volume centers has been widely advocated, the potential beneficial effects of competition and patient choice have received relatively little attention. We aimed to assess the degree of patient choice and competition between adult congenital heart disease units and to investigate whether competition indices correlate with clinical quality or research output. | METHODS AND RESULTS: Competition between the 10 major adult congenital heart disease units in England was evaluated based on the Herfindahl-Hirschman Index, representing the sum of squared market shares of individual units. In addition, to account for geography and feasible access, we calculated spatial indices of competition based on travel time by road. These indices were correlated with 30-day mortality postpulmonary valve replacement in adult patients (as obtained from the National Central Cardiac Audit Database) and the aggregate research impact factors of individual centers. On a national level, a high level of competition without obvious dominant players was found (Herfindahl-Hirschman Index between 0.107 and 0.013). When accounting for geography, however, important disparities in patient choice and competition faced by individual centers emerged. The degree of local competition was correlated significantly with clinical outcomes and research output. In contrast, no association between center volume and outcome could be established.<br><br>CONCLUSIONS: Beyond the usual focus on concentrating services at high-volume centers, the potentially beneficial effects of competition should not be ignored. Therefore, policymakers should consider fostering a competitive environment for adult congenital heart disease centers or at least avoiding creating government-granted monopolies in the field. |
| Ho, Town et al. (2007).<br><br>Pancreatic cancer<br><br>Regionalization versus competition in complex cancer surgery. | The empirical association between high hospital procedure volume and lower mortality rates has led to recommendations for the regionalization of | We confirm that increased hospital volume and surgeon volume are associated with lower inpatient mortality rates. We then predict the price and outcome consequences of concentrating Whipple surgery at hospitals that perform at least two, four, and six procedures respectively per year. Our consumer surplus calculations suggest that regionalization can increase consumer surplus, |

| Author(s) & clinical area | Objectives & studied factors | Results and comments |
|---|---|---|
| Health Economics, Policy, and Law, 2(Pt 1), 51-71. | complex surgical procedures. While regionalization may improve outcomes, it also reduces market competition, which has been found to lower prices and improve health care quality.<br>This study estimates the potential net benefits of regionalizing the Whipple surgery for pancreatic cancer patients. | but potential price increases extract over half of the value of reduced deaths from regionalization. We reach three conclusions. First, regionalization can increase consumer surplus, but the benefits may be substantially less than implied by examining only the outcome side of the equation. Second, modest changes in outcomes due to regionalization may lead to decreases in consumer surplus. Third, before any regionalization policy is implemented, a deep and precise understanding of the nature of both outcome/volume and price/competition relationships is needed. |

# Bilag 5 Systematisk litteratursøgning

Generelt for søgningen: Der er ikke begrænset vedrørende tidsramme eller publikationstype. Der er søgt efter dansk, norsk, svensk og engelsk litteratur.

**PubMed, søgning 1 (12. 1. 2017) – Filters activated: Danish, Norwegian, Swedish, English**

(Der er i dele af søgningen nedenfor valgt at bruge anførselstegn om på forhånd definerede ordkombinationer (dvs. at frasen ”låses” = forekommer præcis sådan, som ordene står mellem anførselstegnene). Dette frakobler PubMeds indbyggede 'smarte' søgefunktion, men i dette tilfælde er det valgt for at fokusere søgningen til potentielt mere relevante fund).

#1 "Organization and Administration"[Mesh]

#2 (Organizational[All fields]) OR Organisational[All fields] - Søges/”oversættes” således i Pub-Med ("Organizations"[MeSH Terms] OR "organizations"[All Fields] OR "organizational"[All Fields]) OR organisational[All Fields]

#3 (#1 OR #2): (1.568.276 fund)

#4 ((…("institution volume") OR "institutional volume") OR "centre volume") OR "center volume") OR "patient volume") OR "surgeon volume") OR "operator volume") OR "physician volume") OR "specialist volume") OR "consultant volume") OR "procedural volume") OR "surgery volume") OR "hospital volume") OR "care volume") OR "centralized procedure") OR "centralized procedures") OR "specialized procedure") OR "specialized procedures") OR "centralization of care") OR "operating volume") OR "expertise volume") OR "expertise effect") OR "specialist effect") OR "expert effect") OR "lowest-volume") OR "highest-volume") OR "middle-volume") OR "volume-outcome") OR "volume-quality") OR "Hospitals, Low-Volume"[Mesh]) OR "Hospitals, High-Volume"[Mesh]): 6.536 fund

#5 (#3 AND #4): 1891 fund, til Refworks

**PubMed, søgning 2 (18. 1. 2017) – Filters activated: Danish, Norwegian, Swedish, English**

#1 ((("Hospitals, High-Volume"[Mesh]) OR "Hospitals, Low-Volume"[Mesh]) OR "Specialization"[Mesh]) OR "Centralized Hospital Services"[Mesh]: (19.368)

#2 ("Organizations"[Mesh]) OR (Organizational[Title/Abstract]) OR Organisational [Title/Abstract]

#3 (#1 AND #2): (2025)

#4 ("Outcome Assessment (Health Care)"[Mesh]) OR ("Quality of Health Care"[Mesh]) OR (Outcome[Title/Abstract]) OR Quality[Title/Abstract]: (5.623.284)

#5 (#3 AND #4): 759 fund, til Refworks

I alt fra søgn. 1 og 2 efter frasortering af dubletter: 2614 fund til gennemsyn i Refworks

**PubMed, søgning 3 (19. 1. 2017) – Filters activated: Danish, Norwegian, Swedish, English**

#1 "Centralized Hospital Services/standards"[Mesh]: 51 fund gennemset: 35 valgt til Refworks

#2 "Organizational decline": 6 fund gennemset, heraf 4 til Refworks

#3 ("Decline in skill" OR "Decline in skills"): Quoted phrase not found / 0 fund

#4 (Deskilled OR Deskilling)[All Fields]: 89 fund gennemset, heraf 21 til Refworks

I alt: 60 fund til gennemsyn i Refworks

**PubMed, søgning 4 (19. 1. 2017) – Filters activated: Danish, Norwegian, Swedish, English**

#1 (((Interprofessional relations[MeSH Terms]) OR Patient care team[MeSH Terms]) OR Co-operative behavior[MeSH Terms]) OR Teamwork[All fields]

#2 (((Centralized[Title]) OR centralised[Title]) OR specialized[Title]) OR specialised[Title]

#3 (#1 AND #2): I alt 172 fund til gennemsyn i Refworks

**PubMed, søgning 5 (23. 1. 2017) – Filters activated: Danish, Norwegian, Swedish, English**

#1 Regionalisation[Title] OR Regionalization[Title] AND Volume[All Fields]: 81 fund til Ref-works

#2 ((("Organization and Administration"[Mesh])) OR Organizational[All fields) OR Organisational[All fields]: (1.397.229)

#3 ((Regional medical programs[MeSH Terms]) OR Regionalisation[Title]) OR Regionalization[Title]: (3641)

#4 (#2 AND #3): 1710 fund – begrænset til reviews og meta-analyser: 106 fund til Refworks, dubletter frasorteret: I alt 106 fund til Refworks

I alt fra søgning 5 efter frasortering af dubletter: 169 fund til gennemsyn i Refworks

**PubMed, søgning 6 (24. 1. 2017) – Filters activated: Danish, Norwegian, Swedish, English**

#1 ((("Quality Improvement"[Mesh]) OR "Outcome Assessment (Health Care)"[Mesh]) OR Quality[Title]) OR Outcome[Title]: (969.216)

#2 (unit-volume[All Fields]: (1455)

#3 (#1 AND #2): 36 fund gennemset, 13 eventuelt relevante til Refworks, efter frasortering af dubletter: 8 fund til gennemsyn i Refworks

**Embase (20. 1. 2017)**

#1 exp organization/ or exp hospital organization/

#2 exp organizational restructuring/

#3 (#1 OR #2): (540.974)

#4 exp high volume hospital/ or exp low volume hospital/ (1240)

#5 (procedure volume or case volume or surgery volume or surgeon volume or surgical volume or operator volume or physician volume or consultant volume or specialist volume or institution volume or institutional volume or center volume or centre volume or hospital volume or patient volume or expertise volume).ti.: (1543)

#6 (#4 or #5): (2594)

#7 (#3 AND #6): 223, limit to Danish, Norwegian, Swedish, English: 221 fund til Refworks, dubletter frasorteret, derefter: I alt til gennemsyn 153 fund

#8 Deskilling {Including Related Terms}, limit to Danish, Norwegian, Swedish, English: 70 fund, gennemset, eventuelt relevante alle dubletter fra PubMed

**Cochrane (23. 1. 2017)**

#1 MeSH descriptor: [Hospitals, High-Volume] explode all trees

#2 MeSH descriptor: [Hospitals, Low-Volume] explode all trees

#3 MeSH descriptor: [Specialization] explode all trees

#4 MeSH descriptor: [Regional Medical Programs] explode all trees

#5 MeSH descriptor: [Centralized Hospital Services] explode all trees

#6 (#1 OR #2 OR #3 OR #4 OR #5): (152)

#7 MeSH descriptor: [Organizations] explode all trees

#8 MeSH descriptor: [Models, Organizational] explode all trees

#9 MeSH descriptor: [Organization and Administration] explode all trees

#10 (#7 OR #8 OR #9): (Cochrane-reviews: 3, Other reviews: 5, Trials: 43, Technology assessments: 5, Economic evaluations: 10): 66 fund til Refworks

#11 Deskilled OR Deskilling [in Title, Abstract, Keywords]: 1 fund (ikke relevant)

#12 "Organizational decline" [in Title, Abstract, Keywords]: 0 fund

#13 MeSH descriptor: [Centralized Hospital Services], qualifier: [Standards - ST]: 0 fund

#14 MeSH descriptor: [Interprofessional Relations] explode all trees

#15 MeSH descriptor: [Patient Care Team] explode all trees

#16 MeSH descriptor: [Cooperative Behavior] explode all trees

#17 "teamwork":ti,ab,kw (Word variations have been searched)

#18 (#13 OR #14 OR #15 OR #16): (2806)

#19 "specialized":ti (Word variations have been searched)

#20 "specialised":ti (Word variations have been searched)

#21 centralized:ti (Word variations have been searched)

#22 centralised:ti (Word variations have been searched)

#23 (#19 OR #20 OR #21 OR #22): (346)

#24 (#18 AND #23): 11 fund, til Refworks

Efter frasortering af dubletter: I alt 75 fund til gennemsyn i Refworks

**Cinahl (23. 1. 2017) – Language: Danish, Norwegian, Swedish, English**

#1 MW (=Word in Subject Heading) Specialization OR MW specialisation OR MW centralization OR MW centralization: (2.429)

#2 TI (=Word in Title) Specialization OR TI specialisation OR TI centralization OR TI centralization: (540)

#3 TI Centralized OR TI centralised OR TI specialized OR TI spesialised: (1.147)

#4 (#1 OR #2 OR #3): (3.968)

#5 TI "high volume hospital" OR TI "low volume hospital"

#6 "AB "high volume hospital" OR AB "low volume hospital"

#7 (#5 OR #6): (38)

#8 (#4 OR #7): (4005)

#9 "TI volume": (7.099)

#10 (#8 OR #9): (11.071)

#11 "TI regionalisation OR TI regionalization"

#12 "TI regionalised OR TI regionalized"

#13 (#11 OR #12): (210)

#14 (#10 OR #14): (11.270)

#15 "Centralized Hospital Services"[Smart text search]: (385)

#16 (#14 OR #15): (11.291)

#17 "TI organizational OR TI organisational": (4.352)

#18 "AB organizational OR AB organisational": (14.561)

#19 (#17 OR #18): (16.865)

#20 "MW organization OR MW organization: (15.219)

#21 (#19 OR #20): (32.029)

#22 (#16 AND #21): 84, Narrow by Language: – English (Danish, Norwegian, Swedish): 80, efter frasortering af dubletter: 64 fund til Refworks

#23 (TX Unit-volume OR TX Unit-size) AND TX Hospital: 46 fund, åbenlyst irrelevante + dubletter frasorteret: 24 fund til Refworks

#24 (TI volume AND TI outcome) OR TI volume-outcome AND (Narrow by Subject, Major: Quality of health care OR Outcome assessment OR Treatment outcomes OR Outcomes (health care)): 44 fund, efter bortsortering af dubletter: 29 fund til Refworks

I alt fra Cinahl-søgning: 117 fund til gennemsyn i Refworks

**EconLit (25. 1. 2017) – Language: Danish, Norwegian, Swedish, English**

#1 Volume-outcome*[Anywhere]: 15 fund, dubletter frasorteret: 7 fund

#2 (High-Volume Hospital*) OR (Low-Volume Hospital*): 14 fund, dubletter frasorteret, herefter 10 fund

#3 "Procedure volume*"[Anywhere]: 11 fund, dubletter frasorteret, herefter 7 fund

#4 Hospital* AND (centraliz* OR centralis*): 50 fund, dubletter samt åbenlyst irrelevante bortsorteret, derefter 35 fund

I alt: 59 fund i Refworks til videre gennemsyn

**CRD-databases (30. 1. 2017)**

#1 ((Centralization):TI OR (centralized):TI): 10 fund gennemset, ingen valgt

#2 ((Centralisation):TI OR (centralised):TI): 7 fund gennemset, 1 til Refworks

#3 ((Specialization):TI OR (specialized):TI): 45 fund, gennemset 1 til Refworks

#4 ((Regionalization):TI OR (regionalized):TI): 8 fund, ingen valgt

#5 ((Regionalisation):TI OR (regionalised):TI): 0 fund

**DanBib (Netpunkt) (1. 2. 2017)**

#1 (specialise? eller specialfunktion?) og (hospital? eller sygehus? eller behandl?)

#2 (lem=specialisering og lem=hospitaler) eller (lem=specialisering og lem=behandling)

#3 (#1 eller #2): (338 fund)

#4 ((lem=organisation) eller (organis? eller organiz?)): (463.869 fund)

#5 (#3 og #5): 70 fund, heraf 15 til Refworks til videre gennemsyn

NETSØGNING

Hjemmesider (30.-31. jan. 2017)

**Kunnskapssenteret for helsetjenesten i Folkehelseinstituttet, Norge: http://www.kunnskapssenteret.no/**

#1 Pasientvolum: 114 fund, heraf 9 indlagt i Refworks til gennemsyn

#2 Volum (OG) Kvalitet: 197 fund, gennemset, 2 valgt til Refworks

#2 Sentralisering: 6 fund, 1 til Refworks

**SBU – Statens beredning för medicinsk och social utvärdering, Sverige: http://www.sbu.se/**

#1 Patientvolym: 0 fund

#2 Volym (OCH) Kvalitet: 6 fund, 1 til Refworks

#3 Volym: 22 fund, 3 til Refworks

#4 Centralisering: 1 fund, ikke relevant / centraliserad: 2 fund: ikke relevante

#5 Specialiserad: 10 fund, ingen valgt

**Sundhedsstyrelsen, Danmark: https://www.sst.dk/**

#1 Specialiseret / Højt specialiseret: de første sider gennemset, 5 fund til Refworks

#2 Volumen: de første sider gennemset, 1 fund til Refworks

**Google (31. jan. 2017)**

#1 Volumen kvalitet hospital: de første 5 sider gennemset, 4 fund til Refworks

#2 Samling specialiserede funktioner hospital: 3 fund til Refworks

I alt fra hjemmesider og Google: 30 fund i Refworks (mappen Skandinavien)

I alt 3483 fund efter ”1. runde”

VIVE

DET NATIONALE FORSKNINGS- OG ANALYSECENTER FOR VELFÆRD