Ontario Health
Cancer Care Ontario

Evidence-Based Series Special Report 17-2 Version 3

A Quality Initiative of the
Program in Evidence-based Care (PEBC), Cancer Care Ontario (CCO)

Hepatic, Pancreatic, and Biliary Tract (HPB) Surgical Oncology Standards

Members of the HPB Surgical Oncology Expert Panel

A Special Project of the Surgical Oncology Program, Cancer Care Ontario and
The Program in Evidence-Based Care, Cancer Care Ontario
Developed by the Expert Panel on HPB Surgical Oncology

Report Date: April 14, 2026

Evidence-Based Series (EBS) 17-2 Version 2 was reviewed in 2026 and ENDORSED by the HPB Surgical Oncology Expert Panel.
(See Section 5 Document Assessment and Review for details)

EBS 17-2 Version 3 is comprised of 5 sections. You can access the summary and full report here: https://www.cancercareontario.ca/en/guidelines-advice/types-of-cancer/546

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Guideline Report History

GUIDELINE VERSION	SYSTEMATIC REVIEW		PUBLICATIONS	NOTES and KEY CHANGES
	Search Dates	Data		
Original June 2006	1990 through September 2006	Full Report	Peer review publication Web publication	NA
Version 2 December 2015	2006 to May 2015	New data found in Section 4: Document Review Summary and Review Tool	Updated web publication	Guideline recommendations remain the same as the 2006 version of the report. Evidence-base updated.
Version 3 March 2026	May 2025-November 2024	New data found in Section 5: Document Review Summary and Review Tool	Updated web publication	2006 recommendations are ENDORSED with some modifications.

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Ontario Health
Cancer Care Ontario

Evidence-Based Series #17-2 Version 3: Section 1

Hepatic, Pancreatic, and Biliary Tract (HPB) Surgical Oncology Standards

Guideline 17-2 Version 3 was reviewed in 2026 and ENDORSED by the HPB Surgical Oncology Expert Panel. Some standards were added and some other minor wording changes were made that are explained in Section 5.

QUESTION

What is the optimum organization for the delivery of cancer-related hepatic, pancreatic, and biliary tract surgery in Ontario?

SCOPE OF STANDARDS

The following standards, developed by the Expert Panel on HPB Surgical Oncology, apply to hepatic, pancreatic, and biliary tract cancer surgery and include the full spectrum of multidisciplinary assessment and treatment:

- Management of primary and secondary liver cancer by hepatic resection or locally destructive techniques (ablation by any modality, hepatic artery embolization with or without chemotherapy, etc.).
- Management of cancer of the pancreas and peri-ampullary region by pancreatic resection.
- Management of tumours of the biliary tract (including gallbladder) by surgical resection.

The standards cover the full range of resources and expertise needed for the care of these patients and recognize that a multidisciplinary team approach is necessary for optimum management. Specific criteria relating to the characteristics of surgeons and institutions involved in HPB surgery are described.

SURGEON CRITERIA

General Characteristics

General characteristics for surgeons undertaking the management of patients with HPB cancer are as follows:

- Knowledgeable regarding the biology of HPB cancer, its natural history, appropriate investigation, and the whole range of treatment options.
- Skilled in modern techniques of surgery of the liver, pancreas, and biliary tract, including capability for managing vascular complications and vascular reconstruction.
- Experienced in the management of patients with hepatobiliary and pancreatic diseases, especially the management of early and late postoperative complications.
- Committed to providing excellence in care to patients with HPB diseases and to advancing knowledge in the field in order to improve patient outcomes.

- Committed to participating as a member of a multidisciplinary oncology team.
- Committed to participating in Cancer Care Ontario quality initiatives.

Training

Although there is not a formally recognized subspecialty in HPB surgery, the complex nature of this subspecialty area has lead to the development of training programs designed to provide the kind of expertise and experience necessary to appropriately manage patients with HPB diseases. Thus, appropriate training would include certification by the Royal College of Physicians and Surgeons of Canada in General Surgery (or its equivalent) plus the completion of a period of advanced training in HPB surgery designed to attain a high level of proficiency in the management of the complex surgical problems found in this patient population. The training program should specifically focus on the management of malignant disease and result in the trainee acquiring competence to manage not only routine cases but also those requiring more complex resection and reconstruction. Thus, surgeons practicing HPB surgery should have completed one of the following:

- A specific formal Fellowship in HPB surgery, or
- A Fellowship in liver transplant that includes a major focus in non-transplant HPB cases, or
- A Surgical Oncology Fellowship with a major emphasis on HPB surgery

Surgeons that trained prior to the existence of HPB or Surgical Oncology Fellowships may have received such training in less formal ways, such as extended post-residency training in a busy HPB service or mentoring and progressive experience in the early years of their staff appointment in a hospital where a busy HPB service was present. The increasing complexity of HPB surgery and the development of excellent quality formal fellowship training supports the use of the new standard for surgeons now entering the system.

All surgeons should maintain their expertise and knowledge through continuing professional development programs and a commitment to a career focussed on HPB surgery.

HOSPITAL CRITERIA

General Characteristics

A tertiary care HPB surgical centre should be capable of managing the full range of surgical care for patients with diseases of the liver, pancreas, and biliary tract, from the most complex to the most common, in a single hospital. A minimum of three HPB surgeons should be on staff in order to provide intraoperative assistance and continuous preoperative and postoperative care, while allowing for appropriate personal and professional leave. Where appropriate, complex HPB procedures may benefit from two HPB surgeons being present at the same operation to assist each other to enhance efficiency, safety, and outcomes. The hospital should have an affiliation with a Regional Cancer Program, and the HPB Program should include teaching, research, quality improvement, and program advancement elements.

Hospitals that do not have tertiary HPB services will provide care for patients with common HPB conditions. They should have an established relationship with a tertiary care HPB Centre to facilitate consultation and the referral of common and uncommon cases through a regional care network such as the Regional Cancer Program (RCP; previously known as Local Health Integration Network (LHIN)) so that all patients may have access to high-quality care in the appropriate setting. These hospitals and their professional staff would also play an important role in the initial diagnostic investigation and surgical follow-up of patients with complex problems. Participation in such a regional care network should lead to both better access to and quality of care.

The capability to provide optimal HPB care requires that an institution ensure the availability of the appropriate physical, fiscal, and human resources needed for the complete

spectrum of patient care, from early diagnosis to long-term management and supportive care. A hospital should have a definable system of care for HPB patients that is integrated with the other components of the broader cancer care system.

Specific System Requirements

- Formal acknowledgement by the hospital that it is a Centre for HPB Surgery and therefore has a distinct HPB Surgery Program with definable leadership structure and accountability.
- A commitment to provide HPB surgery in a timely manner, including the support of and commitment to the targets set by the provincial wait-time strategy.
- A system of patient care that ensures multidisciplinary management, including Multidisciplinary Cancer Conferences (i.e., tumour boards) involving the appropriate health care professionals to ensure that patients receive the most appropriate treatment. This is essential for the achievement of optimal patient outcomes.
- A system for the regular review of the program, including clinical and educational rounds, morbidity and mortality review, and quality assurance, including a system for regular tracking of patient outcomes. This includes participation in all quality improvement programs of Cancer Care Ontario.
- Participation in regional cancer programs and the planning processes of the LHINs.
- Infrastructure support for participation in local and national clinical research studies.

Physical Resources

- Appropriately equipped operating rooms available 24 hours a day, seven days a week. This includes the capability for intraoperative imaging (fluoroscopy and ultrasound) and appropriate adjunctive therapy (e.g., microwave ablation).
- Full range of diagnostic imaging ability, including ultrasound (all modalities, including Doppler), computerized tomography (CT) scan, magnetic resonance imaging (MRI), and angiography, with the appropriate staff skilled in HPB interventions.
- ***Added April 2026:*** On site Interventional Radiology (not requiring patient transfer to another hospital) available on call 24 hours per day, seven days per week.
- Diagnostic and therapeutic Interventional Endoscopy available 24 hours per day, seven days per week, including Endoscopic Retrograde Cholangiopancreatography (ERCP). Endoscopic Ultrasound (EUS) should be available within a timely manner (either available on-site or within close proximity to the hospital). (See Section 5 for details).
- An appropriately equipped intensive care unit (ICU) capable of providing the appropriate range of ventilation modalities, dialysis, and the physical facilities for management of complex infectious problems.
- A fully developed nutrition service, including total parenteral nutrition (TPN).

Human Resources

HPB services are optimally delivered in a multidisciplinary team setting and require a full range of skilled health care professionals for optimum outcomes. These include:

- Qualified HPB surgeons (see Surgeon Criteria and Training).
- Radiologists with appropriate expertise across the full range of angiography, biliary tree imaging, abscess management, and ablative techniques.
- Dedicated, certified critical care physicians.
- An endoscopy service with advanced skills in biliary therapeutic endoscopy.
- Nursing personnel experienced in the management of complex abdominal surgical problems, particularly HPB diseases, abdominal sepsis, and fistulae.
- Medical and radiation oncology services available for consultation and interdisciplinary decision making.

- Supportive care, including pain management, psychosocial support, and palliative care.
- Allied health professionals, including nutritional care, occupational, and physical therapists.
- A pathologist with a special interest in HPB diseases and a commitment to developing the appropriate expertise.
- Administrative support, including a system of data management to meet the needs of the HPB Service.
- Availability of an appropriate spectrum of physician subspecialties to provide the required support to HPB patients, especially infectious disease practitioners.
- Anesthesiologists with expertise in managing long complex operations in which patients may potentially become unstable and in patients with impaired liver function.
- ***Added April 2026:*** A core anesthesiology team with expertise in HPB should be established to provide HPB anesthesia. There is limited but emerging evidence suggesting that care provided by anesthesiologists with high procedure volume versus care by anesthesiologists with low procedure volume was associated with lower risk of combined 90-day major morbidity (including mortality) and readmission, after adjusting for patient case mix, institutional volume, and surgeon volume. (See Section 5 for details).

Volume of HPB Surgery

The hospital with an HPB Service should have an adequate volume of index cases to maintain the skills of the multidisciplinary team, function as a tertiary referral centre, justify the resource investment required, and assure that optimum outcomes are achieved.

An HPB Centre should carry out a minimum of 50 index HPB cases per year (index cases include formal anatomic resection of one or more liver segments, all Whipple and total pancreatic resections, and all resections with reconstruction of the biliary tract). The volume should include at least 20 Whipple and total pancreatic resections.

OUTCOME MEASURES, BENCHMARKS, AND QUALITY ASSURANCE

Modified in April 2026:

The following outcomes are considered reasonable and achievable at HPB Centres across Ontario:

- A 30-day mortality rate of less than 3% for major pancreatic resection
- A 30-day mortality rate of less than 3% for anatomical liver resection.

DEVELOPMENT OF THE STANDARDS DOCUMENT

Evidence on HPB cancer surgery was gathered through a systematic search of the literature and a scan of documents from organizations concerned with quality practice in HPB surgery. Evidence was reviewed by members of the Expert Panel on HPB Surgical Oncology (see Appendix 1, Section 3) investigating the delivery of cancer-related HPB surgery in Ontario. The Panel included HPB surgeons, general surgeons, a medical oncologist, a radiation oncologist, a hospital chief executive officer, a Cancer Care Ontario regional vice president, a pathologist, a radiologist, and methodologists. The members came from across the province and provided appropriate regional representation.

The Expert Panel developed the standards, using a combination of evidence-based analysis, recommendations from other jurisdictions, and their own expert opinion based on experience. The Panel analyzed data on the current distribution of HPB cancer surgery across Ontario to inform the process, and in particular to assist in developing the volume standards. The standards proposed represent a consensus of the Expert Panel and are intended to accommodate the long-range needs of the province, including the ability to manage the projected increase in demand for HPB cancer surgical care over the next decade due to the growing and aging population.

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Contact Information

For information about the PEBC and the most current version of all reports, please visit the CCO Web site at https://www.cancercareontario.ca/en/guidelines-advice or contact the PEBC office at:

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Ontario Health
Cancer Care Ontario

Evidence-Based Series 17-2 Version 3: Section 2

Hepatic, Pancreatic, and Biliary Tract (HPB) Surgical Oncology Standards: The Systematic Review

Report Date: June 14, 2006

The 2006 guideline recommendations are

ENDORSED

This means that the recommendations are still current and relevant for decision making.

QUESTION

What is the optimum organization for the delivery of cancer-related hepatic, pancreatic, and biliary tract surgery in Ontario?

INTRODUCTION

Malignant diseases of the liver, pancreas, and biliary tract are complex problems that require multidisciplinary assessment and care in order to achieve optimum outcomes. At present, surgical resection remains the only realistic hope for long-term control of these tumours, yet outcomes for surgical resection are still far less than ideal. The surgical procedures themselves, along with the required preoperative investigation and perioperative care, are complex, resource intensive, and not without significant risk. While surgical treatment will benefit many, the combination of complexity and risk in the face of less than desirable tumour control requires that the highest possible standard of care be delivered in order to ensure that an appropriate ratio of benefit and risk can be obtained. Many patients with advanced disease will not benefit from aggressive surgical resection. Management of all patients, including those who are resectable and those who are not, requires a multidisciplinary team with the knowledge and tools to provide a full array of surgical intervention and systemic and radiation treatments. Additionally, supportive and palliative care is essential and will ultimately be needed by the majority of patients.

The Canadian Institute of Health Information (CIHI) data show that approximately 600 major liver, biliary tract, and pancreas resections were performed for cancer in Ontario in 2004/2005. The incidence of hepatic, pancreatic, and biliary malignancies is increasing at over 3% per year, as a function of our growing and aging population. The natural history of these cancers is dismal, with survival rates for pancreas cancer being less than 30% at one year and less than 5% at five years and for liver and biliary tract being less than 30% at five years. While there is demonstrable survival benefit from appropriate surgical and other treatment, the amount of benefit achievable is considerably less than in many other types of cancer. These results have aroused intense interest

in finding new management strategies that will improve outcomes. There is a need for HPB Centres that have a focused interest in these disorders and a commitment to innovation and clinical research, in order to both provide appropriate and up to date care and to develop the new therapies that will improve outcomes.

A comprehensive approach to the investigation of these patients is required in order to establish a correct diagnosis at the earliest possible time. Sophisticated technology and diagnostic expertise, especially in imaging and pathology, may not be widely available but is often required to sort out the more difficult cases. Accurate tumour staging forms an essential part of most treatment decisions and is critical in selecting appropriate patients for surgical resection.

The surgery itself requires judgment, experience, and technical skill to ensure proper preoperative planning, determine the appropriate extent of resection, exercise correct intraoperative decision making, and recognize and manage postoperative problems, including reoperative surgery when required. There is increasing evidence that larger volumes of surgery are associated with better outcomes for many kinds of surgical procedures, including liver and pancreatic resections. This relationship applies to both the individual surgeon and to the hospital. Although there may be many individual surgeon and hospital factors that underlie this effect, volume alone has been a consistent surrogate.

In 1999, a research project conducted under the auspices of the Institute of Clinical Evaluative Sciences was published in the *Canadian Medical Association Journal* (1). It reported wide variations in postoperative mortality among Ontario hospitals over a seven-year period, and noted the relationship between increased volume and better outcomes for complex resections involving the head of the pancreas. In response to this report, Cancer Care Ontario (CCO) convened an Expert Panel to discuss strategies to improve the care of these patients. A standards document (2) was developed that described the Panel's opinion with respect to the characteristics of surgeons and institutions involved in the care of these patients that would lead to optimum outcomes. The Panel also recommended a minimum volume threshold for hospitals of 10 major pancreatic resections and 25 total major liver, biliary, and pancreatic resections per year, and suggested that a benchmark mortality rate for major pancreatic resection of less than 5% was achievable. The guidelines were endorsed by the Board of CCO and widely disseminated, including direct delivery to all hospital Chief Executive Officers and Chiefs of Staff/Chiefs of Surgery.

In 2001, a CCO Surgical Oncology Program working group carried out a qualitative study of the effect of the guidelines on the delivery of complex pancreatic resection for cancer. The review revealed that many hospitals had made changes in their practices, including some that had discontinued these operations and others that had reorganized their care. A more recent review showed that there are significantly fewer hospitals performing pancreatic cancer surgery, the proportion of patients receiving these operations in hospitals doing more than 10 cases per year has increased, and the provincial mortality rate has fallen, compared to the period of study in the 1999 report, but is still higher than 5%. These statistics, however, also show that there are still a significant number of hospitals providing these complex resections but performing fewer than 10 pancreatic resections and 25 complex HPB resections per year.

As one of its initiatives in the area of quality improvement, CCO has initiated the development of standards to guide the evolution of our cancer care system. It was felt timely to review the previous pancreatic cancer surgery standards document and update and incorporate it into a standards document applicable to cancer of the liver, pancreas, and biliary tract, which recognizes the interrelated nature of these diseases. An Expert Panel was therefore convened by the Surgical Oncology Program (SOP) of CCO, in cooperation with the Program in Evidenced-Based Care (PEBC), and charged with the task of developing these standards, utilizing the successful document development process of the PEBC.

METHODS

This report, produced by the SOP and the PEBC, is a convenient and up-to-date source of the best available evidence on volume-related outcomes associated with hepatic, pancreatic, and biliary (HPB) surgery, developed through a systematic review of the available evidence, using the methods of the PEBC Practice Guidelines Development Cycle (3). Members of both the SOP and the PEBC disclosed any potential conflicts of interest. The SOP and the PEBC are both editorially independent of CCO and the Ontario Ministry of Health and Long-term Care (MoH&LTC).

Literature Search Strategy

The MEDLINE database (dB) was searched from 1966 to the second week of September 2005. The EMBASE dB was also searched from 1980 to week 39 2005. Appendix 2 details the MEDLINE search strategy; the EMBASE strategy was comparable but customized for the EMBASE terms. The search terms used covered the appropriate diseases, interventions, settings, and outcomes. Additional articles not located through the formal literature review were provided by some of the authors. A systematic review (4), not found in the formal search as the publication date was too recent to be captured by the review, was also obtained. Relevant articles and abstracts were selected by one reviewer, and data extraction was performed independently by two reviewers, with discrepancies resolved by consensus.

Inclusion Criteria

Articles were selected for inclusion in the systematic review of the evidence if they were fully published English language reports reporting volume-outcome measurements, for either surgeons or hospitals/institutions, in hepatic, pancreatic, or biliary cancer. Ideally, reports would provide both surgeon and hospital/institution volume-outcome measurements. The types of studies eligible for inclusion were randomized controlled trials (RCT), retrospective studies, and case-series reports (with at least 10 patients).

Outcomes of interest

The primary volume-outcome measurements that were of interest included short-term mortality/survival, adverse effects, hospital length of stay, and long-term survival (five-year optimal). Secondary outcomes of interest included costs (as reported in the jurisdiction where the trial was run), physician training, hospital/institutional requirements, and any diagnostic procedures used.

RESULTS

Literature Search Results

A total of 12 trial reports were obtained (1,5-15). None of the trial reports obtained were RCTs; all were retrospective in study design. The data on the relationship between volume categories and mortality, postoperative complications, length of stay, and cost are presented in Table 1 *(Mortality by surgeon-volume, pancreatic resections*), Table 2 (*Mortality by hospital-volume, pancreatic resections*), and Table 3 (*Mortality by hospital-volume, hepatic resections*). The three trials that provided volume-outcome data on surgeons for pancreatic resections (5-7) also provided volume-outcome data on hospitals. Additionally, another 11 trials provided volume-outcome data on hospitals for pancreatic resections only (1,5-14). A single trial reported volume-outcomes for hospitals for hepatic resections (15).

Synthesizing the Evidence

As none of the trials obtained were RCTs, no pooling was possible. Instead, mean cases per hospital per year or mean cases per surgeon per year were calculated and used as the unit of comparison both between trials and between volume categories within trials.

Table 1. Surgeon-Volume measures [3 studies].

Study	Study type	Disease site	Type of intervention	Volume categories (per surgeon per year)	Total No. of surgeons over study period N (%)	Total No. of patients over study period N (%)	Mortality N (%)	Compli-cations (%)	Length of stay d	Cost ($)	Notes
Edge et al, 1993 [USA] (5) Jan 1, 1989 to Dec 31, 1990 [2 years]	Retro-spective audit of discharge coding data	Pan-creas, ampulla of Vater	Pancreaticoduodenectomy, N=168; Total pancreatectomy, N=11; Distal pancreatectomy, N=30; Islet tumour resection, N=14 Total # surgeons: 91 Total # patients: 223	0-0.9	51 (56)	51 (23)	2 (3.9)	14 (27) (major)	17	No compl. $15,424 Minor $21,607 Major $44,899 all per two year	Surgeons performing 0.5-1.5 resections had significantly more minor and major complications than those performing ≥2 (p=0.011)
				1-1.9	22 (24)	50 (22)	5 (10.0)	12 (24) (major)	14.5		
				≥2 Mean = 3.4	18 (20)	122 (55)	6 (4.9)	20 (16) (major) p=0.0163 for 0.5-1.5 cases vs. ≥2 cases	15		
Lieberman et al, 1995 [USA] (6) 1984 to 1991 [8 years]	Retro-spective audit of discharge abstracts from the NY State Depart-ment of Health	Pan-creas, biliary tree, ampulla of Vater	Resections for: Pancreatic ductal adenocarcinomas, 55%; Tumours affecting the Ampulla of Vater, 16%; Distal bile duct adenocarcinoma, 8%; Duodenal adenocarcinoma, 8%; Islet cell tumours, 3% Total # surgeons: 748 Total # patients: 1972	<1.13	687	1321 (67)	172 (13) [a]	NR	34 (a)	NR	Standardized mortality rates reported; Surgeon's experience not significantly related to perioperative deaths when hospital volume is controlled
				1.13-5.13	57	355 (18)	34 (9.7) [b]		26 (b)		
				>5.13 Mean = 9.3	4	296 (15)	18 (6) [c] X^2 p<0.001 for a vs. b, c		27 (c) X^2 p<0.05 for a vs. b, c		
Nordback et al, 2002 [Finland] (7) Study period: 1990 to 1994 [5 years]	Retro-spective study on National Hospital Discharge database	Pancreas (resec-tion of the head of the pan-creas)	Resections for: Multiple indications, 292 pts of 374 pts total required resection for malignancy Standard resection of the head of the pancreas, including partial gastric resection, N=270/350, 77% Pylorus-preserving resection of the head of the pancreas, N= 76/350, 22% Duodenum-preserving resection (Berger's resection), N=4/350, 1% Total # surgeons: 98 Total # patients: 350	0-1.1	74 (75.5%)	NR	Low (<1) 18/125 (14%)	Low (<1) 53/125 (42%)	Low (<1) 24 (range 9-70)	NR	Pancreatic resections performed in high-volume hospitals by high-volume surgeons was associated with decreased postop morbidity, mortality, and hospital stay, and the authors recommend that pancreatic head surgery be limited to only a few hospitals and only a few surgeons.
				1.2-2	20 (20%)	NR	Medium (1-3) 16/164 (10%)	Medium (1-3) 68/164 (41.4%)	Medium (1-3) 23 (range 7-100)		
				2.2-3	1 (1%)	NR	High (>3) 2/61 (3%)	High (>3) 15/61 (24.6%)	High (>3) 18 (range 8-63)		
				3.2-4	2 (2%)	NR					
				4.2-6	1 (1%)	NR					

Abbreviations: compl., complications; d, day; NR, not reported; vs., versus; yr, year; N, number; NA, not applicable.

Table 2. Hospital-Volume measures (pancreatic) [11 studies].

Study	Study type	Disease site	Type of intervention	Volume categories (per hospital per year)	Total No. of hospitals over study period N (%)	Total No. of patients over study period N (%)	Mortality N (%)	Compli-cations	Length of stay d	Cost ($)	Notes
Edge et al, 1993 [USA] (5) Jan 1, 1989 to Dec 31, 1990 [2 years]	Retro-spective audit of discharge coding data	Pan-creas, ampulla of Vater	Pancreaticoduodenectomy, N=168; Total pancreatectomy, N=11; Distal pancreatectomy, N=30; Islet tumour resection, N=14 Total # hospitals: 26 Total # patients: 223	0-0.9	10 (38)	27 (12)	2 (7.4)	7 (25.9) (major)	15	No compl. $15,424 Minor $21,607 Major $44,899 all per two year	Morbidity and mortality did not correlate with caseload
				1-1.9	9 (35)	78 (35)	5 (6.4)	15 (19.2) (major)	16		
				≥2 Mean = 8.4	7 (27)	118 (53)	6 (5.1)	24 (20.3) (major)	15		
Lieberman et al, 1995 [USA] (6) 1984 to 1991 [8 years]	Retro-spective audit of discharge abstracts from the NY State Depart-ment of Health	Pan-creas, biliary tree, ampulla of Vater	Resections for: Pancreatic ductal adenocarcinomas, 55%; Tumours affecting the Ampulla of Vater, 16%; Distal bile duct adenocarcinoma, 8%; Duodenal adenocarcinoma, 8%; Islet cell tumours, 3% Total # hospitals: 184 Total # patients: 1972	<1.25	124 (67)	473 (24)	11 (18.9) [a]	NR	35 (a)	NR	Standardized mortality rates reported; Increased hospital volume associated with decreased mortality and length of stay
				1.25-6.25	57 (31)	1065 (54)	16 (11.8) [b]		32 (b)		
				6.38-10	1 (<1)	59 (3)	1 (12.9) [c]		22 (c)		
				≥10.13 Mean = 23.4	2 (1)	375 (19)	3 (5.5) [d]		27 (d)		
							X^2 test p<0.001 for a vs. b, d and a, b vs. d		X^2 test p<0.05 for a, b vs. c, d		
Glasgow et al, 1996 [USA] (8) 1990 to 1994 [5 years]	Retro-spective audit of discharge abstracts	Pancreas, biliary tree, ampulla of Vater, duo-denum, islet cells	Pancreaticoduodenectomy, 83.5%; Proximal subtotal pancreatectomy, 9.3%; Total pancreatectomy, 7.2% Total # hospitals: 298 Total # patients: 1705	<1	210 (70)	510 (30)	72 (14.1)	NR	22.7	$87,857	Men (p=0.006) and older patients (p<0.0001) had significantly higher operative mortality; High volume centres had reduced resource-demand scale scores
				1.2-2	53 (18)	395 (23)	41 (10.4)		22.7	$76,593	
				2.2-4	20 (7)	258 (15)	23 (8.9)		22.9	$78,003	
				4.2-6	9 (3)	228 (13)	13 (5.7)		20.2	$70,959	
				6.2-10	4 (1)	171 (10)	14 (8.2)		23.9	$111,497	
				>10 Mean = 14.3	2 (1)	143 (8)	5 (3.5)		20.5	$71,588	
							p<0.0001		p=ns	p=ns	
Imperato et al, 1996 [USA] (9) 1991 to 1994	Retrospec tive audit of claims reports from Medicare database	Pancreas	Pancreaticoduodenectomy, 100% Total # hospitals: 117 Total # patients: 579	Regional hospital	2 (2)	138 (24)	3 (2.2)	NR	22.4	NR	A single provider was responsible for all cases in the 5.25-6.25 group; In-hospital mortality and length of stay significantly less at the high-volume regional hospitals when
				Other hospital	115 (98)	441 (76)	54 (12)		32.9		
							p=0.0002		p<0.001		
				0-1.25	89 (76)	2.2 (mean/ hospital)	12.7 (14.3)		NR		

[4 years]							(RR= 6.87)				compared with the low-volume hospitals
				1.5-2.5	19 (16)	7.2 (mean/ hospital)	2.2 (11.7) (RR= 5.08)				
				2.75-3.75	4 (3)	12.0 (mean/ hospital)	<1 (6.3) (RR= 3.08)				
				4-5	2 (2)	19.5 (mean/ hospital)	<1 (5) (RR= 2.09)				
				5.25-6.25	1 (1)	21.0 (mean/ hospital)	<1 (19) (RR= 9.46)				
				>6.25 Mean = 17.2	2 (2)	69.0 (mean/ hospital)	<1 (2.17) (RR= 1.0)				
Gordon et al, 1998 [USA] (10) Jan 1984 to Dec 1995 [12 years]	Retrospective audit of hospital discharge data	Pan-creas	Open Pancreaticoduodenectomy for cancer treatment (Whipple procedure): 100% Total # hospitals: 43 Total # patients: 795	<20 surgeries/yr for 6 of 12 yrs on study	42 (98)	458 (58)	65 (14.2)	NR	NR	NR	Only one hospital met inclusion criteria for high-volume; One pancreaticoduo-denectomy required for inclusion in study; Concluded that regionalization of surgery could lower overall in-hospital mortality rate
				≥20 Mean = 28	1 (2)	337 (42)	6.1 (1.8)				
Sosa et al, 1998 [USA] (11) 1990 to 1995 [6 years]	Retrospective cross-sectional	Pan-creas	<u>Pancreatic resections:</u> Pancreaticoduodenectomy – 36.3% Total pancreatectomy – 3.8% <u>Palliative bypass:</u> Gastrojunostomy Biliary-enteric bypasses such as cholecysto-, choledocho-, and hepaticojejunostomy (all three, 21%), double-bypass (22.8%), stent (16%). Total # hospitals: 48 Total # patients: 1236 (1306 resections)	<5	40 (83)	438 (43)	Resec-tions: 99.3 (18.8)	NR	Resec-tions: 23.6	Resec-tions: US 33,249	Patients appear to benefit from referral to a high-volume provider
							Bypass-es: 80.8 (15.3)		Bypass-es: 19.6	Bypass-es: US 17,483	
							Stents: 51.7 (9.8)		Stents: 11.4	Stents: US 9,564	
							p<0.05		p<0.05	p<0.05	
				5-19	7 (14.6)	270 (21.8)	Resec-tions: 18.6 (6.9)		Resec-tions: 21.1	Resec-tions: US 26,053	
							Bypass-es: 28.4 (10.5)		Bypass-es: 17.2	Bypass-es: US 15,654	

							Stents: 29.4 (10.9)		Stents: 8.6	Stents: US 9,760	
							p<0.05		p<0.05	p<0.05 (med vs. low)	
				≥20 Mean = 88	1 (2)	528 (42.7)	Resec-tions: 4 (0.9)		Resec-tions: 18.2	Resec-tions: US 22,379	
							Bypass-es: 18.4 (4.2)		Bypass-es: 15.1	Bypass-es: US 17,377	
							Stents: 7 (1.6)		Stents: 7.6	Stents: US 8,373	
							p=ns		p<0.05	p=ns	
Simunovic et al, 1999 [Canada] (1) 1988-89 to 1994-95 [6 years]	Retro-spective chart audit	Pancreas	Total pancreatectomy Radical Pancreaticoduodenectomy Total # hospitals: 68 Total # patients: 842	<3.7	56 (82)	354 (42)	5.7 (11.3)	NR	30.5	NR	Outcomes reported without readmissions; Odds of dying from pancreatic resection were 5.1 and 4.5 times greater (p<0.01) and average length of stay for patients 7.7 d and 9.2 longer (p<0.01) in low-volume vs. high-volume and medium-volume vs. high-volume centres respectively
				3.7-7	10 (15)	282 (33)	5 (12.4)		33.5		
				>7 Mean = 17.2	2 (3)	206 (24)	<1 (3.4)		25.3		
							p<0.01		p<0.05		
Gouma et al, 2000 [Nether-lands] (12) Jan 1994 to Dec 1998 [part B] [5 years]	Retrospec tive audit of National Medical Registry	Pancreas	Open pancreaticoduodenectomy; cancer and non cancer treatment Total # hospitals: NR Total # patients: 1124	<1	NR	463 (41)	15 (16)	NR	NR	NR	Average number of resections per year increased from 17 to 50 over the study period; Compared with low-volume hospitals, both relative risk and absolute risk were significantly lower in high-volume hospitals
				1-1.8		205 (18)	5 (13)				
				2-4.8		235 (21)	4 (8)				
				≥5		223 (20)	<1 (1)				
							p<0.05, (<5) vs. (10-24) and (<5) vs. (≥25)				
Birkmeyer et al, 2002 [USA] (13) 1994 to 1999 [6 years]	Retrospec tive audit of Medicare database	Pancreas	Pancreatic resection Total # hospitals: 1868 Total # patients: 10530	<1	1027 (55)	1563 (15)	275 (17.6)	NR	NR	NR	Veterans Affairs Outcome Group study; Included patients between 65-99 years of age covered by fee-for-service
				1-2	560 (30)	2757 (26)	425 (15.4)				
				3-5	168 (9)	1885 (18)	219 (11.6)				

				6-16	93 (5)	2166 (21)	163 (7.5)				
				>16 Mean = 18.9	19 (1)	2159 (21)	82 (3.8)				
Nordback et al, 2002 [Finland] (7) Study period: 1990 to 1994 [5 years]	Retro-spective study on National Hospital discharge database	Pancreas (resec-tion of the head of the pan-creas)	Resections for: Multiple indications, 292 pts of 374 pts total required resection for malignancy Standard resection of the head of the pancreas, including partial gastric resection, N=270/350, 77% Pylorus-preserving resection of the head of the pancreas, N= 76/350, 22% Duodenum-preserving resection (Berger's resection), N=4/350, 1% Total # hospitals: 33 Total # patients: 350	0-5	13 (39%)	NR	Low (<1) 26/201 (13%)	Low (<1) 82/201 (40.7%)	Low (<1) 23 (range 8-100)	NR	Pancreatic resections performed in high-volume hospitals by high-volume surgeons was associated with decreased postop morbidity, mortality, and hospital stay, and the authors recommend that pancreatic head surgery be limited to only a few hospitals and only a few surgeons.
				6-10	11 (33%)						
				11-15	4 (12%)		Medium (1-3) 8/93 (7%)	Medium (1-3) 38/91 (40.8%)	Medium (1-3) 23 (range 7-81)		
				16-20	1 (3%)						
				21-30	1 (3%)		High (>3) 2/56 (4%)	High (>3) 16/50 (28.6%)	High (>3) 18 (range 8-58)		
				31-40	2 (6%)						
				41-50	0						
				>50	1 (3%)						
Ho et al, 2003 [USA] (14) Study period: 1988 to 1998 [11 years]	Retro-spective hospital discharge claims for California and Florida	Pancreas	Pancreaticoduodenectomy (Whipple procedure) Total # hospitals: 500 Total # patients: 6652	1	NR	1197 (18)	159 (13.3)	NR	NR	NR	Higher-volume hospitals reported lower mortality rates, and high-volume was a more reliable predictor of decreased mortality than increased experience was.
				2-3	NR	1996 (30)	236 (11.8)				
				4-9	NR	1929 (29)	170 (8.8)				
				>10	NR	1530 (23)	63 (4.1)				

Abbreviations: d, day; NR, not reported; ns, not significant; OR, odds ratio; RR, relative risk; vs., versus; yr, year

Table 3. Hospital-Volume measures (liver) [1 study].

Study	Study type	Disease site	Type of intervention	Volume categories (per yr)	Total No. of surgeons over study period (%)	Total No. of patients over study period (%)	Mortality N (%)	Compli-cations	Length of stay d	Cost ($)	Notes
Choti et al, 1998 [USA] (15) Jan 1990 to June 1996 [7 years]	Retro-spective hospital discharge data from 52 acute-care hospitals (non-federal)	Liver	Partial hepatectomy Hepatic lobectomy Total # hospitals: 52 Total # patients: 606	Low-volume: ≤15/year High-volume: >15/year Mean = 37.7	35 (97) 1 (3)	342 (56) 264 (44)	4 (7.9) 3.9 (1.5) p<0.01		Low-volume: 13.2 High-volume: 12.7 p=ns	Minor: $17,923 Major: $22,485 p=ns	RR for mortality was 5.2 times higher at low-volume centres compared with high-volume centres (p<0.01). Average costs were higher at low-volume centres for major resections ($21,090 versus $30,000; p<0.05)

The Impact of Surgeon-Volume on Outcomes [Pancreatic]

Three trials were obtained that described the relationship between surgeon volume and patient outcomes (5-7). All three of these trials only included patients undergoing pancreatic resections. The types of procedures used and the reasons for the resection are given in Table 1, along with all reported outcomes. The number of patients included in these trials ranged from a low of 223 (5) to a high of 1,972 (6). All of the trials (5-7) reported mortality rates stratified by surgeon volumes, and in two of the trials (6,7), a trend of lower mortality was observed related to higher surgeon volumes. This trend was not observed in one trial (5), possibly resulting from the volume categories not being wide enough to detect subtle differences, as this trial had a very narrow range with an upper limit of ≥two per year, while the other two trials had upper limits of ≥5.13 per year (6) and 4.2-six per year (7).

Two of these trials (5,7) also provided data on postoperative complications stratified by surgeon volume. A similar trend was observed for postoperative complications, with higher surgeon volume categories being associated with a low incidence of complications.

All of the trials obtained (5-7) provided data on hospital length of stay stratified by surgeon volumes. A similar trend was observed for hospital length of stay, with higher surgeon volume categories being associated with a shorter hospital stay.

The observed trends in these trials provide some evidence that surgeons who perform a greater volume of pancreatic resections per year are also able to provide their patients with benefits in survival, postoperative complication rates, and shorter lengths of stay.

The Impact of Hospital-Volume on Outcomes [Pancreatic]

Eleven trials were obtained that described the relationship between hospital-volumes and patient outcomes in pancreatic resections (1,5-14). Types of procedures used and the reasons for the resection are given in Table 2 along with all outcomes. The number of patients included in these trials ranged from a low of 223 (5) to a high of 10530 (13).

All eleven trials described the relationship between volume categories and mortality. In five studies, overall reductions in mortality were reported from the low to the highest volume category and also between the volume categories within each study itself (5,7,12-14). Another five studies, while reporting variances in the trend towards lower mortality between volume categories within each trial itself, did show overall trends towards lower mortality from the lowest to the highest volume category (1,6,8-10). The trial by Sosa et al (11) showed a trend toward lower mortality between >5 and 5-16 procedures volume categories for resections (<5 volume category, 18.8% versus 5-16 volume category, 6.9%) Five of the eleven studies reported that the observed mortality reductions were statistically significant from low-volume to high-volume centres, either for all volume categories or from the lowest to the highest volume category (1,6,8,11,12).

The data strongly suggests that hospitals with high volumes of pancreatic resections have lower operative mortality rates than those with low volumes. The five studies in which hospitals in high-volume categories achieved postoperative mortality rates below 5% (1,8,9,11,13) had analysis thresholds of 6.25, 10, 16, 17, and 20, respectively. The mean hospital volume/year in those hospitals were 17.2, 14.3, 18.9, 17.2, and 88. It is not possible to calculate an exact threshold that represents a minimum volume to result in a mortality rate of less than 5%, but it is likely that it lies somewhere between 15 and 25 cases per year.

Only three trials reported outcomes on postoperative complications stratified by hospital-volumes (5,7,13). In these trials, the relationship between higher hospital volumes and postoperative complications was not as clear as the relationship between hospital volumes and mortality, as none of the three trials shows a clear association between higher volumes and better outcomes. However, in all three cases, the highest hospital-volume categories reported fewer postoperative complications than the lowest hospital-volume categories.

Nine of the trials reported comparable outcomes on the relationship between hospital volumes and in-hospital length of stay (1,5-9,11,14,15). In these trials, the relationship between higher hospital volumes and in-hospital length of stay was not as clear as the relationship between hospital volumes and mortality. Four trials (7,9,14,15) reported a clear trend with higher hospital volumes being associated with a shorter in-hospital length of stay, and four trials (1,5,6,8) did not.

The Impact of Hospital-Volume on Outcomes [Hepatic]

One trial was obtained that examined the relationship between hospital volumes and mortality in hepatic resections (15). In this study, a statistically significant reduction in mortality was detected for institutions that performed more than 15 hepatic resections per year compared with institutions that performed fewer than 15 hepatic resections per year ($p<0.01$). No difference was detected for comparisons of length of stay between high- and low-volume centres.

Systematic Reviews

In the one systematic review obtained (4), the relationship between hospital volume and mortality following pancreatic resection was explored. A total of 12 retrospective trials involving a total of 19,688 patients were obtained and included in that systematic review, all of which are included in this report (1,5-14). As the trials were too heterogeneous to allow pooling of data, a qualitative analysis was performed. Analysis using two arbitrarily defined cut-off points for clinical importance (a low value of five per year and a high value of 24 per year), found that centres that performed fewer than five pancreatic resections per year reported hospital mortality rates ranging from 13.8% to 16.5%, and in contrast to this, centres that performed 24 or more pancreatic resections per year reported hospital mortality rates ranging from 0% to 3.5%. The authors of that review state that this qualitative analysis provides convincing evidence for an inverse relationship between hospital mortality and hospital volume and are advocating for the centralization of services to provide pancreatic resections.

Environmental Scan Strategy

A Web search of provincial, national, and international surgery associations, including those dedicated to HPB surgery, was conducted between September and November 2005. As well, unpublished sources were sought by contacting surgical opinion leaders in each region and through direct contact with known leaders in the field of HPB surgery. Sources 1 and 2 from the practice organization document list below were forwarded from Expert Panel members.

Environmental Scan Results

Six practice organization documents were located through the search strategy:

1. British Association for the Study of the Liver. National Plan for Liver Services UK. 2004 (18).
2. Cancer Care Ontario Pancreatic Task Force. Criteria for Delivery of Pancreatic Cancer Surgery. 1999 (2).
3. New York State Committee on Quality Improvement in Living Liver Donation. A report to: New York State Transplant Council and New York State Department of Health 2002 (19).
4. Department of Health; National Cancer Guidance Steering Group. Guidance on Commissioning Cancer Services: Improving Outcomes in Upper Gastro-Intestinal Cancers: The Manual. 2001 (20).
5. Guidelines for Resection of Colorectal Cancer Liver Metastases. 2005 (21).
6. The Leapfrog Group. Evidence-Based Hospital Referral Fact Sheet. 2004 Apr 7 version (22).

All of the practice organization documents were developed through expert consensus and were generally similar in that they recognized the need for the regionalization of these complex services in order to concentrate experience in dedicated institutions with dedicated health professionals. Those from the United Kingdom, where there is a more regional approach to healthcare planning, were the most comprehensive.

The recommendations addressed aspects of care that were felt to be important in determining quality and outcomes in this complex area of surgical practice. The necessary components include the formal surgeon and institutional focus on HPB cancer surgery; a comprehensive array of physical and human resources with the training and experience to provide for the most complex patient care situations; a formal organizational structure with administrative leadership and accountability; a commitment to clinical care, education, and innovation; and an adequate volume of procedures (based on either a defined number of index procedures or the size of population served). A summary of key elements from the HPB practice documents are shown in Table 4.

Table 4. Recommendations from HPB practice organization documents.

SURGEON CRITERIA

National Plan for Liver Services UK (2004)

- Sufficient complement of HPB consultant surgeons able to provide continuous 24 hour coverage throughout the year, who are supported by specialist registrars
- Each hepatology centre should be able to provide training in HPB surgery. This is essential to maintain the flow of qualified clinicians in this subspecialty

CCO – Criteria for the Delivery of Pancreatic Cancer Surgery (1999)

- Completion of training in general surgery plus a period of advanced training in HPB and pancreatic surgery
- Competency to manage routine cases and complex resections and reconstructions of biliary tract, intestine, pancreas and vascular structures
- Ideally, there should be more than one surgeon

NY State Committee on Quality Improvement in Living Liver Donation (2002)

- All surgeons should be board certified in general surgery and have demonstrated experience in liver transplant surgery
- Two surgeons should have demonstrated experience in live donor hepactomy (15 procedures) or major hepatobiliary resectional surgery (20 procedures) or surgical fellowship at an American Society of Transplant Surgeons approved liver transplant fellowship program with demonstrated experience (15 procedures)

Guidelines for Resection of Colorectal Cancer Liver Metastases (University of Edinburgh, 2005)

- At least two specialist surgeons trained in, and maintaining a special interest in liver resection surgery, and who can demonstrate a high level of skill and training in this area.

HOSPITAL CRITERIA

National Plan for Liver Services UK (2004)

Volume:

- Each centre should serve a population of 2-4 million

Physical Resources:

- Appropriately equipped facilities (including CUSA dissector, harmonic scalpel, intra-operative ultrasonography, argon beam coagulator, laparoscopic equipment, ablation treatment equipment, etc)
- Sufficient ICU beds to accommodate at least 95% of hepatology/HPB emergencies
- High quality diagnostic facilities (US, CT, MRI, PET) 7 days a week
- Diagnostic and therapeutic endoscopy and ERCP 24 hours a day
- Coverage in hepatology, hepatobiliary surgery and intensive care medicine to provide service 365 days a year

Human Resources:

- Nurse specialists to coordinate the care of patients and to facilitate communication and provide psychological, spiritual, social and palliative care
- Medical support from consultation hepatologists or gastroenterologists with HPB interest able to provide continuous 24 hour coverage
- Interventional radiologist, ideally available 365 days a year
- Specialized liver pathologist onsite
- Intensivist/anaesthetist with interest in hepatology or HPB should be available
- Oncology team - Palliative care professionals, Pharmacist with interest in liver disease, Data Manager

Organization

- Group (10-15) of managed clinical network providing liver services across UK.
- Managed networks responsible for:
  - Targeting resources where most needed
  - Agreeing to common protocols and service patterns
  - Monitoring clinical outcomes of treatment pathways
- Patient pathways to be determined by National and International guidelines
- Meetings weekly with HPB surgery, hepatology, pathology, oncology, radiology and specialist nurses.

Innovation:

- Networks should have clinical trials facility and an active research programme
- MCNs (Multicare Networks) should actively participate in clinical research that aims to improve the management of liver and HPB surgery patients.
- Participation in multi-centre trials…should be a priority.

CCO – Criteria for the Delivery of Pancreatic Cancer Surgery (1999)

Volume:

- Surgical volumes in the range of 25 cases per year (including 10 major pancreatic resections) should be minimum targets, with 50 cases per year an optimum volume for HPB service

Physical Resources:

- Fully equipped; Available 24/7; Capability for intraoperative ultrasound and fluoroscopy; With ventilator capacity; Ultrasound, Colour Doppler, CT, MRI (may be offsite), Angiography, PTC, All available 24/7; Dialysis, PTN

- Infectious disease

Human Resources:

- Ideally more than 1 surgeon involved
- A sufficient complement of HPB consultant surgeons able to provide continuous 24 hour cover throughout the year. The consultants should be supported by specialist registrars.
- Radiologists skilled in angiography, embolization, transhepatic stenting, abscess drainage
- Anesthesiologist with capability to manage long and complex operations
- Dedicated trained critical care physicians
- Endoscopists: Physicians with capability to perform endoscopic diagnosis (ERCP) and treatment (papillotomy, endoscopic stenting)
- Nursing care, experienced in management of complex abdominal surgical problems, particularly HPB and pancreatic diseases, abdominal sepsis and fistulas
- Medical and radiation oncologists to consult for pre and post operative interdisciplinary decision making
- Supportive care, including pain management, psychosocial support and palliative care

Organization

- Team approach, including surgical and non-surgical specialists
- Regular review of patient management (educational round, morbidity and mortality review, formal ongoing outcome measurement and quality assurance)
- Information system in place to support quality assurance and to facilitate interface with Cancer Care Ontario, education, consultation and management programs

Innovation

To advance knowledge in the field to improve patient outcomes

NY State Committee on Quality Improvement in Living Liver Donation (2002)

Human Resources:

- Two liver transplant attending surgeons, one present for entire procedure and both present for critical portions
- A third should be present in recipient operating room
- Two separate anesthesia attending physicians and teams for donor and recipient operations
- 24/7 coverage of transplant service by general surgery residents at year 2 level or higher, transplant fellows or physician extenders (nurse practitioners or physician assistants)
- Nursing staff, with ongoing education and training in live donor transplantation nursing care.
- Radiologist with experience in evaluation of liver transplant patients
- Interventional radiologists

NHS Executive: Improving outcomes in upper gastro-intestinal cancers (2001)

Volume:

- Cancer centres should draw patients from catchment areas of with populations of 2-4 million
- Minimum acceptable population size is 1 million for sparsely populated areas
- Team could expect at least 200 new patients requiring specialist treatment per year

Physical Resources:

- Provision of adequate and appropriate facilities for surgery and post-operative care
- Availability of EUS, spiral CT facilities, MRCP and ERCP at Cancer Centres

Human Resources:

- All members should be specialists in management of pancreatic cancer
- A designated lead clinician (physician or surgeon) who will take overall responsibility for assessment and treatment of patients
- Team Members include: Specialist HPB surgeons, Gastroenterologist, Anesthetist/intensivist, Radiotherapy specialist (clinical oncologist), Chemotherapy specialist with expertise in treatment of upper GI cancers, Radiologist with GI sub-specialty interest and expertise in interventions, Histopathologist, Cytopathologist, Dietitian, Clinical nurse specialist, Palliative care specialist, One or more members should be trained in endoscopic ultrasonography, Gastroenterologist with interest in upper GI cancers, Clinical nurse specialist with knowledge of upper GI cancer, Endoscopist with expertise in stenting, Interventional radiologist

Organization:

- Cancer Network in which roles of hospitals which offer upper GI services are specified
- Systems to link and coordinate activities of the hospitals within the Network
- Adequate systems and support for rapid communication between teams within the Network
- Evidence-based assessment, treatment and referral guidelines agreed by specialist teams throughout the network
- Systems for Network-wide audit of procedures and outcomes
- Evidence of regular team meetings at Cancer Units and Centres

Guidelines for Resection of Colorectal Cancer Liver Metastases (University of Edinburgh, 2005)

Volume:

- Liver resection should be based in a cancer centre serving a population of at least two million

Human Resources:

- At least two specialist surgeons trained in, and maintaining a special interest in liver resection surgery, and who can demonstrate a high level of skill and training in this area.

Organization

▪ Consideration of patients for resection of liver metastases should be carried out in a single high volume centre ▪ Patients under consideration of treatment for hepatic metastases should be discussed at a multidisciplinary meeting ▪ The team should also include an oncologist, diagnostic and interventional radiologist with an expertise in hepatobiliary disease, histopathologist, and clinical nurse specialist.
The Leapfrog Group: Evidence-Based Hospital Referral Fact Sheet (2004) Volume: ▪ Evidence-based hospital referral Safety Standard indicates that the volume of surgery procedures for pancreatic resection is > 11/year

Abbreviations: NHS, National Health Service; NY, New York; UK, United Kingdom

DISCUSSION

The Expert Panel on HPB Surgical Oncology used the evidence that was available from the published literature, standards from other jurisdictions, data on provincial activity, and their own expert opinion to reach consensus on standards for HPB cancer surgery in Ontario. They also took into account issues of population distribution in Ontario, current regional service organization, distribution of HPB surgery volumes and the educational and research mandates of the various stakeholders.

The body of evidence on the optimum organization for delivery of HPB cancer surgery in the published and unpublished literature is quite limited. Most studies are focused on the volume-outcome relationship. As indicators of performance in an individual institution, the studies have significant limitations, including the inherent risk of referral bias and potentially confounding co-interactions. The published studies are also limited by a lack of standardization in their reporting of outcomes and in the methodology used to define high- and low-volume centres. They also tended to focus on single procedures or types of procedures rather than the full range of HPB cancer surgery. The Panel considered trying to plot a volume-outcomes curve from raw data in the studies but this proved to not be feasible.

Notwithstanding these limitations, the Panel noted that all the studies did show a definite trend for improved outcome with increasing volume, both for surgeons and hospitals. There was consensus for the concept that these patients present very complex oncological problems and require an integrated approach by a dedicated team with access to advanced levels of expertise, system resources, and integrated care, in order to achieve the best possible outcomes. The Panel felt quite strongly that carrying out isolated surgical procedures in the absence of a comprehensive system of care is not likely to result in appropriate outcomes. There was consensus that, in keeping with the current trend within Ontario, the centralization of complex surgical procedures should continue and that the development of integrated regional networks of care will allow appropriate participation in HPB cancer care by the remaining institutions. This will assist in the goal of providing appropriate care as close to home as possible, whenever possible.

The Expert Panel on HPB Surgical Oncology discussed the issue of volume standards and, while acknowledging the previously discussed problems in the available literature, did reach consensus on this issue. The Panel agreed that the specific structural or process factors that influence the volume-outcome relationship were not discernable from the current literature. They felt that the predominant focus at this time should be on the institution as a whole and, therefore, felt it most appropriate to define an overall volume for an institution rather than define an individual surgeon volume. The Panel also felt it appropriate to consider the major hepatopancreaticobiliary surgical procedures, for both benign and malignant disease, as part of the institutional volume. This opinion is based on the similarities in the surgical management of these patients and the fact that the volume-outcome data is often based on all procedures rather than only cancer procedures. The procedures are resection of the pancreatic head (or total pancreatectomy) with duodenum, anatomic resection of the liver, and resection and reconstruction of the biliary tract. The Panel also felt that, in developing the volume standard of the number of index surgical procedures per institution, there should be some consideration also of the size of the population served, the optimum utilization of specialized hospital resources, and the need to maintain expertise and skills in the entire interdisciplinary team. This recognizes the realities of population distribution and current health care organization in the province of Ontario, and the Panel felt that the number of index cases would serve as an adequate surrogate for the volumes of the other components of comprehensive cancer care.

After due deliberation, the Expert Panel reached consensus that a minimum institutional volume of 50 index HPB surgery cases per year is required to maintain the skills of the multidisciplinary team, provide the regional consultation and referral service, and achieve appropriate outcomes in Ontario. The Panel

also concluded that the evidence demonstrated better outcomes with increasing volume at all volume levels. The Panel recognized that applying a criterion based on this finding would result in a relatively small number of institutions providing complex HPB cancer surgery and that the development of regional networks of care will be critical to providing optimum integrated care across the province. It is also recognized that some regions do not currently have the case volume to support the recommended targets. Additionally, some major University Centres, where participation in complex HPB surgery is important to the broader institutional educational mandate, will also face challenges in meeting the volume targets. However, the Panel believes that the combination of further regional consolidation and the increasing volume of care required by a growing and aging population will provide solutions to these difficult issues and that it will be possible to provide both excellent care and meet regional and institutional needs with the standards described.

CONCLUSIONS

Based on its study of the available evidence and the consensus process, the Expert Panel on HPB Surgical Oncology have identified several characteristics that institutions and surgeons providing care for patients with cancer of the liver, pancreas, and biliary tract should have in order to achieve the best possible outcomes for this patient population.

Surgeon Criteria

General characteristics for surgeons undertaking the management of patients with HPB cancer include knowledge of the biological behaviour and natural history of and range of treatment options for these patients. The surgeons are to be skilled in modern techniques of HPB surgery, and knowledgeable about the management of the early and late postoperative complications. They are committed to providing excellence in care, and to advancing knowledge in the field. They support and participate actively as a member of a multidisciplinary team and are committed to advancing knowledge to improve the care of these patients. They are also committed to participation in quality assurance initiatives.

Surgeons carrying out complex operations will have advanced training in HPB surgery and provide consultation services, leadership, and professional development support to other surgical providers who also have an important role in the care of patients with hepatopancreaticobiliary disorders including cancer.

Hospital Criteria

Institutions providing complex surgical procedures for HPB cancer require a comprehensive range of fiscal and human resources in order to meet the needs of this patient population. Organizationally, institutional commitment to multidisciplinary care that includes regular case conferencing, quality assurance activities (including regular outcomes review), and an information management system to provide the necessary data is a key requirement. Such institutions must be committed to working in a system of regional care, including a linkage with a regional cancer centre, and have a commitment to evidence-based practice, including the use of appropriately developed guidelines.

They will have the human resources required to provide the full range of necessary care on a continuous basis. This includes a minimum of two surgeons with specific training in HPB surgery and access to all necessary medical specialists, specifically including focused expertise in diagnostic and interventional radiology, HPB pathology, anaesthesiology, medical oncology, and radiation oncology.

They will have the physical resources necessary, including fully equipped and available operating rooms that have intraoperative imaging and adjunct modalities such as radiofrequency ablation, technologies for liver parenchymal division, and technologies for minimally invasive surgery. They will have appropriate facilities for postoperative care (ward and ICU) that are able to deal with the common postoperative problems, including renal failure. Imaging services for both diagnostic and interventional purposes need to be available on a continuous basis and to include a full array of technologies.

An HPB Surgical Centre needs to have a critical mass of patients in order to achieve appropriate outcomes. The recommendation is that they carry out at least 50 major HPB cases annually, including at least 20 pancreatic resections.

Overall, the Expert Panel on HPB Surgical Oncology believes that the benefits associated with the implementation of these standards would result in improvements in patient outcomes, including lower operative mortality rates, the reduced frequency of serious complications, better disease-free and overall survival, and improved quality of life for HPB cancer patients. The Expert Panel feels that these standards will provide useful guidelines to those responsible for the organization of health care, including governments, Cancer Care regional vice presidents, regional planning authorities (LHINs), hospital CEOs, surgeons, and other health care professionals, in the planning of integrated regional and provincial cancer services.

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REFERENCES

1. Simunovic M, Ho T, Theriault M, and Langer B. Relation between hospital surgical volume and outcome for pancreatic resection for neoplasm in a publicly funded health care system. CMAJ 1999;160:643-8.
2. Cancer Care Ontario Pancreatic Task Force. Criteria for delivery of pancreatic cancer surgery [internal document]. In: Cancer Care Ontario: regionalization of pancreatic cancer surgery in Ontario; 1999.
3. Browman GP, Levine MN, Mohide EA, Hayward RSA, Pritchard KI, Gafni A, et al. The practice guidelines development cycle: a conceptual tool for practice guidelines development and implementation. J Clin Oncol. 1995;13:502-12.
4. van Heek NT, Kuhlmann KFD, Scholten RJ, de Castro SMM, Busch ORC, van Gulik TM, et al. Hospital volume and mortality after pancreatic resection: a systematic review and an evaluation of intervention in the Netherlands. Ann Surg 2005;242:781-90.
5. Edge SB, Schmieg RE Jr., Rosenlof LK, and Wilhelm MC. Pancreas cancer resection outcome in American University Centres in 1989-1990. Cancer 1993;71:3502-8.
6. Lieberman MD, Kilburn H, Lindsay M, and Brennan MF. Relation of perioperative deaths to hospital volume among patients undergoing pancreatic resection for malignancy. Ann Surg 1995;222(5):638-45.
7. Nordback I, Parviainen M, Räty S, Kuivanen H, and Sand J. Resection of the head of the pancreas in Finland: effects of hospital and surgeon on short-term and long-term results. Scand J Gastroenterol 2002;37:1454-60.
8. Glasgow RE, Mulvihill SJ. Hospital volume influences outcome in patients undergoing pancreatic resection for cancer. West J Med 1996;165:294-300.
9. Imperato PJ, Nenner RP, Starr HA, Will TO, Rosenberg CR, and Dearie MB. The effects of regionalization of outcomes for a high risk surgical procedure: a study of the Whipple procedure in New York State. Am J Med Qual 1996;11(4):193-7.
10. Gordon TA, Bowman HM, Tielsch JM, Bass EB, Burleyson GP, et al. Statewide regionalization of Pancreaticoduodenectomy and its effect on in-hospital mortality. Ann Surg 1998;228(1):71-8.
11. Sosa JA, Bowman HM, Gordon TA, Bass EB, Yeo CJ, Lillemoe KD, et al. Importance of hospital volume in the overall management of pancreatic cancer. Ann Surg 1998;228(3):429-38.
12. Gouma DJ, van Geenen RCI, van Gulik TM, de Haan RJ, de Wit LT, Busch ORC, et al. Rates of complications and death after Pancreaticoduodenectomy: risk factors and the impact of hospital volume. Ann Surg 2000;232(6):786-95.
13. Birkmeyer JD, Siewers AE, Finlayson EVA, Stukel TA, Lucas FL, Batista I, et al. Hospital volume and surgical mortality in the United States. New Engl J Med 2002;346(15):1128-37.
14. Ho V and Heslin MJ. Effect of hospital volume and experience on in-hospital mortality for pancreaticoduodenectomy. Ann Surg 2003;237(4):509-14.
15. Choti MA, Bowman MH, Pitt HA, Sosa JA, Sitzmann JV, Cameron JL, et al. Should hepatic resections be performed at high-volume referral centers. J Gastrointest Surg 1998;2:11-20.
16. Belghiti J. et al, Seven hundred forty-seven hepatectomies in the 1990's: an update to evaluate the actual risk of liver resection; J Am Coll Surg. 2000 Jul;191(1):38-46.
17. Jose A Melendez et al, Perioperative outcomes of major hepatic resections. J Am Coll Surg. 1998 Dec;187(6):620-5.
18. Moore K, Thursz M, Mirza DF. National plan for liver services UK—specialised services for hepatology, hepatobiliary and pancreatic surgery [monograph on the Internet]. 2004 May [cited 2005 Nov 12]. Report prepared for the British Association for the Study of the Liver. Available from: http://www.basl.org.uk/National%20Plan%20for%20Liver%20Services%20UK%20Final-May04.pdf.
19. New York State Committee on Quality Improvement in Living Liver Donation. A report to: New York State Transplant Council and New York State Department of Health [monograph on the

Internet]. New York: New York State Department of Health; 2002 Dec [cited 2005 Nov 12]. Available from: http://www.health.state.ny.us/nysdoh/liver_donation/pdf/liver_donor_report_web.pdf.
20. Department of Health; National Cancer Guidance Steering Group. Guidance on commissioning cancer services: improving outcomes in upper gastro-intestinal cancers: the manual [monograph on the Internet]. London: Department of Health; 2001 Jan [cited 2005 Nov 12]. Available from: http://www.dh.gov.uk/assetRoot/04/08/02/78/04080278.pdf.
21. Garden OJ, Rees M, Mirza D, Poston G, Ledermann J, Saunders M, et al. Guidelines for resection of colorectal cancer liver metastases [unpublished monograph]. British Association of Surgical Oncology. 2005.
22. The Leapfrog Group. Evidence based hospital referral fact sheet. 2004 Apr 7 [cited 2005 Nov 12]. Available from: http://www.leapfroggroup.org/media/file/Leapfrog-Evidence-Based_Hospital_Referral_Fact_Sheet.pdf.

Ontario Health
Cancer Care Ontario

Evidence-Based Series #17-2 Version 3: Section 3

Hepatic, Pancreatic, and Biliary Tract (HPB) Surgical Oncology Standards: Standards Development and External Review—Methods and Results

Report Date: June 14, 2006

The 2006 guideline recommendations are

ENDORSED

This means that the recommendations are still current and relevant for decision making.

THE SURGICAL ONCOLOGY PROGRAM AND THE PROGRAM IN EVIDENCE-BASED CARE COLLABORATION

The Surgical Oncology Program (SOP) and the Program in Evidence-Based Care (PEBC) are initiatives of Cancer Care Ontario (CCO). The mandate of the SOP is to improve the delivery of cancer surgery in Ontario through initiatives designed to increase access to care, improve the quality of care, support the recruitment and retention of cancer surgeons, support knowledge transfer and evidence-based practice, and foster research and innovation. The mandate of the PEBC is to improve the lives of Ontarians affected by cancer, through the development, dissemination, implementation, and the evaluation of evidence-based products designed to facilitate clinical, planning, and policy decisions about cancer care. The SOP and the PEBC have worked collaboratively on a number of occasions to develop evidence-based materials relevant to the surgical community in Ontario, which includes the creation of HPB surgical oncology standards.

The PEBC is best known for producing high-quality evidence-based practice guideline reports, using the methods of the Practice Guidelines Development Cycle (1,2). A typical PEBC report consists of the comprehensive systematic review of the clinical evidence on a specific cancer-related topic, the interpretation of and consensus agreement on that evidence, the resulting clinical recommendations, and the results of an external review by Ontario clinicians for whom the topic is relevant. The PEBC has a formal standardized process to ensure the timeliness of each clinical practice guideline report, conducting routine periodic reviews and evaluations of the scientific literature and, where appropriate, integrating that literature with the original practice guideline report information.

As part of its quality improvement mandate, the SOP convenes expert panels for the selection of quality indicators and the development of clinical guidelines and organizational standards. The panels are comprised of surgeons, other clinicians, health care administrators, other health care professionals, and methodologists and are established on an as-needed basis for specific quality initiatives, such as the development of the HPB surgical oncology standards. In this instance, the SOP coordinated the development of the Expert Panel on HPB Surgical Oncology, and the PEBC contributed methodological expertise. The PEBC process and report format has been adapted for this HPB standards document.

The Evidence-Based Series

This Evidence-Based Series is comprised of the following three sections:

- *Section 1: Standards* This section contains the standards derived by the Expert Panel on HPB Surgical Oncology through systematic review, an environmental scan, interpretation of the clinical and scientific literature, and consensus process, as well as through a formalized external review by Ontario practitioners and administrators.
- *Section 2: Systematic Review* This section presents the comprehensive systematic review of the clinical and scientific research, the environmental scan, and the Panel discussion on the topic and the conclusions drawn by the Expert Panel on HPB Surgical Oncology
- *Section 3: Methodology of the Standards Development and External Review Process* This section summarizes the standards development process and the results of the formal external review by Ontario practitioners and administrators of the draft version of the HPB surgical oncology standards and systematic review.

DEVELOPMENT OF THE EVIDENCED-BASED SERIES

Developing the Draft Systematic Review and Standards

This Evidence-Based Series was developed by the Expert Panel on HPB Surgical Oncology. The series is a convenient and up-to-date source of the best available evidence on hepatic, pancreatic, and biliary tract surgical oncology standards, developed through systematic review, evidence synthesis, and input from practitioners and health care administrators in Ontario. Section 2 contains the systematic review of the evidence on outcomes related to the optimum delivery of cancer-related HPB surgery. The draft recommendations derived from the interpretation of that evidence by members of the Expert Panel are detailed in Section 1. Sections 1 and 2, along with Section 3, were circulated to Ontario practitioners and administrators for their feedback. Section 3 presents the feedback process results and any changes made to the draft document. This series represents the third collaboration between Cancer Care Ontario's SOP and PEBC.

Expert Panel Consensus Process

The recommendations were based on available information regarding surgeon and other team member training and experience, resource requirements, centre organization, and the relationship of volumes to outcomes. Information from the environmental scan plus the experience of panel members led to a consensus on all issues but the volume thresholds. The literature search showed a consistent relationship between centre volume and postoperative mortality for radical pancreatic resection but not as consistent a relationship for liver resection. Members of the Expert Panel agreed with this interpretation of the evidence, and the main discussion within the Expert Panel focused on what would be a reasonable minimum volume to set as the provincial standard, given the limitations of the data reviewed. Members of the Expert Panel reached consensus on the volume numbers as stated.

External Review by Ontario Clinicians

Following the review and discussion of Sections 1 and 2 of this evidence-based series, the Expert panel on HPB Surgical Oncology circulated the clinical practice guideline and systematic review

to clinicians, hospital administrators, and other stakeholders within the Province of Ontario for review and feedback. Box 1 summarizes the draft standards and supporting evidence developed by the panel.

BOX 1:
DRAFT RECOMMENDATIONS
(approved for external review March 20, 2006)

SURGEON CRITERIA

General Characteristics

The general characteristics for surgeons undertaking the management of patients with HPB cancer are as follows:

- Knowledgeable regarding the biology of HPB cancer, its natural history, appropriate investigation and the whole range of treatment options.
- Skilled in modern techniques of surgery of the liver, pancreas, and biliary tract, including the capability for managing vascular complications and vascular reconstruction.
- Experienced in the management of patients with hepatobiliary and pancreatic diseases, especially the management of early and late postoperative complications.
- Committed to providing excellence in care to patients with HPB diseases and to advancing knowledge in the field in order to improve patient outcomes.
- Committed to participating as a member of a multidisciplinary oncology team.
- Committed to participating in Cancer Care Ontario (CCO) quality initiatives.

Training

Although there is not a formally recognized subspecialty in HPB surgery, the complex nature of this subspecialty area has lead to the development of training programs designed to provide the kind of expertise and experience necessary to appropriately manage patients with HPB diseases. Thus, appropriate training would include certification by the Royal College of Physicians and Surgeons of Canada in General Surgery (or its equivalent) plus the completion of a period of advanced training in HPB surgery designed to reach a high level of proficiency in the management of the complex surgical problems found in this patient population. The training program should focus specifically on the management of malignant disease and result in the trainee acquiring competence to manage not only routine cases but also those requiring more complex resection and reconstruction. Thus, surgeons practicing HPB surgery should have completed either:

- A specific formal Fellowship in HPB surgery, or
- A Surgical Oncology Fellowship with a major emphasis on HPB surgery

Surgeons who trained prior to the existence of HPB or Surgical Oncology Fellowships may have had such training in less formal ways, such as extended post-residency training in a busy HPB service or mentoring and progressive experience in the early years of their staff appointment in a hospital with a busy HPB service. The increasing complexity of HPB surgery and the development of excellent-quality, formal fellowship training support the use of the new standards for surgeons now entering the system. All surgeons should maintain their expertise and knowledge through continuing professional development programs and a commitment to a career focus on HPB surgery.

HOSPITAL CRITERIA

General Characteristics

A tertiary care HPB surgical centre should be capable of managing the full range of surgical care for patients with diseases of the liver, pancreas, and biliary tract, from the most complex to the most common, in a single hospital. A minimum of two HPB surgeons should be on staff in order to provide intraoperative assistance and continuous preoperative and postoperative care, while allowing for appropriate personal and professional leave. The hospital should have an affiliation with a Regional Cancer Program, and the HPB Program should include teaching, research, quality improvement, and program advancement elements.

Hospitals that do not have tertiary HPB services will provide care for patients with common HPB conditions. They should have an established relationship with a tertiary care HPB Centre to facilitate consultation and referral of common and uncommon cases through a regional network of care such as

Local Health Integrated Networks (LHINs), so that all patients may have access to high-quality care in the appropriate setting. These hospitals and their professional staff would also play an important role in the initial diagnostic investigation and surgical follow-up of patients with complex problems. Participation in such a regional care network should lead to both better access to and quality of care.

The capability to provide optimal HPB care requires that an institution ensure the availability of the appropriate physical, fiscal, and human resources needed to provide for the complete spectrum of patient care from early diagnosis to long-term management and supportive care. Hospitals should have a definable system of care for HPB patients' that is integrated with the other components of the broader cancer care system.

Specific System Requirements

- Formal acknowledgement by the hospital that it is a Centre for HPB Surgery and, therefore, has a distinct HPB Surgery Program with definable leadership structure and accountability.
- A commitment to provide HPB surgery in a timely manner, including support of and commitment to the targets set by the provincial wait-time strategy
- A system of patient care that ensures multidisciplinary management, including Multidisciplinary Cancer Conferences (i.e., tumour boards) involving the appropriate health care professionals to ensure that patients receive the most appropriate treatment. This is essential for the achievement of optimal patient outcomes.
- A system of regular review of the program, including clinical and educational rounds, morbidity and mortality review, and quality assurance, including a system for the regular tracking of patient outcomes. This includes participation in all quality improvement programs of Cancer Care Ontario.
- Participation in Regional and Provincial Integrated Networks of Care as outlined in the CCO Provincial Cancer Plan (2004), through the LHINs.
- Infrastructure Support for Participation in Local and National Clinical Research Studies

Physical Resources

Appropriately equipped operating rooms available 24 hours a day, seven days a week. This includes the capability for intraoperative imaging (fluoroscopy and ultrasound) and appropriate adjunctive therapy (i.e., radiofrequency ablation).

- A full range of diagnostic imaging ability including ultrasound (all modalities including Doppler), CT scan, MRI, angiography, and interventional radiology with appropriate skills in HPB interventions.
- Diagnostic and therapeutic Interventional endoscopy available 24 hours per day, seven days per week.
- An appropriately equipped intensive care unit (ICU) capable of providing the appropriate range of ventilation modalities, dialysis, and the physical facilities for management of complex infectious problems.
- A fully developed nutrition service including total parenteral nutrition (TPN).

Human Resources

HPB services are optimally delivered in a multidisciplinary team setting and require a full range of skilled health care professionals for optimum outcomes. These include:

- Qualified HPB surgeons (see Surgeon Criteria and Training).
- Radiologists with appropriate expertise across the full range of angiographic, biliary tree imaging, abscess management, and ablative techniques.
- Dedicated, certified critical care physicians.
- An endoscopy service with advanced skills in biliary therapeutic endoscopy.
- Nursing personnel experienced in the management of complex abdominal surgical problems, particularly HPB diseases, abdominal sepsis, and fistulae.
- Medical and radiation oncology services available for consultation and interdisciplinary decision making.
- Supportive care, including pain management, psychosocial support, and palliative care.
- Allied health professionals including nutritional care and occupational and physical therapists.

- Pathologist with a special interest in HPB diseases and a commitment to developing the appropriate expertise.
- Administrative support, including a system of data management to meet the needs of the HPB Service.
- Availability of an appropriate spectrum of physician subspecialties to provide the required support to HPB patients, especially infectious disease practitioners.
- Anaesthesiologists with expertise in managing long, complex operations in which patients may potentially become unstable and in patients with impaired liver function.

Volume of HPB Surgery

The hospital with an HPB service should have an adequate volume of index cases to maintain the skills of the multidisciplinary team as required in a tertiary referral centre, to justify the resource investment required, and to assure that optimum outcomes are achieved.

An HPB Centre should carry out a minimum of 50 index HPB cases per year (index cases include formal anatomic resection of one or more liver segments, all resections of the head of the pancreas, and all resections with reconstruction of the biliary tract). The volume should include at least 20 pancreatic resections.

OUTCOME MEASURES, BENCHMARKS, AND QUALITY ASSURANCE

The following outcomes are considered reasonable and achievable at HPB Centres across Ontario:

- A mortality rate (30-day plus in hospital) of less than 5% for major pancreatic resection
- A mortality rate (30-day plus in hospital) of less than 3% for anatomical liver resection.

Methods

Feedback was obtained through a mailed survey of 264 clinicians and other relevant stakeholders (see Table 1 for a description of the population surveyed). The survey sample was comprised of 239 clinicians and 25 administrators or other stakeholders. The survey consisted of items evaluating the methods, results, and interpretive summary used to inform the draft standards and whether the draft standards should be approved as a standards document. Written comments were invited. The survey was mailed out on March 20, 2006. Follow-up reminders were sent at two weeks (post card) and four weeks (complete package mailed again). The Expert Panel on HPB Surgical Oncology reviewed the results of the survey.

Results

Ninety-one responses were received out of the 264 surveys sent (34.5% response rate; average response rate for PEBC/SOP collaborative reports = 42.4% (n=4)). Responses include returned completed surveys as well as phone, fax, and email responses. Of the practitioners who responded, 55 indicated that the report was relevant to their clinical practice, and they completed the survey. See Table 1 for a breakdown of survey results obtained by respondent category. Key results of the practitioner feedback survey are summarized in Table 2.

Table 1. Description of survey sample population

Category	Sent	Received
Medical oncologists	17	4
Radiation oncologists	13	6
Surgeons	145	53
Pathologists	1	-
Gastroenterologists	1	1
Medical imaging specialists	4	2
LHIN CEOs	7	-

Hospital Chief of Staff	12	3
Hospital Chief of Surgery	16	6
Cancer Surgery Investment personnel	8	3
Head, Surgical Oncology	7	4
Hospital CEO	19	7
Medical School Representative	3	1
Regional Vice-President	6	1
Other (various)	5	-
TOTALS	**264**	**91**

Note: LHIN, Local Health Integration Networks; CEO, Chief Executive Officer.

Table 2. Responses to eighteen items on the external review survey.

Item	Number (%)		
	Strongly agree or agree	**Neither agree nor disagree**	**Strongly disagree or disagree**
There is a need for a standards document on this topic	87	11	2
The evidence (literature search and environmental scan) is relevant and complete (e.g., no key information sources or studies missed, nor any included that should not have been)	84	9	7
I agree with the methodology used to summarize the evidence	85	7	7
The draft standards are in agreement with my understanding of the evidence	82	7	11
The draft standards in this report are clear	93	6	2
I agree with the draft standards as stated	75	13	13
The draft standards are suitable for the Ontario context.	67	15	18
The draft standards are too rigid to apply in the Ontario context	40	9	51
When applied, the draft standards will produce more benefits for patients than harms	82	11	7
The draft standards report presents a series of options that can be implemented	59	24	17
To apply the draft standards will require reorganization of services/care in my practice setting	50	13	37
The standards will be associated with more appropriate utilization of health care resources	60	29	11
The draft standards in this report are achievable	76	9	15
The draft report presents standards that are likely to be supported by a majority of my colleagues	69	15	15
The draft standards reflect a more desirable system for improving the quality of patient care than current practice	78	17	6
I would feel comfortable if patients received the care recommended in these draft standards	86	9	5
These draft standards should be formally approved	74	11	15
	Not at all likely or unlikely	**Unsure**	**Very likely or likely**
If these draft standards were to be approved how likely would you be to apply the recommendations to the clinical care or organizational and/or administrative decisions for which you are professionally responsible?	77	9	13

Eighty-seven percent of all respondents agreed that there exists a need for guidance on this clinical topic, 84% agreed that the evidence reviewed was relevant and complete, 85% agreed that the methods used in formulating the standards was correct, and 82% of all respondents were in complete agreement with the draft standards. Seventy-four percent of all respondents supported the draft report being approved as a standards document and stated that they would use the recommended standards in their own practice. The observed discordance between the result for the final question and the preceding 18 questions may be explained by the change in response structure where the previous 18 questions used a consistent scoring method but the final question deviated from this, which may explain the low approval score for the final question. The change in response structure for the final question was intentional to monitor the attentiveness of the respondents. The incongruent result suggests there may be some level of inattentiveness on part of the respondents.

Summary of Written Comments and Expert Panel Responses

Twenty-five of the 55 total respondents (45.5%) provided written comments. The main points contained in the written comments are displayed in the following chart along with the Expert Panel discussion and responses.

Comment 1: SURGEON NUMBERS: Several respondents forwarded concerns regarding the recommendation that a minimum of two HPB surgeons should be on staff in order to provide intra-operative assistance and continuous preoperative and postoperative care, while allowing for appropriate personal and professional leave.
Response: The overall emphasis of the standards reflects the concept of a designated unit, based on at least 2 surgeons for coverage, and continuity of care. Even in smaller tertiary centres, it should be possible to have two surgeons, who have the training described, commit to the level of participation in HPB care required by the standard. *Overall:* Agreed no changes to the HPB Standards document are warranted.
Comment 2: CASE VOLUME: Several respondents raised concern with respect to the validity of the volume target. A question was raised about including a specific target for liver resection.
Response: While, in some of the studies, there may be occasional high-volume centres with a high mortality rate, they are relatively few and do not diminish the consistent and clear evidence of improved outcomes with higher volumes. The Expert Panel reaffirms that using the mean cases per hospital per year or the mean cases per surgeon per year as the unit of comparison, as was performed in this document, is a valid method, given the limitations of the data obtained. Distal pancreatectomies are not considered to be index cases, and the 50-case minimum refers to procedures listed in the Standards document. There is evidence to support the minimum number of pancreatic resections, but there is very little volume data available for liver resections. The total of 50 HPB cases per year is the number expected to be generated in a population of 1 million and includes 20 pancreatic resections. *Overall:* Agreed under Volume of HPB Surgery replace “all resections of the head of the pancreas with “all Whipple and total pancreatic resections”.
Comment 3:

IMPACT OF VOLUME TARGET: Several respondents raised concerns that the standards in general, and volume targets in particular, would lead to some institutions and surgeons no longer being able to perform the index procedures.

Response:
In order to meet the volume standards, HPB index cases will be done in a relatively small number of centres. The number reflects the caseload expected to be generated by a referral population of one million and is appropriate for the Ontario situation. Regions will have to support their referral centres, in order to help them achieve the target. For the most part, this has already occurred in Ontario.

Overall: Agreed no changes to the HPB Standards document are warranted.

Comment 4:
FUNDING: The question of funding being withheld from institutions performing these procedures at low volumes was raised.

Response:
Funding of procedures is a hospital-based decision, and outside the mandate of the PEBC and the Expert Panel.

Overall: Agreed no changes to the HPB Standards document are warranted.

Comment 5:
TEACHING REQUIREMENT: Concern was expressed that the teaching requirement would exclude non-university hospitals

Response:
The teaching requirement is not specifically for undergraduate or postgraduate training in medicine; it reflects the need for education of the team and the broader health care community in the appropriate management of these problems. This is necessary for appropriate quality in both teaching and non-teaching centres.

Overall: Agreed no changes to the HPB Standards document are warranted.

Comment 6:
INFRASTRUCTURE REQUIREMENTS: Clarification was requested with respect to the location and availability of some of the support resources

Response:
The required support services do not necessarily have to be continuously on site, rather they need to be continuously available when required. The wording in the Standards reflects this.

Overall: Agreed no changes to the HPB Standards document are warranted.

Comment 7:
TRAINING REQUIREMENTS: Questions were raised with respect to whether transplant training would meet the standard. It was also suggested that more specificity be included with respect to the term “major focus on HPB surgery.”

Response:
These standards have been modified to reflect that HPB training can be achieved in both transplant and non-transplant programs, as well as surgical oncology fellowships. It is difficult to be more specific in defining the components of training as there are no agreed-upon standards for these training programs at this time.

Overall: Agreed add a second bullet under Training Requirements "A Fellowship in liver transplant which includes a major focus in non-transplant HPB cases, or…"

Report Approval Panel

The PEBC Report Approval Panel (RAP) reviewed the draft Standards document in an advisory capacity in March 2006. The RAP consists of two members, including an oncologist, with expertise in clinical and methodology issues. Following review, the RAP motioned to fully endorse this document. No comments, requests for clarifications, or revisions were submitted for Expert Panel consideration.

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Contact Information

For information about the PEBC and the most current version of all reports,
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REFERENCES

1. Browman GP, Levine MN, Mohide EA, Hayward RSA, Pritchard KI, Gafni A, et al. The practice guidelines development cycle: a conceptual tool for practice guidelines development and implementation. J Clin Oncol. 1995;13:502-12.
2. Browman GP, Newman TE, Mohide EA, Graham ID, Levine MN, Pritchard KI, et al. Progress of clinical oncology guidelines development using the practice guidelines development cycle: the role of practitioner feedback. J Clin Oncol. 1998;16(3):1226-31.

Appendix 1: Expert Panel on HPB Surgical Oncology members.

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Appendix 2: Literature search (MEDLINE).

exp Liver Neoplasms/su [Surgery]
exp HEPATECTOMY/ 5265
http://gateway.ut.ovid.com/gw1/ovidweb.cgi?Titles+Display=2&S=IDNJHKKOCGKGIO00Dexp Liver Neoplasms/su [Surgery] 5249
hepatic surgery.mp. 180
exp LIVER/su [Surgery] 1430
1 or 2 or 3 or 4 or 5 9268
exp PANCREAS/su [Surgery] 857
exp Pancreatic Neoplasms/su [Surgery] 3132
pancreas surgery.mp. 25
exp PANCREATECTOMY/ 1864
7 or 8 or 9 or 10 4724
http://gateway.ut.ovid.com/gw1/ovidweb.cgi?Titles+Display=11&S=IDNJHKKOCGKGIO00Dexp Biliary Tract Diseases/su [Surgery] 7065
biliary surgery.mp. 195
exp CHOLECYSTECTOMY/ 5855
exp Biliary Tract Surgical Procedures/ 7771
12 or 13 or 14 or 15 11471
6 or 11 or 16 23954
surgery/st 448
surgery/ma 252
surgery/sn 185
http://gateway.ut.ovid.com/gw1/ovidweb.cgi?Titles+Display=20&S=IDNJHKKOCGKGIO00Dsurgical procedures, operative/ 6597
http://gateway.ut.ovid.com/gw1/ovidweb.cgi?Titles+Display=21&S=IDNJHKKOCGKGIO00Dsurgery department, hospital/ 1062
general surgeon$.tw. 749
general surgery$.ti. 360
exp Colorectal Surgery/ 420
http://gateway.ut.ovid.com/gw1/ovidweb.cgi?Titles+Display=25&S=IDNJHKKOCGKGIO00D"colon and rectal surgery (specialty)"/ 420
18 or 19 or 20 or 21 or 22 or 23 or 24 or 25 or 26 9558
exp Disease-Free Survival/ 14682
exp SURVIVAL/ 1134
exp Survival Rate/ 46033
http://gateway.ut.ovid.com/gw1/ovidweb.cgi?Titles+Display=30&S=IDNJHKKOCGKGIO00Dexp Patient Readmission/ 2044
http://gateway.ut.ovid.com/gw1/ovidweb.cgi?Titles+Display=31&S=IDNJHKKOCGKGIO00Dexp Postoperative Complications/ 101643
"outcome assessment (health care)"/ 18519
exp "outcome and process assessment (health care)"/ 232760
28 or 29 or 30 or 31 or 32 or 33 or 34 354262
exp Patient Admission/ 6118
http://gateway.ut.ovid.com/gw1/ovidweb.cgi?Titles+Display=36&S=IDNJHKKOCGKGIO00Dexp Health Manpower/ 1315
hospital volume$.tw. 233
http://gateway.ut.ovid.com/gw1/ovidweb.cgi?Titles+Display=38&S=IDNJHKKOCGKGIO00Dexp Hospital Mortality/ 6570
surgeon volume$.tw. 95

surgical volume$.tw. 97
exp HOSPITALS/
36 or 37 or 38 or 39 or 40 or 41 or 42
17 and 27 and 35 and 4

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Evidence-Based Series #17-2 Version 2: Section 4

Hepatic, Pancreatic, and Biliary Tract (HPB) Surgical Oncology Standards: Standards Development and External Review—Guideline Review Summary and Review Tool

M. Marcaccio, L.D. Durocher-Allen and the Expert Panel on HPB Surgical Oncology

Review Date: December 1, 2015

The 2006 guideline recommendations are

ENDORSED

This means that the recommendations are still current and relevant for decision making.

The original version of this guidance document was released by Cancer Care Ontario's Program in Evidence-based Care in 2006, and reviewed in 2015. In September 2014, this document was assessed in accordance with the PEBC Document Assessment and Review Protocol and was determined to require a review. As part of the review, a PEBC methodologist conducted an updated search of the literature. A clinical expert (MM) reviewed and interpreted the new eligible evidence and proposed the existing recommendations could be endorsed. The HPB Surgical Oncology Expert Panel endorsed the recommendations found in Section 1 (Clinical Practice Guideline) in December 1, 2015.

DOCUMENT ASSESSMENT AND REVIEW RESULTS

Questions Considered

1. What is the optimum organization for the delivery of cancer-related hepatic, pancreatic, and biliary tract surgery in Ontario?

Literature Search and New Evidence

The new search (January 2006 to May 2015) yielded a total of 4 systematic reviews and 61 publications of primary studies. The results of the included systematic reviews and primary studies can be found in the Document Review Tool (page 33).

Impact on Guidelines and Its Recommendations

The evidence supports the existing recommendations; specifically, the identified systematic reviews and meta-analysis provide strong evidence of a volume-outcome relationship, for both hospital and surgeon volume, in hepatic, pancreatic, and biliary tract surgical oncology. Both high hospital volume and high surgeon volume are associated with lower 30-day mortality. The evidence shows a weaker link between hospital or surgeon volume and long-term survival.

There is a recent study (Kanhere 2014) that suggests that it is not the volume of any one individual procedure, but the aggregate volume of complex surgical procedures that is the key quality metric. This is not to say that the volume of an individual procedure is not important to outcomes and quality. There are many more dimensions to quality than perioperative mortality. With periampullary cancer/pancreaticoduodenectomy in particular, a potentially much larger influence on quality is the judgement of what is resectable, both on preoperative assessment and in the operating room. It is currently understood that if this could be measured, individual procedure volumes would likely have a major impact.

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Document Review Tool

Number and title of document under review	17-2 Hepatic, Pancreatic, and Biliary Tract (HPB) Surgical Oncology Standards
Current Report Date	June 14, 2006
Clinical Expert	Michael Marcaccio
Research Coordinator	Lisa Durocher-Allen
Date Assessed	December 3, 2013
Approval Date and Review Outcome (once completed)	Endorsed December 1 2015

Original Question(s):
What is the optimum organization for the delivery of cancer-related hepatic, pancreatic, and biliary tract surgery in Ontario?

Target Population:
The following standards, developed by the Expert Panel on HPB Surgical Oncology, apply to hepatic, pancreatic, and biliary tract cancer surgery and include the full spectrum of multidisciplinary assessment and treatment:

- Management of primary and secondary liver cancer by hepatic resection or locally destructive techniques (ablation by any modality, hepatic artery embolization with or without chemotherapy, etc.).
- Management of cancer of the pancreas and peri-ampullary region by pancreatic resection.
- Management of tumours of the biliary tract (including gallbladder) by surgical resection.

Study Section Criteria:

Inclusion Criteria

Articles were selected for inclusion in the systematic review of the evidence if they were fully published English language reports reporting volume-outcome measurements, for either surgeons or hospitals/institutions, in hepatic, pancreatic, or biliary cancer. Ideally, reports would provide both surgeon and hospital/institution volume-outcome measurements. The types of studies eligible for inclusion were randomized controlled trials (RCT), retrospective studies, and case-series reports (with at least 10 patients).

Outcomes of interest

The primary volume-outcome measurements that were of interest included short-term mortality/survival, adverse effects, hospital length of stay, and long-term survival (five-year optimal). Secondary outcomes of interest included costs (as reported in the jurisdiction where the trial was run), physician training, hospital/institutional requirements, and any diagnostic procedures used.

Search Details:
2006 – February 2014 (Medline Week 5)
2006- February 2014 (Embase Week 5)
Also searched: Cochrane library via OVID (CDSR [Feb 2014], CCTR [Feb 2014], and DARE [1st quarter, 2014).

Brief Summary/Discussion of New Evidence:

A total of 8,682 citations were identified from MEDLINE, EMBASE, CDSR, CCTR, and DARE via OVID. Of those, 169 were selected for full text review. A total of 72 met the inclusion criteria, 3 publications were irretrievable, and 94 publications were excluded.
Of the 72 identified publications, there were 4 publications of 4 systematic reviews. The remaining 59 publications were primary studies and 14 abstracts.

The results of the systematic reviews can be found in Table 1. Of the 72 identified publications, 65 publications of primary studies and abstracts that were not included in at least one of the identified systematic reviews (Table 1) can be found in Table 2, 3, and 4. Seven primary studies were included in at least one of the identified systematic reviews; the results of those studies are not reported here. Appendix 1 consists of a bibliography of those studies.

Clinical Expert Interest Declaration: None to declare

Table 1. Systematic reviews meeting inclusion criteria for EBS #17-2

Author, year, reference	Inclusion criteria	Methods	Intervention/ Comparison	Outcomes of interest	Brief results
van Heek 2005 Systematic review; data on Dutch nationwide registry Pancreatic resection for pancreatic and periampullary malignancy	All studies comparing mortality rates of patients w/PR between hospitals w/ diff volumes	**Systematic review:** Medline and Embase: 1966-2004 Cochrane library: 1996-2004 RR calculated for high vs low volume hospitals (using multiple cutoff points as data allowed) **Registry:** Data from 1994-2004, 4 time intervals ('94-'95, '96-'98, '99-'00, '01-'03)	Hospital volume (high vs low) **SR:** Categorized by cutoff values of high/low Four cutoff points defined: I: 2 PR/y II: 5 PR/y III: 10 PR/y IV: 20 PR/y **Registry:** 4 volume categories: <5, 5-9, 10-24, >25 PR/y	Hospital or 30-day mortality	***Systematic review*** 12 included studies, PR from 1984-1998, n=19,68 patients (b/w 130-7229 per study) ***Mortality (high vs low), RR*** Cutoff I: (6 studies) 6.6% vs 19.0%, RR 0.25-1.10 Cutoff II: (9 studies) 5.2% vs 12.6%, RR 0.29-0.76 Cutoff III: (7 studies) 3.8% vs 11.8%, RR 0.21-0.62 Cutoff IV: (2 studies) 2.2% vs 15.4%, RR 0.07-0.15 (12 studies included; 24 total analyses done usin as many cutoff points as available data allowed RR of 16/24 analyses statistically significan (p=0.05) ***Dutch registry data*** *Mortality in <5 vs >25* 94-95: 16.1% vs 1.5% 96-98: 15.9% vs 0.6% 99-00 and 01-03: Comparative mortality rate unchanged, exact numbers not given.
Gooiker 2011 Systematic review and meta-analysis Surgical treatment of pancreatic cancer	All studies measuring association between hospital or surgeon volume and clinical outcomes, for surgical treatment of pancreatic cancer; excluded single-hospital or surgeon studies, and used primary data (no SR)	Medline, Embase, Cochrane Library, search done on Feb 1 2010, also reference lists of relevant articles, and "related articles" on PubMed. MA: OR for mortality or HR for survival reflects odds of mortality in highest-volume vs lowest-volume group	Hospital or surgeon volume	Postoperative mortality (30-day, 60-day, in- hospital or postoperative mortality), or survival	***Systematic review*** 14 included studies, 11 hospital volume, 2 surgeo volume, one study had both Cutoff values varied: low-volume ranged from 1- procedures/year, high volume ranged from min 7 36 procedures/year ***Meta-analysis*** *Hospital volume and postoperative mortality* OR: 0.32 (0.16-0.64), RR: 0.16 (0.02-1.36), HR: 0.4 (0.35-0.56) *Surgeon volume and postoperative mortality* OR: 0.46 (0.17-1.26), HR: 0.49 (0.29-0.84) *Hospital volume and 5-year survival* HR: 0.79 (0.70-0.89)
Garcea 2009 Systematic review Hepatic surgery	Comparative studies of pre-/post-centralization data, Comparative studies of different	CINAHL, Clinical Trials Database, Current Contents Connect, Current Controlled Trials, EMBASE, medline, National Research Register, National health service	Centralization, hospital or surgeon volume	Mortality (hospital or 30-day), morbidity, duration of stay, resource utilization	10 studies included hepatic resection between 2003. N= 30,421 patients, between 293-16,582 per study Diagnoses: primary liver cancer, metastatic cancer other diagnoses (trauma, benign, infectious) ***Hospital Volume*** Significant heterogeneity in high/low definitions All studies showed improved outcomes for highe

	volume surgeons and/or hospitals as proxy	centre research and Dissemination, PubMed, Cochrane library 1997-June 2007 Also: grey lit			vs lower volume hospitals after adjustment for patient factors with logistic regression (numbers not given) ***Surgeon volume*** No studies reported on surgeon volume and outcome ***Overall survival*** One study showed overall survival advantage for high volume vs low volume after 3 years (P=0.02) ***Mortality*** 5/10 studies reported significantly lesser risk-adjusted mortality rate in higher vs lower volume hospitals, range 5.8-22.7% in low volume vs 1.5-9.4% in high volume ***Morbidity*** One study reported on this. Surgery at low-volume hospitals associated with increased risks of: reintubation RR, 2.5; 95% confidence inter9val [CI], 1.8--3.4), pulmonary failure (RR, 2.3; 95% CI, 1.6--3.5), pneumonia (RR, 0.35; 95% CI, 1.05-- 5.6), acute renal failure (RR, 2.0; 95% CI, 1.1-- 3.7), acute myocardial infarction (RR, 2.6; 95% CI 1.2--5.9), and aspiration pneumonitis (RR, 1.4; 95% CI, 0.9--2.0). ***Duration of stay*** 4/5 studies that reported this found significantly lesser postoperative hospital stay in high vs low volume hospitals ***Costs*** two studies reported; one found no difference between high and low volume hospitals, one study found that costs of resection in low-volume hospitals higher than in high volume

PR: pancreatic resection; RR: relative risk; MA: meta-analysis; OR: odds ratio; HR: hazard ratio;

See Appendix 1 for a list of identified studies that were included in at least one of the systematic reviews in Table 1. Please note that these studies were not included in Table 2.

Table 2. Pancreatic primary studies meeting inclusion criteria for EBS #17-2

Author, year, etc	Procedure and population	Methods	Intervention	Outcomes of interest	Brief results
Hospital volume					
Alsfasser 2012	Pancreatic surgery (for tumor or for chronic pancreatitis) Germany	Survey of German Society of General and GI surgery, info on pancreatic operations in 2006, 2008, 2009 Type of hospital, size/number of beds, number of PR	Hospital volume; university vs teaching vs other hospital *Volume cutoff** In 2006: 1-11, 12-17, 18-31, 32+ in 2008-9: 1-11, 12-18, 19-33, 34+	Mortality, reoperations,	Data received from 222 hospitals for 2006, 154 hospitals in 2008, 158 hospitals in 2009 Relative number of operations increased in university hospitals and decreased in teaching hospitals from 2006-2008 (p≤0.03) Chi-square values showed no difference between mortality rates for any of the volume categories, in any of the given years No difference between rates of reoperation for any volume category in any given year (p>0.08)
Allareddy 2007	Pancreatectomy (as one of several procedures studied)	Retrospective analysis of NIS 2000-2003 Multivariable logistic regression	Hospital volume *Volume cutoff:* Leapfrog threshold**	In-hospital mortality, spillover effect	Data on 4931 PAN available Overall in-hospital mortality for PD: 6.21% LV hospitals associated with higher odds for in-hospital mortality compared to HV: OR 2.09 (1.46-2.98) P<0.001 *Spillover effect*

			For ESO: cutoff is ≥13		Mortality OR for PAN compared against hospital volume cutoffs for CABG, PCI, AAA and ESO All non-significant except for ESO <u>OR of PAN mortality vs ESO HV criteria:</u> Met ESO: ref Did not meet ESO: 2.64 (1.63-4.30) No ESO: 3.18 (1.77-5.74)
Anderson 2012 , **Abstract**	Pancreaticoduod enectomy, bile duct resection, and combine liver bile duct section	Retrospective analysis of the US Nationwide Inpatient Sample database, 1998-2009	Hospital volume (high vs low), teaching/non-teaching	Rates of surgical treatment over time	N = 32 561 HV or teaching hospital more likely to receive surgical treatment (OR 1.3, p>0.001; OR 1.4, p<0.0001) and more surgery (OR 2.0, p<0.001; OR 2.3, p<0.001) Patients at HV or teaching hospitals were more likely to receive combined BD and liver resection, liver resection, or bile duct resection, compared to each less aggressive procedure (OR 1.2-6.6, p < 0.05
Balzano 2008	PD, Patients with pancreatic or periampullary disease [cancer], chronic pancreatitis Pancreatic cancer: 66.2% Other periampullary cancer: 23.5%	Bureau of Statistics, Italian ministry of health Inpatient discharge in Italy Logistic regression (OR adjusted for sex, payer, age, co morbidities and primary diagnosis)	Hospital volume *Volume cutoff:* 1-5, 6-13, 14-51, 89-104	Operative (hospital) mortality, length of stay	#PDs per volume category, lowest to highest: 518, 410, 455, 193 **Adjusted OR** *Highest category vs lowest:* OR 0.208 (0.082-0.526) OR significant for each volume category relative to the lowest volume category ***Length of stay*** Mean (sd) postoperative stay decreased from low- to very high-volume hospitals: 22.5 (15.7), 22.0 (15.1), 20.7 (14.4) and 18.4 (14.2) days respectively LOS at highest-volume hospitals significantly shorter than all other hospitals (P<0.001)
Bilimoria 2008	Patients 1994-1999 for 7 malignancies, including pancreatic	ROADS, in NCDB Cox proportional hazards, adjusting for sex, age, race, SES, stage, Charlson score, resection type, chemotherapy administration, radiation, and year of diagnosis	Hospital Volume *Volume cutoff:* No explicit cutoffs are given.	5 year survival rate	N = 13, 107 # hospitals per volume category (lowest & highest): 764, 37 Adjusted for Perioperative Mortality: 2.26 (1.78-2.86) Adjusted 5-year Survival : 1.22 (1.14-1.31)
Birkmeyer 2007	All patients 65-99, PR for cancer, years 1992-99	1992-2002 SEER-Medicare database Cox proportional hazards, adjusting for patient characteristics, censoring at end of follow-up (Dec 31, 2002) Adjusted: age, sex, race, year of procedure, acuity of admission	Hospital volume *Volume cutoff:* 0.3-2.0, 2.0-7.3, 8.3-135.5	5-year survival (or through to Dec 31, 2002)	# patients per volume category (lowest to highest): 286, 287, 282, respectively # hospitals per volume category (lowest to highest): 143, 59, 25 *Hazard ratio of mortality, high volume vs low* <u>Unadjusted</u> All patients: 0.77 (0.63-0.95) Survived surgery: 0.87 (0.71-1.05) <u>Adjusted for patient characteristics</u> All patients: 0.71 (0.58-0.87) Survived surgery: 0.78 (0.64-0.95)
Cox 2010 **Abstract**	PD or total PAN for malignancy	Statewide Planning and Research Cooperative hospital data between 2002 and 2007 (after regionalization). Logistic regression analysis. Same dataset was used in a previous study from 1984-	Hospital volume, Surgeon volume	Perioperative mortality, LOS	3051 procedures in 121 hospitals by 392 surgeons Overall perioperative mortality was 4.7%, which was lower than 15 years earlier (12.9%) 58.6% of cases performed at HV centers and 47.3% of procedures performed by HV surgeons *Mortality and surgeon volume:* HV 2.6%, moderate 4.0%, LV 9.9% *LOS and surgeon volume* HV 14.6, moderate 17.6 and LV 24.1 Compared to hospitals and surgeons with high caseloads, 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)

		1991 (before regionalization).			
de Wilde 2012	PD 100% cancer patients is implied, but not stated	Kiwa Prismant nationwide registry 2004-2009	Centralization, volume *Volume cutoff:* <5, 5-10, 11-19, ≥20 (but analyzed using Leapfrog cutoff)	In-hospital mortality	N=2156 patients ***Centralization*** Proportion of PD in centres ≥11 PD/y increased from 52.9% to 91.2% from 2004-2009 Mortality rate in <11 vs ≥11 hospitals was 11% vs 4.5% over 2004-2009 (p<0.001) *Volume vs Mortality, 2004-2009* OR , vs ≥20 category 11-19: 2.00 (1.23-3.25) 5-10: 3.22 (2.00-5.18) <5: 5.08 (2.84-9.07)
Ghaferi 2011	Pancreatectomy (cancer operation) – implied that all diagnosis codes were for cancer	Medicare Provider Analysis and Review files from 2005-2007 Risk-adjustment for age, sex, race, urgency, comorbidities Logistic regression	Hospital volume *Volume cutoff:* LV: <2 HV: >27	30-day or in-hospital mortality; Major complications; Failure to rescue (mortality following complication)	*Risk-adjusted mortality:* 3.1% vs 13.3% in HV vs LV hospitals ***Odds ratios*** Overall mortality: OR 4.85 (3.53-6.68) Major complications: OR 1.72 (1.39-2.13) Failure to Rescue: OR 3.21 (2.18-4.72)
Gasper et al. 2009	Pancreatic resection (as one of several procedures)	California Office of Statewide Health Planning and Development (OSHPD) patient discharge data	Hospital Volume *Volume cutoff:* No explicit cutoffs are given.	In hospital mortality	Of 8901 patients, 5294 patients had pancreatic cancer. Data split into 2- 5 year periods, 1995-1999 (period B) and 2000-2004 (period C) to compare to original data – 1990-1994 (period A). ***Risk Adjusted Mortality Rate*** HV: 3.5% (Period A), 1.8% (Period B), 1.5% (Period C) LV: 14.1% (Period A), 7.0 (Period B), 5.6% (Period C) ***Odds ratio*** Period A – N/A OR from low- to very high-volume hospitals (Period B): 7.60 (2.89 =20), 5.24 (2.05-13.40), 4.40 (1.73-11.2), 2.08 (0.70-6.22), 2.27 (0.83-6.25),1 OR from low- to very high-volume hospitals (Period C): 4.02 (2.42-6.66), 3.27 (1.86-5.77), 2.50 (1.50-4.15), 1.39 (0.80-2.42), 1.66 (0.94-2.91),1
Ho 2006	Whipple procedure (PD) for cancer	Statewide hospital discharge files for Florida, NJ, NY, 1988-2000. Three time periods: 88-91, 92-96, 97-00 Logistic regression, adjusting for clustering of patients within surgeons and surgeons in hospitals, as well as patient/hospital characteristics	Hospital procedure volume surgeon procedure volume *Volume cutoff:* No explicit cutoffs are given, volume may be treated as continuous	Inpatient mortality	8253 Whipple procedures performed ***Adjusted OR for inpatient mortality*** 1992-96: OR 0.97 (0.76-1.23) 1997-2000: OR 0.91 (0.71-1.17) Hospital volume (ln): OR 0.85 (0.74-0.97) Surgeon volume (ln): OR 0.80 (0.69-0.92)

<table>
<tr>
<td>Jensen 2007</td>
<td>Pancreaticoduodenectomy (Whipple procedure)</td>
<td>National Patient Registry and discharge information 1996-2004</td>
<td>Hospital procedure volume

Cut offs
<5, 5-20, >20</td>
<td>Length of stay, Hospital mortality</td>
<td># patients, 1996-2001 =363, 2002-2004 = 218
Length of stay (mean)
1996-2001= 24.5, 2002-2004 = 23.9
Hospital mortality
<table>
<tr><td></td><td>1996-2001</td><td>2002-2004</td></tr>
<tr><td><5</td><td>10.0 (3.3-21.8)</td><td>6.3 (0.2-30.2)</td></tr>
<tr><td>5-20</td><td>10.2 (7.0-13.4)</td><td>7.6 (3.7-13.7)</td></tr>
<tr><td>>20</td><td>-</td><td>5.6 (1.6-13.8)</td></tr>
</table>
</td>
</tr>
<tr>
<td>Joseph 2009</td>
<td>Pancreatectomy</td>
<td>2005 Leapfrog Group database and Health Grades Website</td>
<td>Hospital Volume

Part 1: Hospital cutoffs (very low to very high), 1-5, 6-10, 11-30, >30

Part 2 LV (< 10 a year), HV (>11 per year)</td>
<td>Mortality, system clinical resources,</td>
<td>N=434 hospitals
Clinical support factor:
<table>
<tr><td></td><td>Odds Ratio</td><td>P value</td></tr>
<tr><td>ICU staffing</td><td>1.76 (1-45-2.13)</td><td><.0001</td></tr>
<tr><td>Safe Practice Score</td><td>1.27 (1.05-1.52)</td><td>0.01</td></tr>
<tr><td>HeathGrades 5 start rating</td><td>1.48 (1.16-1.88)</td><td><0.001</td></tr>
<tr><td>General surgery residency</td><td>2.74 (2.21-3.40)</td><td><0.0001</td></tr>
<tr><td>Gastroenterology fellowship</td><td>3.85 (3.00-4.95)</td><td><0.0001</td></tr>
<tr><td>Interventional radiology</td><td>2.02 (1.64-2.47)</td><td><0.0001</td></tr>
</table>
Mortality
N=28 hospitals, LV = 19, HV =9
Volume OR 0.86 (0.60-1.24), ns
Cumulative system clinical support OR = 0.78 (0.73-0.87), p <0.001*
*non-significant results when 6 support factors were analyzed separately.</td>
</tr>
<tr>
<td>Kim 2011</td>
<td>Pancreatic resection, including PAN, Whipple's PD, and pylorus-preserving PD</td>
<td>HIRA claims database (2005-2006)
Logistic regression adjusted for age, sex, route of admission , type of health security , and comorbidity</td>
<td>Hospital Volume

Hospital cut offs not mentioned</td>
<td>mortality</td>
<td># patients 3,168
<u>Odds ratios associated with mortality</u>:
Very low =1
Low 0.58 (0.29-1.11), p=0.11
Medium 0.57 (0.29-1.08), p = 0.09
High 0.21 (0.08-0.49), p=0.0008
Very high, 0.24 (0.08-0.58), p <0.0037</td>
</tr>
<tr>
<td>LaPar 2012</td>
<td>Patients who underwent pancreatic resection in 2008.
This study also included esophagectomy, abdominal aortic aneurysm repair, and coronary artery bypass grafting.</td>
<td>Retrospective cohort from the HCUP-NIS (U.S.) comparing inpatient mortality by hospital volume.
Hierarchical generalized linear models, adjusted by patient age, gender, and comorbid disease: 3 models: 1) volume as linear effect; 2) volume using restricted cubic spline; 3) volume using quintiles.</td>
<td>Volume cutoffs:

NR</td>
<td>In-hospital mortality</td>
<td>Weighted total of 19,194 patients

In hospital mortality
Linear effect total:: LR = 3.24, p=0.0719
Quintile total: LR: 5.53, p=0.2371
Spline total: LR 4.59, p=0.2044</td>
</tr>
<tr>
<td>Learn, 2010</td>
<td>Patients aged 18 years or older who underwent pancreatectomy</td>
<td>Retrospective cohort from the HCUP-NIS (U.S.) from 1997 to 2006 comparing</td>
<td>Volume cutoff (annual)

High>9</td>
<td>Inpatient mortality</td>
<td>7542 patients
Inpatient mortality
Annual volume of procedures at treating hospitals: OR (per case): 0.97 95% CI 0.95-0.99, p =0.018</td>
</tr>
</table>

	for pancreatic cancer in the US. This study also included esophagectomy, gastrectomy, and major lung resection.	inpatient mortality between time periods, by hospital volume, by hospital type (teaching vs. non-teaching). Logit-linked generalized estimating equations adjusted using Elixhauser comorbidity index	Medium: 4-9 Low 1-3		Teaching vs non-teaching: OR= 0.68 95% CI 0.53-0.87, p =0.002
Lemmens 2011	Patients diagnosed with primary cancer of the pancreatic head, extrahepatic bile ducts, ampulla of Vater or duodenum.	Retrospective cohort from the Eindhoven Cancer Registry (Netherlands) from 1995-2000 and 2005-2008 comparing hospital volume and surgical volume and in-hospital mortality between time periods using Kaplan-Meier time series analysis.	Hospital Volume, Surgical Volume	In-hospital mortality,	2129 patients (1139 patients between 1995-2000; 990 patients between 2005-2008) ***Number and Proportion of Resections (%)*** 1995-2000 vs 2005-2008: 19.0 vs 30.0, p<0.001 ***In-hospital mortality:*** The in-hospital mortality rate dropped from 24% in 1995-2000 to 3.6% in 2005-2008 (p<0.001). In 2008, the in-hospital mortality rate was zero. Adjusted HR associated with mortality between time periods: 0.70 (95% 0.51-0.97)
McDade 2012 **Abstract**	Patients undergoing PR	Retrospective analysis using the Massachusetts Division of Health Care Finance and Policy data between 2005-2009 comparing the number of PR performed yearly in hospital death and LOS	Hospital Volume Leapfrog criteria (>11 per year)	Hospital LOS, in hospital death	N = 704 Majority resected at HV hospital (76%) Median LOS 8/- days, with LOS >1 week associated with LV hospitals (p = 0.0002) In hospital deaths LV 7 pts, 4.14% of 169 pts vs HV 7 pts, 1.31% of 535 pts, p= 0.0214
Mukherjee 2008	Patients with pancreatic pathologies who underwent a surgical procedure	Retrospective cohort from January 1999 to December 2006 comparing the number PDs performed yearly as well as grouping pre-Cancer Outcome Guideline (COG) and post COG, hospital stay and 30 day mortality and mean survival	Hospital Volume	Hospital LOS, 30 day mortality and mean survival	N = 140 patients 30 day operative mortality was 2.86% Median hospital stay was 16 days (7-318 days) **Mean Survival** Pancreaticductal adenocarcinoma : 24.8 months (95% CI 19.6-30.0) Bile duct cancer: 26 months (95% CI .76-34.3) Duodenal cancer: 33.26 months (95% CI 18.73-47.78) Ampullary cancer: 45.1 months (95% CI 28.7-61.64) Mortality decreased from 9.7% (pre-COG) to 5.0% (post-COG) (Fisher's exact test, p= .448; OR = 2.74 (95% CI 0.58-12.88). Morbidity decreased from 41.6% (pre COG) to 35.3% (post COG) (Fisher's exact test, p = 0.565 OR = 1.29 (95% CI, 0.74-3.56)
Nathan 2009	Patient > 18 years who underwent pancreatic resection between 1999-2005 This study also included hepatic resection (please see Table 3 for details).	Retrospective analysis from the Sate Inpatient Database between 1999 and 2005 comparing hospital and surgical volume and in patient mortality. Three level mixed effects logistic regression models	Hospital Volume, Surgery Volume Surgery volume cut off: LV 1-24 MV 25-124 HV 125-358	In patient mortality	N = 10,694 Overall mortality = 3.3% ***Mortality*** High Vs Low Hospital volume: OR 0.32, p<0.001 The effect of hospital volume did not persist after adjusting for surgeon volume (p = 0.28) High Vs Low Surgery volume: Or 0.30, p< 0.001 The effect of surgeon volume remained significant after adjusting for hospital volume (p<0.001)

Rangelova 2012 **Abstract**	PR	Retrospective analysis using the Swedish Patient Register comparing hospital volume effects on long term mortality after PR in Sweden between 1987 and 2008. Multivariate Cox regression analyses adjusted for age, sex, Charlson index, type of procedure, tumour location.	Hospital Volume Birkmeyer criteria : LV: 1-2 resections/yr; HV: >16 resections/year	Mortality, long term survival	N = 6101 pts Mortality Overall : HR 0.76; CI 0.67-0.85 90 day: HR 0.57; CI 0.42-0.77 5 year: HR 0.82; 0.71-0.95 Mortality decreased in HV compared to LV hospitals (p<0.01) Mortality (resections due to malignant disease) 90 day: HR 0.65, CI 0.45-0.93 5 year: HR 0.61, CI 0.39-0.93 Mortality further decreased in HV compare to LV hospitals (p = 0.01)
Reames, 2013 **Abstract**	Patients who underwent a pancreatic resection. This study also included: abdominal aortic aneurysm repair; aortic valve surgery, mitral valve surgery, coronary artery bypass, carotid endarterectomy, colon resection, and esophageal resection.	Retrospective cohort study using National Medicare claims data from 1998 through 2008 to compare operative mortality by hospital volume. Multivariate logistic regression models adjusted by patient characteristics.	Hospital Volume cutoffs: Hospitals were grouped into quintiles of operative volume. Cutoffs were NR.	Operative mortality	Operative mortality: 1998-1999: Adjusted OR: 5.46 (95% CI : 2.97-10.01) 2007-2008: Adjusted OR: 3.27 (95% CI: 2.31-4.62)
Riall 2008	Patients who underwent a pancreatic resection between 1999 and 2005	Retrospective analysis from the Texas Hospital Inpatient Discharge Public Use Data between 1999 and 2005 investigating variability among high-volume hospitals in comparison to mortality and length of stay	High Volume Hospitals	LOS, mortality	N patients = 2481 N HV hospitals = 12 Overall mortality was 2.8% Number of resections ranged at each hospital from 78-608 cases for the 7 years Significant HV hospital variability in mortality (range, 0.7% - 7.7%, p<.0001) Significant HV hospital variability in LOS (range of medians 9-21 days, p<.0001
Schmidt 2010	Patients who underwent a PD between 1980 and 2007	Retrospective analysis from the Indiana University Hospital between 1980 and 2007 comparing surgical volume, hospital volume, mortality and morbidity.	Hospital Volume, Surgeon Experience, Surgical Volume There was a steady increase in hospital volume, but a dramatic difference in 2003. Due to this, outcomes were analyzed before and after rapid increase in 2003. (i.e. Periods 1 and 2).	Mortality, morbidity	***Hospital Volume:*** Period 1 (1980-2003) N = 563, Mean 24/yr Period 2 (2004-2007) N = 440, Mean 110/yr Mortality: Period 1 vs 2 = 4% vs 2%, p = 0.04 Morbidity: Remained the same in both periods ***Surgeon Experience*** Experience surgeon = >50 PD during the two periods Less experienced surgeon: < 50 PD during the two periods Less experienced surgeons performed PD with comparable mortality (4% vs 3%) Experience surgeons had proportionally less morbidity (39% vs 53%, p =.001) ***Surgeon Volume*** Low volume <20/yr High volume >20/yr Mortality 4% vs 2%, p = 0.09 Morbidity 44% vs 38% = p = 0.07

<table>
<tr>
<td>Schneider 2013</td>
<td>Patients who underwent PD</td>
<td>Retrospective cross-sectional analysis from the Agency for healthcare Research and Quality Healthcare Costs and Utilization Project NIS dataset between 2003 and 2009 comparing length of stay , hospital volume, surgical volume, hospital teaching status and complications</td>
<td>Surgical Volume and Hospital Volume

Surgery Volume:
Low 1-4/yr
Med: 5-15/yr
High: >16/yr

Hospital Volume
Low 1-9 /yr
Med: 10-31/yr
High >32 /yr</td>
<td>LOS, Teaching Status, and medical complications</td>
<td>N = 25 464
Hospital Teaching Status
Hospital Volume : p<.001
Teaching: LV 59% MV 87.1% HV 100%
Non-teaching: LV 41.0% MV 12.9% HV 0%
Surgery Volume: P<.001
Teaching: LV 66.2% MV 88.6% HV 93.8%
Non-teaching: LV 33.8%, MV 11.4%, HV 6.2%
Medical Complications (adjusted, controlling for age, gender, comorbidity, hospital factors)
Hospital Volume, p <.001:
MV RR 0.88 (CI 95% 0.81-0.95)
HV RR 0.74 (CI 95% 0.67-0.82)
Surgeon Volume, p<.001:
MV RR 0.56 (CI 95% 0.41-0.78)
HV RR 0.46 (CI 95% 0.29-0.79)
Length of stay
Median 13, mean 16.7 days
Teaching vs non-teaching (median) 12 vs 16 days p <.001
Hospital volume, p<.001
MV RR 0.88 (CI 95% 0.81-0.95)
HV RR 0.74 (CI 95% 0.66-0.91)
Surgeon Volume, p<.001
MV RR 0.67 (95% CI 0.62-0.73)
HV 0.67 (CI 95% 0.60-0-74)</td>
</tr>
<tr>
<td>Schneider 2013
Abstract</td>
<td>Pancreatic Cancer patient's undergoing PD</td>
<td>Retrospective analysis using the NIS database to compare variation in LOS after PD for pancreatic cancer at the patient, surgeon and hospital levels between 2003-2009</td>
<td>Hospital Volume

Surgeon Volume

Surgeon terciles low 1-4; medium 5-15; high >16

Hospital terciles: low 1-9; medium 10-31; high >32</td>
<td>Morbidity, mortality, LOS,</td>
<td>N = 5,190
Median LOS: 13 days
Surgeon volume
Median annual surgeon volume= 8, range 1-54 procedures
Associated with median LOS (low-16 days, med-11 days, high-12 days, p<0.001)
Hospital volume
Median annual hospital volume = 18 (range 1-129)
Associated with median LOS (low-16 days, med-11 days, high-11 days, p<0.001)
Patients operated on by HV surgeons (RR=0.67) or at HV hospitals (RR=0.75) had reduced risk of a LOS that exceeded the median (both P<0.001).</td>
</tr>
<tr>
<td>Skipworth, 2010</td>
<td>Patients' undergoing pancreatectomy (PAN) between 1982 and 2003

This study also included hepatic resection (details below).</td>
<td>Retrospective analysis of post-operative in-hospital records and mortality data between 1982 and 2013 from the Information Services Division (ISD) Scotland investigating hospital volume and in-hospital mortality.</td>
<td>Hospital volume

In Scotland, few hospitals are likely to reach criteria for HV according to international standards. For this study, data from all hospitals across the 22 years were analyzed independently to derive "hospital-years", ie one hospital would have 22 associated hospital year mortality rates if it performed a resection every year for the</td>
<td>In hospital mortality

Death during the admission for which the patient underwent surgery and was not risk adjusted.</td>
<td>N = 61 hospitals, 10,625 all patients, 1014 PAN
In hospital mortality (1982-2003) = 8.1%
Annual PAN (1982-2003) –from 0.31 per 100,000 to 1.60 (chi square p<0.001).
Hospital Volume:
The number of centres performing PAN remained relatively static over the 22 year study period (Approx 11 hospitals per year).
The percentage of PAN performed in the highest-volume centres increased significantly (1982 – 0.0% - 2003 – 88.9%, p <0.001)
Mortality Rates:
<table>
<tr><td></td><td>Resection /yr</td><td>Resection (N)</td><td>Death (N / %)</td></tr>
<tr><td>Q1</td><td>1</td><td>97</td><td>17/ 17.5%</td></tr>
<tr><td>Q2</td><td>2</td><td>102</td><td>11 /10.8%</td></tr>
<tr><td>Q3</td><td>3-5</td><td>133</td><td>7 / 5.3%</td></tr>
<tr><td>Q4</td><td>>6</td><td>682</td><td>47 / 6.9%</td></tr>
</table>
Postoperative in hospital mortality decreased as quartiles of hospitals increased (chi square p = 0.002.</td>
</tr>
</table>

			entire study period.		OR of in hospital death was significantly reduced (OR = 0.35; 95% CI 0.19, 0.64, p< 0.001)
Stitzenberg, 2010	Patients 18 years of age or older who underwent pancreatic procedures between 1999-2007 Also looked at esophagus, colon and rectum.	A retrospective observational study from NIS between 1999-2009 examining trends in hospital procedure volume for pancreatic cancer procedures.	Hospital volume Hospital volume cut points were created by dividing 1999 population cases into 3 equal-sized groups on the basis of procedure volume of the treating hospital in 1999. LV 1-6, MV 7-26, HV >26	Mortality. Teaching hospital, payer, admission type	*N = 17, 658* ***Hospital Volume :*** Decrease in total number of hospitals performing pancreas procedures from 1999-2007, but a significant increase in HV (1999 = 38 vs 2007 = 101, p = 0.003). Proportion of procedures in LV in 2007 was significantly less than in 1999 (OR = 0.40, 95% CI 0.35, 0.46). Hospitals that were HV for one disease site tended to be HV for other disease sites (i.e. high correlations = esophagus: pancreas 0.557; pancreas: colon 0.439; pancreas: rectum 0.545). HV centers were likely to be teaching hospitals (e.g pancreas 100%, p<0.001). ***Admittance:*** 16.9% of all patients were admitted through emergency room (8.3% pancreas). This was associated with higher likelihood of surgery at LV center
Swan 2011 **Abstract**	Patients undergoing PD for pancreatic cancer	A retrospective comparative study from the NC Hospital Based And Freestanding Ambulatory Surgery Facility Database between two time periods 2004-2006 and 2007-2009. Regionalization of center in late 2006. Chi Square and Fisher's Exact Test	Hospital Volume Low (1-9 PD/yr), Med (10-19 PD/yr), High (>20 PD/yr)	Mortality, Morbidity	2004-2006 N (LV-HV) = 62, 80, 129 2007-2009 N (LV-HV) = 58, 46, 246 % of PD at HV increased significantly (47.6% to 70.3%), while decreasing for MV and LV centers, p<0.001 Mortality was less at HV (2.8%) compared to LV (10.3%) for the 2007-2009 timeframe (p=0.038). Non-significant across periods for any group. Overall mortality decreased from 6.6% to 4.6% across time periods (p = 0.31) Major morbidity at LV centers increased (p = 0.018). Morbidity was not significantly different between volume groups within either time period.
Topal 2008	Patients undergoing PD in 126 hospitals between 2000-2004	Retrospective analysis from the Federal Ministry of Public Health of Belgian hospitals of in-hospital death (surgery related or not) and length of stay after PD from 2000-2004	Hospital Volume Cut off quintiles: 1-2. 3-5, 6-10, 11-20, >20	Hospital mortality; hospital stay	*126 hospitals, 1794 patients* *Mortality:* Cut offs / # PD / OR 1-2 / 352 / 1 3-5 / 480 / 0.883 (0.535, 1.469) 6-10 / 187 / 0.931 (0.488, 1.788) 11-20 / 358 / 0.487 (0.259, 0.911) >20 / 417 / 0.409 (0.221, 0.774) Difference between 5 volume categories (p = 0.011) Difference between <10 PD/yr (10.7%) vs >10 PD/yr (5.4%; p <0.001) Overall hospital mortality : 8.4% Overall hospital days was 21.6 (range 3-117)
Yun 2012	Patients 20 years or older with pancreatic cancer undergoing surgery. Also looked at stomach, colon, rectum, lung and breast cancers	Population-based retrospective cohort analysis from the Korean Central Cancer Registry of hospital volume, From 2001-2005	Hospital volume Tertiles: high, med, low. Based on mean number of procedures (NR) Recategorize for sensitivity analysis (binary): Leapfrog Group (11 cases/yr)	5 year survival, Patient wait times	Total N= 147, 662; Pancreatic pts = 2,309 ***5 year Survival and Hospital Volume*** Overall survival for pancreatic 16.2%, Unadjusted HR = 1.49 (95% CI 1.34-1.66), Adjusted* HR = 1.26 (95% CI 1.11-1.43) *adjusted for age, sex, Charlson scale, hospital type, insurance, radiotherapy, chemotherapy, type of medical care institution, year of diagnosis and treatment delay or hospital volume ***Overall survival, surgical treatment delay and hospital volume (sensitivity analysis)*** HV and >31 day: adjusted HR = 1.07 (0.84-1.36) LV and 31 day: adjusted HR = 1.21 (1.08-1.36) LV and >31 day: adjusted HR = 1.60 (1.33-1.92)

<table>
<tr><td>Zarate, 2011
Abstract</td><td>Patients undergoing PAN</td><td>Retrospective analysis of 24 hospitals in Queensland from 2000-2007
Cox proportional hazards regression model adjusted for comorbidity and other characteristics</td><td>Hospital Volume Cut offs:
Low <3
Medium 3-6
High >6</td><td>In patient mortality, 2 year survival rates</td><td>N = 410 patients
Mortality (low-high) = 8.1%, 3.1%, 1.4%
Relative to HV, inpatient death was 5.7 times higher (95% CI 1.3-26.2) in LV
LV were 1.5 times more likely (95% CI 1.1-2.0) to die within 2 years compared to HV</td></tr>
<tr><td colspan="6">Hospital Other</td></tr>
<tr><td>Bilimoria 2007</td><td>Patients 1985-2004, pancreatectomy and other pancreatic surgeries</td><td>ROADS and FORDS, in NCDB
Cox proportional hazards, adjusting for sex, age, race, SES, stage, grade, resection type</td><td>Veterans Affairs hospitals versus non-VA hospitals (academic, community)</td><td>60 day mortality, 3 year survival</td><td>60-day mortality
<u>Adjusted HR, versus VA hospital</u>
Academic: 0.71 (0.41-1.24), p=0.23
Community: 0.80 (0.45-1.40), p=0.43
3 year survival
<u>Adjusted HR, versus VA hospital</u>
Academic: 1.63 (0.42-6.24), p=0.48
Community: 2.34 (0.6-9.2), p=0.22</td></tr>
<tr><td>Gooiker 2011</td><td>Patients with pancreatic surgery for malignancy of pancreas, duodenum, ampulla of Vater, hepatic bile duct</td><td>Comprehensive Cancer Centre West (western part of Netherlands), patients from Jan 1 1996 to Dec 31 2008
Three time periods:
1996-2000
2001-2005
2006-2008

Quality standards implemented in 2001, centralization in 2006
Crude outcomes only</td><td>Year of surgery</td><td>30 day mortality
90 day survival
1 year survival
2 year survival</td><td>Crude mortality outcomes (%)
<table>
<tr><td colspan="5">All pancreatic malignancies</td></tr>
<tr><td></td><td>1996-2000</td><td>2001-2005</td><td>2006-2008</td><td>p</td></tr>
<tr><td></td><td>N=85</td><td>N=89</td><td>N= 110</td><td></td></tr>
<tr><td>30-d</td><td>8</td><td>0</td><td>2</td><td>n/a</td></tr>
<tr><td>90-d</td><td>88</td><td>97</td><td>96</td><td>0.03</td></tr>
<tr><td>1-y</td><td>65</td><td>65</td><td>74</td><td>0.31</td></tr>
<tr><td>2-y</td><td>39</td><td>40</td><td>55</td><td>0.09</td></tr>
<tr><td colspan="5">Pancreatic adecnocarcinoma only</td></tr>
<tr><td></td><td>N=72</td><td>N=71</td><td>N=98</td><td>p</td></tr>
<tr><td>30-d</td><td>7</td><td>0</td><td>2</td><td>n/a</td></tr>
<tr><td>90-d</td><td>89</td><td>96</td><td>96</td><td>.12</td></tr>
<tr><td>1-y</td><td>64</td><td>56</td><td>71</td><td>.13</td></tr>
<tr><td>2-y</td><td>38</td><td>28</td><td>49</td><td>.04</td></tr>
</table></td></tr>
<tr><td>Merkow 2013</td><td>Patients who underwent a pancreatic resection with oncologic intent</td><td>Retrospective analysis from the American College of Surgeons National Surgical Quality Improvements Program between January 1, 2007 and December 31, 2011, comparing National Cancer Institute Cancer Centers (NCI-CC) and Non NCI CC and 30 days morbidity, mortality and prolonged LOS

Colorectal and Esophagogastric Surgery were also investigated.
Logistic Regression Model</td><td>NCI-CC vs Non NCI-CC</td><td>30 day morbidity, 30 day mortality, prolonged LOS</td><td>259 centers and 1,838 patients
NCI-CC Versus Non-NCI
Unadjusted OR (95% CI)
Mortality OR 0.74 (0.58-0.94), p<0.05
Serious morbidity OR 0.87 (0.80 -0.94), p <0.05
Prolonged LOS OR 0.66 (0.61-0.71), p<0.05
Risk-adjusted OR (95% CI)
Mortality OR 0.79 (0.60-1.05), p = ns
Serious morbidity OR 0.85 (0.73-1.00), p = ns
Prolonged LOS OR 0.54 (0.40-0.74), p < 0.05</td></tr>
<tr><td colspan="6">Surgeon volume</td></tr>
<tr><td>Balzano 2010; abstract</td><td>Patients undergoing PD</td><td>Retrospective analysis of surgeon</td><td>Surgeon volume</td><td>Operative mortality (30</td><td># patients: 610
Mortality: HVS 3.9% vs LVS 4.3%, ns</td></tr>
</table>

	from August 2001 to August 2009	volume in a single high-volume institution	*Volume cutoff (median):* Low ≤18 High ≥18	day post discharge), morbidity, postoperative stay	*Morbidity:* HVS 56.6% vs LVS 67.7%, p= .03 Severe complications (grade 3b-5): HVS 9.8% vs LVS 10.4%, ns Mild complications (1-3a): HVS 46.8% vs LVS 57.4%, p = 0.01 Median postoperative stay: HVS 13 days vs LVS 14 days (p = 0.04)
Boudourakis 2009	Patients ≥18, pancreatectomy with primary diagnosis of cancer	Cross-sectional analysis, comparing 1999 and 2005 discharge information from HCUP-NIS administrative database	Surgeon volume *Volume cutoff:* Low: ≤1 High: ≥5	Inpatient mortality, LOS	#patients: 1999: 306, 2005: 275 Unadjusted outcomes *Mortality (%)* 1999: HV: 2.5, LV: 10.3, p<0.05 2005: HV: 2.5, LV: 9.0, p=ns *LOS (mean d)* 1999: HV 13.3, LV: 20.6, p<0.001 2005: HV 13.6, LV: 24.1, p<0.001
Eppsteiner 2009	PR (distal pancreatectomy and PD) Any cause, malignancy =68% patients	Retrospective analysis using NIS discharge records, 1998-2005 Logistic regression (adjusted, propensity matching)	Surgeon volume; hospital volume *Volume cutoffs:* Surgeon: ≥5 HV Hospital: Leapfrog (≥11)	In-hospital Mortality	N= 3581 PR *Adjusted Mortality* LV vs HV surgeon: 6.4% vs 2.4%, p<0.001 Hazard ratios associated with mortality: HV hospital: HR 0.55 (0.32-0.97), p=0.04 HV surgeon: HR 0.49 (0.28-0.83), p=0.009 Malignant diagnosis: 1.19 (0.68-2.10), p=0.54 Teaching hospital: 0.93 (0.59-1.48), p=0.77
Hyder 2013	Pancreatectomy patients with available physician and hospital specific data	Retrospective analysis using SEER Medicare-linked database, 1998-2005 Logistic regression	Surgeon volume; hospital volume; *Volume cutoff:* Surgeon quartiles: very-low (1-2/yr); low (3-6/yr), medium (7-20/yr) and high (21-84/yr) Hospital quartiles: very low (1-4/yr), low (5-12/yr), medium (13-24/yr), and high (25-53/yr).	In-hospital morbidity, mortality, length of stay	# patients 1488 *Length of stay (median)* Very LV hospital vs HV hospital 17 days vs 13 days (p<0.001). Very LV surgeon vs HV surgeon 18 days vs 12.5 days (p<0.01). *90 day mortality (%)* Very LV hospital vs HV hospital: 17.2% vs 8.0% Very LV surgeon vs HV surgeon: 16.7% vs 7.7%
Kennedy 2010	PD	Providence Portland Healthy System electronic hospital record system and pancreatic database, Jan 2005- June 2008 T test(two tailed), Chi square, Logistic and linear regression	Surgical volume *Cut offs* HV ≥ 10 PD per year, LV < 9 PD per year	Mortality, Major Complications, Length of Stay, Total Cost	# patients: 94 Unadjusted outcomes *Mortality (%)* HV: 2.2, LV: 16, p=0.024 *LOS (median/mean)* HV 10/112.6/1, LV: 13/15.4, p=0.008 *Major Complications (%)* HV: 18, LV 44, p = 0.003 *Median total cost ($)* HV: $27,185, LV $33,007, ns
Kim 2012,	PD	Health Insurance Review and Assessment Service (2005-2008) T-test, Chi square, logistic regression	Surgical volume Quintiles, very-low, low, medium, high and very high	Hospital mortality (adjusted for risk factors: sex, age, admission route, general condition, SES	# patients: 4975 Unadjusted outcomes *Hospital volume (%) Very low-very high:* <10, 10-18, 19-35, 54-111, 215, p =ns Odds ratios associated with mortality: *HV, OR= 0.13 (0.05-0.32), <0.001* *Very HV OR = 0.16 (0.06-0.41), p<0.001*
Nienhuijs 2010	PR	Prospective cohort study comparing operative mortality, morbidity and surgical volume	Surgical volume	Mortality, morbidity	*Period A N = 82 Period B N = 76* *Morbidity* *Post-operative complications* A Vs B: 59 (71.9%) vs 26 (34.2%), p<0.001 *Re-operations*

		before regionalization (Jan 1995- April 2000) and after (July 2005- July 2009) Fisher's exact test			A Vs B: 31 (37.8%) vs 14 (18.4%), p = 0.008 *Intra-operative complications* A Vs B: 8 (9.8%) vs 3 (3.9%), p = 0.214 *Mortality* A Vs B: 20 (24.4%) vs 2 (2.6%), p< .0001
Pal 2008	Patients who underwent PD This study also included liver resection (details below)	Retrospective analysis from the Hospital Episode Statistic data between 1999-2005 comparing surgical volume and mortality. Data was divided into two cohorts (1999-2002, 2002-2005) in relation with the release of COG guideline.	Surgical Volume Quartiles: Very Low 1-43, Low 46-77, Medium 81-144, High 173-317	30 day mortality	*N = 3,378 pts, N= 159 centers* *% Mortality* 1999-2002: 6.2% 2002-2005: 5.7 % % Mortality in Quartiles (very low-high) 6.5, 8.0, 5.4, 3.8 % Mortality by volume (low vs high) 7.2% vs 4.5% OR = 1.60 (1.10 to 2.41) p = 0.016
Pecorelli 2012	Patients who underwent PD in a single high volume institution	Retrospective analysis from a electronic pancreatic surgery database between August 2001 and August 2009 comparing surgical volume, operative mortality and length of stay	Surgical volume The cutoff value to categorize high-volume surgeons and low volume surgeons was defined as 12 procedures per year	Operative mortality, LOS	*N = 610 patients* No difference between HVS and LVS groups was found in operative mortality (HV 14 vs LV 11, p = 0.84) and LOS (HV 13(7-102) vs LV 14 (7-73), p = 0.11)
Rosemurgy 2008	Patients who underwent a PD	Retrospective analysis from the State of Florida Agency for Health Care comparing PD undertaken over a 33 month period between January 1 2003 and September 30 2005 comparing surgical volume, average LOS, and in hospital mortality. Also compared with a previous report dataset conducted over 33 month period from January 1 1995 through September 30 1997	Surgical Volume Surgeons were grouped by the number of PD performed over 33 months. 1-3 PD (1 or fewer a year), 4-9 PD (1-3 per year), 10-16 PD (4-6 per year) or 17 or more PD (i.e. more than one every other month).	In hospital mortality, Average LOS	*# Surgeons, #PD over 33 months* 1995-1997 = 282, 698 2003-2005 = 266, 1314 88% increase in the number of PD with 6% fewer surgeons in 2003-2005 *Average LOS* 1995-1997= 21 days, 2003-2005= 16 days Average LOS was inversely related to the frequency with which surgeons undertook PD in 1995-1997 (p=0.03) and in 2003-2005 (p=0.001, Spearman regression). *In hospital mortality* 1995-1997 5.1%, 2003-2005 = 5.9%, p= 0.45 In both 1995-1997 and 2003-2005, in hospital mortality inversely related to frequency with which surgeons carried out PD (p=0.001)
Waljee, 2006	Patients aged 65- 99 who underwent PAN Study also invested coronary artery bypass grafting, elective abdominal aortic aneurysm repair, aortic valve replaced, carotid	Center for Medicare and Medicaid Services, 1998-1999	Surgeon's age Surgeon volume, hospital volume Cutoffs: NR	Operative mortality	Total N 460,738 *Operative death & Surgeon Age* *Adjusted for Patient Characteristics (severity, race, gender, age):* <40 years vs >61 Years = OR 0.91 (95% CI 0.63-1.31) vs OR 1.39 (95% CI 0.85-2.27) *Adjusted for Patient and Provider Characteristics (surgeon volume, hospital volume, and hospital teaching status):* <40 years vs >61 Years =OR 0.88 (95% CI 0.62-1.24) vs 1.67 (95% CI 1.12-2.49)

Practice setting according to surgeon age					
		<40	41-50	51-60	>60

	endarterectomy, esophagectomy, lung resection, cystectomy.				Surgeon volume: Low 36.3 33.6 36.8 38.5; Med 34.9 31.7 26.7 21.1; High 28.8 34.7 36.6 40.5; Hospital volume: Low 31.4 30.7 35.0 31.3; Med 37.4 41.0 29.8 22.2; High 31.2 28.3 35.2 46.4; Teaching hospital: Yes 48.0 50.0 47.9 60.4
Surgeon other					
Clark 2010	PD, % cancer diagnosis not specified	Florida Agency for Healthcare Admin Database, Jan 2002-Dec 2007 Chi-square and Mann-Whitney U tests	Surgical residency training programs	In-hospital mortality, LOS	#patients: 2345 <u>Training vs Non-Training</u> *Mortality* 2.7% vs 11%, p<0.001 *Median Length of stay (range)* 12 days (1-197) vs 17 days (1-85), P<0.001
Dai 2011, **Abstract**	Patients undergoing PD for periampullary cancer	Prospective analysis between pancreatic specialty group and non-pancreatic group in a tertiary teaching hospital between January 1986 to August 2010	Pancreatic Specialty vs non-pancreatic	Mortality	Total N 790 , specialty group N = 610, non-specialty group N = 180 *Mortality* Specialty (1.1%) vs non-specialty (2.8%), p=0.221
Minami 2011 **Abstract**	Patients undergoing PD in a medium-scale hospital	Prospective analysis of a medium scale hospital (10 PD/yr) comparing young trainees and skilled surgeons between 2006 and Jul 2010.	Surgeons skill level (<6 after medical school vs >6 years medical school)	Hospital stay	Trainee N = 17, skilled N = 35 Hospital stay 29.2 + 13.5 (range 12-60) vs 23.8 +12.1 (range 11-54), ns NS difference in operation complications and operation time
Wellner, 2011 **Abstract**	Patients undergoing pancreatic surgery	Over the 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. The study was held in a high volume center	Surgeon experience	Mortality, morbidity	Total surgery N 583 (N = 245 for 2 SPS, N = 212 JPS) 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 surgeries Mortality rate – 4% to 0%, p=ns

*Volume cutoffs: all studies defined different cutoffs for volume levels (usually data-driven to create quartiles or quintiles). Numbers given represent the numbers of resections/operations used to define the study's volume categories.

**Leapfrog thresholds: ≥11 for pancreatic resection

PR: pancreatic resection; GI: gastrointestinal; PAN: pancreatectomy; PD: pancreaticoduodenectomy; NIS: Nationwide Inpatient Sample of the Healthcare Cost and Utilization Project; LV: low volume; HV: high volume; LOS: length of stay; HR: hazard ratio; ROADS: Commission on Cancer's Registry Operations and Data Standards; FORDS: Commission on Cancer's Facility Oncology Registry Data Standards; NCDB: National Cancer Database; SES: socioeconomic status; HCUP-NIS: Health care utilization project national inpatient sample; ESO: esophagi ectomy; CABG: coronary artery bypass graft; PCI: percutaneous coronary interventions; AAA: elective abdominal aortic aneurysm repair; ln: natural log;

Table 3. Hepatic primary studies meeting inclusion criteria for EBS #17-2

	Procedure and population	Methods	Intervention	Outcomes of interest	Brief results
Hospital volume					
Dixon 2009	Hepatic resections, any cause (51.9% cancer-related,	Calgary Health region administrative data, from 1991/92 to 2003/04	Regional volume of LR	Operative mortality (death before discharge);	From 1991-2004, 424 LR Over time (from 1991-2004) steady decrease in annual mortality rate (prior to 2000, mortality rate 9.7%, afterward, dropped to 4.1%, p=0.020),

	primary or metastatic)	Crude mortality rates using chi-squared, ANOVA, or Kruskal-Wallis			corresponding to increase in overall volume of LR in CHR (figure 5)
Gasper et al. 2009	Hepatic resection (as one of several procedures)	California Office of Statewide Health Planning and Development (OSHPD) patient discharge data	Hospital Volume *Volume cutoff:* No explicit cutoffs are given.	In hospital mortality	Of 8901 patients, 1203 patients had pancreatic cancer. Data split into 2- 5 year periods, 1995-1999 (period B) and 2000-2004 (period C) to compare to original data – 1990-1994 (period A). *Risk Adjusted Mortality Rate* HV: 9.4% (Period A), 4.4%% (Period B), 2.8% (Period C) LV: 22.7% (Period A), 8.6%(Period B), 5.6% (Period C) Period A – N/A OR from low- to very high-volume hospitals (Period B): 4.32 (2.10-8.86), 3.53 (1.64-7.60), 0.47 (0.12-1.86), 1 OR from low- to very high-volume hospitals (Period C): 2.26 (0.94-5.41), 2.87 (1.24-6.61), 0.60 (0.22-1.62)
Lin, 2009	Patients with primary liver malignancy and underwent hepatectomies	Retrospective study from the Taiwan National Health Insurance Research Database and the Cause of Death Data File (Taiwan Department of Health), comparing hospital and surgical volume on 5 year survival.	Hospital volume, Surgeon volume Surgeon volume: low ≤ 19, medium 20-95, ≥ 96 cases Hospital Volume: low ≤ 87 cases, medium 88-298, ≥ 299 cases	5 year survival	N = 2799 patients <u>Hazard ratios associated with 5 year survival</u>: ***Unadjusted surgical volume:*** Low HR 1.516 (1.349-1.704), p<0.001 Med: HR 1.203 (1.066-1.357), p<0.01 ***Adjusted surgical volume:*** Low HR 1.411 (1.232-1.617), p<0.001 Med HR 1.189 (0.871-1.620), p ns ***Unadjusted hospital volume:*** Low: HR 1.335 (1.191-1.496), p<0.001 Med HR 0.925 (0.819-1.045), p ns ***Adjusted hospital volume*** Low: HR 1.211 (0.832-1.751), p ns Med: HR 1.110 (0.834-1.452), p ns
McKay 2008,	Patients 18 years or older who underwent hepatic resection	Retrospective study from Calgary and Capital health regions records from the years 1991-1992 to 2003-2004, comparing hospital and surgical volume, and surgical training on mortality Hierarchical Multilevel Regression	Hospital Volume, Surgeon volume, Surgeon Training Surgeon volume cutoff: HV >5, LV <5 Hospital volume cutoff (median): HV >24, LV <24	Operative mortality	# Patients = 1107 Average LOS – 13.5 (median 9 days, range 1-154 days), no different by either surgeon training or volume In-hospital mortality rate of 6.0% *Percentage of mortality rate in* Hospital HV vs LV 5.6% vs 13.6%, p =.0334 Surgeon HV vs LV 4.8% vs 10.9%, p=.0009 Surgeon training, p = .0032 Hepatopancreaticobiliary 4.6% Surgical oncology 6.3% Other subspecialty 7.2% General surgeons 15.3%
Nathan 2009	Patients who underwent hepatic resection between 1999-2005 This study also include pancreatic resection (please see Table 2).	Retrospective analysis from the Sate Inpatient Database between 1999 and 2005 comparing hospital and surgical volume and in patient mortality. Three level mixed effects logistic regression models	Hospital Volume, Surgery Volume	In patient mortality	N = 6,871 Overall mortality = 3.1% *Mortality* High Vs Low Hospital volume: OR 0.48, p = 0.04 High Vs Low Surgery volume: OR = 0.74, p = 0.42
Scarborough 2008	Patients 18 years or older who underwent	Retrospective analysis from the Nationwide Inpatient Sample	Year of Study	Hospital Volume, Annual Surgeon Volume,	*Surgical Volume* Shift of patients from lower-volume surgeons to higher volume surgeons from 1988-2003.

	a hepatic resection between 1988 and 2003	database between 1988 and 2003 comparing 4 time periods, hospital volume, annual surgeon volume, and postoperative mortality. 4 time periods: 1) 1988-1991 1992-1995 1996-1999 2000-2003		Postoperative mortality *Surgical Volume* Low 1/yr Low-int 2/yr Int 3-5/yr High int 6-16 /yr High >17/yr *Hospital Volume* Low <2/yr Low-int 3-7/yr Inter 8-17/yr High-int 18-44/yr High > 45/yr	Low Volume – Period 1 vs 4: 53.9% vs 29.5%, p< .0001 High Volume – Period 1 vs 4: 10.4% vs 25.8%, p<.0001 *Hospital Volume* Increasing percentage of patients had their hepatic resections performed in higher volume hospitals during 15 year study period. High volume- Period 1 vs 4: 2.7% vs 29.9%, p<0.0001 Low volume- Period 1 vs 4: 61.6% vs 30.7%, p<.0001 Postoperative mortality have decreased significantly with time, from 10.0% in period ! to 4.7% in period 4 (p<0.001 after adjusting for patient age, gender, race, income, and co morbidity.)
Simunovic 2006	Patients who underwent livery procedure related to cancer diagnosis between 1990-1995 Study also looked at breast, colon, lung, esophagus	Retrospective analysis from the Ontario Cancer Registry between 1990-2000 comparing hospital volume, in hospital operative mortality, and hospital teaching status	Hospital volume HV- greater or equal to 23 LV less than 23	Hospital Teaching Status, in hospital operative mortality	N = 362 *In hospital operative mortality* Hospital Volume: LV= HR 6.7% vs HV 0.5%, p <.01 OR 7.1 (95% CI 0.5-99.7), p =0.15 Non-Teaching Status- HR 0.4 (95% CI 0.1-1.9), p = 0.22 *Long term survival* Hospital Volume : HR = 1.7 (95% CI 1.0-2.7), p =0.04 Teaching Status: HR = 1.0 (95% CI 0.6-1.5) p = 0.97
Simunovic 2010	Patients 20 years and older who underwent pancreatic resection between 1994 and 2004 in Ontario and Quebec, Canada.	Retrospective analysis from the Canadian Institute of Health Information database from 1994 -2004 comparing hospital volume and operative mortality	Hospital Volume HV greater or equal to 10 procedures in a given calendar year	Operative Mortality adjusted for increases in provincials case numbers over the 11 year study period, expected due to an aging population and potentially improved access to surgery	N = 1895 Ontario (ON) , 1396 Quebec (QC) *Provincial Rates* *Cases performed HV (1994 vs 2004)* ON: 33% vs 71% QC: 36% vs7.6% *Operative mortality-* ON: 10.4% vs 2.2% QC: 7.2% vs 9.8% Over the years 1994-2004, the slope of the log rate for regionalization of surgery to HV hospital increased significantly for ON (.08, p<.001) and QC (.07, p<.001). For periods 1994-1999 versus 2000-2004 and for regionalization to HV hospital, in the second period the mean log rate was significantly higher in ON and QC (0.41, p<.001 and .38, p<.001. **HV vs LV Hospital** ON= OR = .46 (95% CI 0.29-0.72), p<.001 QC= OR = .63 (95% CI 0.35-1.13, p =.12)
Skipworth, 2010	Patients' undergoing hepatectomy between 1982 and 2003 This study also included pancreatectomy (details above).	Retrospective analysis of post-operative in-hospital records and mortality data between 1982 and 2013 from the Information Services Division (ISD) Scotland investigating hospital volume and in-hospital mortality.	Hospital volume In Scotland, few hospitals are likely to reach criteria for HV according to international standards. For this study, data from all hospitals across the 22 years were analyzed independently to derive "hospital-	In hospital mortality Death during the admission for which the patient underwent surgery and was not risk adjusted.	*N = 61 hospitals, 10,625 all patients, 757 Hepatectomy* *In hospital mortality (1982-2003) = 3.2%* *Annual hepatectomy (1982-2003) –from 0.02 per 100,000 to 1.56 (chi square p<0.001).* *Hospital Volume:* The number of centres performing PAN remained relatively static over the 22 year study period (Approx 6 hospitals per year). The percentage of PAN performed in the highest-volume centres increased significantly (1982 – 0.0% - 2003 – 98.7%, p <0.001) *Mortality Rates:*

	Resection /yr	*Resection (N)*	*Death (N / %)*
Q1	*1*	*66*	*4/ 6.1%*
Q2	*2*	*34*	*4 /11.8%*
Q3	*3-6*	*78*	*4 / 5.1%*

			years", ie one hospital would have 22 associated hospital year mortality rates if it performed a resection every year for the entire study period.		*Q4* | *>7* | *579* | *12 / 2.1%* Postoperative in hospital mortality decreased as quartiles of hospitals increased (chi square p = 0.004. OR of in hospital death was reduced in highest volume hospital but it was not significant (OR = 0.33; 95% CI 0.10, 1.05, p ns)
Yasunaga 2012	Patients undergoing liver resections	Japanese Diagnosis Procedure Combination Database, July and December 2007-2009	Hospital Volume Quartiles: very low (<18/year), low (18-35/year), high (36-70/year), very high (>70/year)	LOS, post-operative mortality	*# pts = 18 046, # hospitals 855* ***Length of stay rates for volume (mean, SD)*** very low to very high = 24.0 (20.5), 21.6 (19.2), 20.5 (17.2), 21.5 (16.5) ***In hospital mortality rates for volume (%)*** Very low to very high = 1.6%, 1.3%, 1.1%, 0.4% ***In hospital mortality rates for volume (OR)*** *Low OR 0.70 (95% CI 0.48-1.02) p = 0.060* *High OR 0.52 (95% CI 0.34-0.81), p = 0.004* *Very high Or 0.16 (95% CI 0.09-0.30), p<0.001*
Young 2010 **Abstract**	Patients older than 18 years of age undergoing hepatic resection	NIS, 1998-2007 Chi-square, multivariate logistic regression	Hospital Volume LV < 20 HV > 20	Mortality	*N = 9 289* LV patients 1.4 times (CI = 1.02-1.93) as likely to die as patients at HV
\Hospital other					
Dixon 2007	Patients w/ partial hepatectomy or lobectomy	Medicare Provider Analysis and review files from CMS, 1999-2000 Regression modeling, and binary logistic to account for clustering	Presence or absence of a liver transplant program, Also hospital volume *Volume cutoff:* LV 1-9 HV ≥10	30-day operative mortality (w/I 30 days of index procedure) LOS	N=4661 patients, 1235 hospitals, of which 79 had a transplant program ***Unadjusted mortality rates for volume:*** HV: 4.41% LV: 7.64% ***Length of Stay (OR)*** LV hospital: OR 0.958 (0.918-0.999), p = 0.0472 Transplant program: OR 0.975 (0.932-1.018), p = 0.2482 ***Mortality (OR)*** LV: 1.705 (1.221-2.381), p =0.0017 No transplant program: 0.987 (0.724-1.346), p = ns
Lancaster 2007	Hepatic Resection	Veterans Affairs NSQIP October 2001-September 2004 Logistic Regression and T-test	Type of Hospital (Veteran Affair vs Private Sector)	30 day Mortality, 30 day Morbidity, Length of Stay	N = 1,020 hepatic resections ***Unadjusted Outcomes*** ***30-d Mortality (%)*** *Private Sector(PS) Veteran Affair (VA) = 2.55% vs 6.75%, p= 0.0022* ***30-d Morbidity (%)*** *PS vs VA = 22.61% vs 27.85%, p = 0.0969* ***Total LOS (mean, SD)*** *PS vs VA = 9.78 (9.02) vs 11.65 (9.79), p = 0.0062* **Adjusted Outcomes** *After risk adjustment and potential confounds, the morbidity rate was found to be equivalent at the two types of hospitals (OR = 0.94; 95% CI, 0.62-1.42, p =0.77).* *After risk adjustment and potential confounds, there was no significant difference in mortality between the two type of hospitals (OR = 1.62, 95% CI, 0.61-4-32, p =0.33).*
Lordon 2008,	Patients with colorectal liver metastases referred to the hepatobiliary unit between September 1996	Retrospective analysis, hospital records from September 1996-November 2006	Referral to single centre with multidisciplinary team and liver surgeon (MDT)	Hospital Stay, Overall Survival	N = 331 patients *Hospital stay (days)* MDT vs other: 11.4 vs 11.4, p> ns *Overall survival (years)* MDT vs other: 3.6 (0.08-7.8) vs 2.61 (0-9.6), p< 0.0001

	and November 2006	Chi Square, t test, log ranking and Cox regression	vs other hospitals		
Surgeon Volume					
Eppsteiner 2008	Liver resection (wedge res or lobectomy), any cause % malignant diagnosis: ~76.7%	Retrospective analysis, discharge records of NIS 1998-2005 Propensity scores, logistic regression Case-controlled cohort comparison for adjusted models	Surgeon volume, hospital volume, *Volume cutoff*: HV surgeons: ≥10 LR/y HV hospital: ≥ LR/y	Mortality: death to any cause prior to discharge	2949 LR in time period Separately, neither treatment at HV center (HR 0.81, 0.48-1.38) or by HV surgeon (HR 0.68, 0.39-1.19) protective for mortality Malignant diagnosis: HR 0.73 (1.46-1.16) p=0.42 Teaching hospital: HR 1.06 (0.66-1.68), p=0.91 *Adjusted mortality models* N=1678 patients Patients at HV hospitals had lower adjusted mortality rate (2.6% vs 4.8% at LV, p=0.02) HV surgeon at HV hospital beneficial (HR 0.40, 0.21-0.80) (no other combination significant);
Kohn 2010	Hepatectomy	NIS: 1998-2006 Logistic Regression controlling for annual improvement in outcomes and Charlson comorbidity index score	Surgeon volume	Mortality, morbidity, Surgical Residency, fellowship program	# patients: 5298 ***Unadjusted outcomes*** Mortality : 6.44% ***Adjusted outcomes*** ***Effects of volume on*** Morbidity: OR 0.992 (0.987-0.996), p= .0006 Mortality: OR 0.975 (0.967-0.983), p <0.0001 ***Relation to Surgical Residency*** Morbidity: OR 0.851 (0.757-0.957), p= 0.0072 Mortality: OR 0.815 (0.706-0.941), p= 0.0052 ***Relations to Fellowship Program*** Morbidity: OR 0.931 (0.786-1.103), p = ns Mortality:: OR 0.855 (0.712-1.027), p =ns
McColl, 2013	Patients 18 years of age and older who underwent hepatic resections	Patient health records between 1995-2004 in either the Calgary or Capital (Edmonton) health regions. Chi square, Mann-WhitneyU tests, logistic regression, multiple linear regression models	Surgeon volume, training in hospital	In hospital mortality	# patients = 676 **Predictors of in-hospital mortality** *Unadjusted OR* HV Surgeon OR = 0.54 (0.31-0.93), p =05 Surgical oncology training OR = 1.52 (0.73-3.16), p = .05 Other surgical training OR = 1.95 (1.08-3.52), p = .05 *Adjusted OR* HV Surgeon OR = 0.42 (0.17-1.05), p = .05 Surgical oncology training OR = 0.51 (0.19-1.40), p = .05 Other surgical training OR = 0.59- (0.23-1.53), p = .05
Pal 2008 *(J Gastrointest Surg)*	Patients who underwent liver resection This study also included PD(details above)	Retrospective analysis from the Hospital Episode Statistic data between 1999-2005 comparing surgical volume and mortality. Data was divided into two cohorts (1999-2002, 2002-2005) in relation with the release of COG guideline.	Surgical Volume Quartiles: Very Low 1-43, Low 46-77, Medium 81-144, High 173-317	30 day mortality	*N = 5,672* *% Mortality* 1999-2002: 2.2% 2002-2005: 2.6 % %Mortality in Quartiles (very low-high) 3.1, 1.2,3.3,2.0 % Mortality by volume (low vs high) 2.2 vs 2.7 OR = 0.82 (0.50 – 1.67), p = 0.51
Surgeon other					
Bhayani 2013	Patients with partial, left or right hepatectomy, trisectionectomy	Retrospective analysis of NSQIP data, 2005-2011	Presence of fellows during hepatectomy (Attending vs Fellow)	Mortality; morbidity; Length of stay	#patients: 2877, 46.1% attending, 54% fellow <u>Attending vs Fellow</u> *Mortality* 2.7% vs 3.2%, p=0.5, *Morbidity* 26.2 % vs 30.7%, p=0.008 *Median Length of Stay* 6 d vs 6 d, p=0.8

					Odds of morbidity associated with fellow involvement Mortality: OR 1.1 (0.7-2.6), p =0.08 Morbidity: OR 1.21 (1.02-1.4), p = 0.03
Shaw, 2012 **Abstract**	Patients undergoing hepatectomy	Retrospective analysis of the University Health Consortium from 2008-2011	Surgeon specialty (general surgeon, surgical oncologist, transplant surgeon)	Mortality, LOS, 30 day re-admission	General Surgeon N= 643, 19% Surgical oncologist N= 1538, 44% Transplant surgeon N= 1283, 37% No difference between general and specialist surgeons for in hospital mortality (1.9% vs 2.4%), total LOS (7 days vs 7 days) and 30 day re-admission (12% vs 8%).

*Volume cutoffs: all studies defined different cutoffs for volume levels (usually data-driven to create quartiles or quintiles). Numbers given represent the numbers of resections/operations used to define the study's volume categories.

NIS: Nationwide Inpatient Sample of the Healthcare Cost and Utilization Project; LV: low volume; HV: high volume; LOS: length of stay; HR: hazard ratio; ROADS: Commission on Cancer's Registry Operations and Data Standards; FORDS: Commission on Cancer's Facility Oncology Registry Data Standards; NCDB: National Cancer Database; SES: socioeconomic status; HCUP-NIS: Health care utilization project national inpatient sample; ESO: esophagi ectomy; CABG: coronary artery bypass graft; PCI: percutaneous coronary interventions; AAA: elective abdominal aortic aneurysm repair; ln: natural log

Table 4. Hepatio-Pancreatico-Bilary primary studies meeting inclusion criteria for EBS #17-2

	Procedure and population	Methods	Intervention	Outcomes of interest	Brief results
Hospital volume					
Schneider, 2014 **Abstract**	Patients undergoing complex hepato pancreato biliary surgery	Retrospective analysis using the Surveillance, Epidemiology and End Results (SEER)-Medicare linked data from 1998-2007 examining hospital-volume related differences, LOS and mortality	Hospital Volume Tertiles: LV <4 cases/year Intermediate (IV) 4-10 cases/yr HV >11 cases/yr	LOS Mortality	N = 12, 209 Patients treated at HV centers (75.8%) were more likely to have >3 comorbidities vs IV (71.5%) or LV (67.3%) centers (p<0.001) Mortality (LV-HV)= 10.7%, 8.4%, 5.6%, p<0.001 LOS (LV-HV)= 12 days, 11 days, 10 days, P<0.001
Surgeon other					
Csikesz 2008 *(J Gastrointes Surg)*	12,004 Hepato-Pancreatico-Biliary surgeries between 1998-2005	Retrospective analysis using NIS discharge records, 1998-2005	hospital volume, surgeon volume, surgeon specialty *Volume cutoff*: HV surgeons: ≥15 cases/yr MV surgeons: 3-14 cases/yr	In-hospital mortality	12,004 HPB surgeries by 4,355 surgeons Surgeon volume per HPB surgery, LV, MV, HV, 10%, 30% 60% *Mortality* No difference in mortality after HPB surgery depending on surgeon specialty (p = 0.59). Surgery performed at transplant center had lower odds of perioperative mortality (OR= 0.79 (0.63-0.98), p= 0.04)

See Appendix 1 for a list of identified studies that were included in at least one of the systematic reviews in Table 1. Please note that these studies were not included in Table 2.

Because the initial search was conducted in February 2014, an updated search was run from January 2014 to May 2015. A total of 2,344 citations were identified via OVID. Of those, 25 were selected for full text review. Two studies that reported different results from those reported above were included in Table 7. Studies that confirmed the results and were not extracted are listed in Appendix 2.

Table 5. Updated literature search January 2014 to May 2015.

	Procedure and population	Methods	Intervention	Outcomes of interest	Brief results
Hospital other					
Kanhere 2014	53 patients undergoing PD between 1998-2003	Retrospective analysis of database for periampullary carcinoma, 1998-2003. Study was performed at a low volume university teaching hospital in Australia equipped with all the expertise and infrastructure to provide a health care delivery system that is equivalent to high-volume centres.	Age (<74, >74)	Postoperative morbidity, in-hospital mortality, operating time, LOS	N = 53 patients Group A (<74) = 34; Group B (>74) =19 Operating Time : Group A = 399 (253-960), Group B 395 (254-1,104, p = ns Median LOS = 14 (8-180) days Morbidity rate was 41% (22/53 patients) Mortality 3.8% * If the system processes at high volume centres can be replicated in low-volume centres with good surgical expertise, equivalent outcomes can be achieved. * Whilst centralization for complex surgery is logical to obtain the best outcome, study shows that replicating the system processes at high-volume centres makes it possible to achieve good outcomes in low-volume centres with adequate expertise. This is good alternative when centralization is not feasible due to geographic and logistic reasons.
Hospital Volume					
Ravaioli 2014	Patients undergoing curative HPB resection)	Patients were evaluated at an LV hospital before (2006-2008) and during the collaboration between HV and LV centres (2009-2012) and at 2 hospitals with HV for either liver of pancreatic resection (2009-2012)	Hospital Volume	LOS, Hospital mortality	LV : N liver: 2006-08 = 29, 2009-12= 85 LV: N pancreas: 2006- 08 = 17, 2009-12 = 63 *Hospital Mortality:* Liver: 2006-2008 3.5%; 2009-2010 2.9%; 2011-2012 - Pancreas: 2006-2008 17.6%; 2009-2010 11.1%; 2011-2012 2.8% *Overall mortality at 6 months:* 2006-2008 17.8%, 2009-2012 6%, p<0.05 *LOS (median)* Liver: Before : 10 days During : 7 days, p =ns Pancreas: Before: 14 days, During: 11 days, p=ns The reoperation rate was higher at the LV center (14% vs 5% at the HV center, p<0.05), although rates at the LV hospital decreased year on year and were similar to those at the HV center by the last study year (27% in 2009, 17% in 2010, 13% in 2011, and 5% in 2012). *Collaborative efforts between centers with low and high HPB surgical volume resulted in significant improvement in outcomes at the LV hospital, which achieve results similar to those at the HV centers *objective of the collaboration was not to transform an LV center into an HV center, but to pragmatically improve HPB results in the LV center in accordance with health organization, costs, and patient features.

Instructions. Instructions. For each document, please respond YES or NO to all the questions below. Provide an explanation of each answer as necessary.

1. Does any of the newly identified evidence, on initial review, contradict the current recommendations, such that the current recommendations may cause harm or lead to unnecessary or improper treatment if followed?	No
2. On initial review, a. Does the newly identified evidence support the existing recommendations? b. Do the current recommendations cover all relevant subjects addressed by the evidence, such that no new recommendations are necessary?	Yes Yes
3. Is there a good reason (e.g., new stronger evidence will be published soon, changes to current recommendations are trivial or address very limited situations) to postpone updating the guideline? Answer Yes or No, and explain if necessary:	No
4. Do the PEBC and the DSG/GDG responsible for this document have the resources available to write a full update of this document within the next year?	N/A

Review Outcome	ENDORSED
DSG/GDG Approval Date	December 1st, 2015
DSG/GDG Commentary	

References

1. Allareddy V, Allareddy V, Konety BR. Specificity of procedure volume and in-hospital mortality association. Annals of Surgery. 2007;246(1):135-9.
2. Alsfasser G, Kittner J, Eisold S, Klar E. Volume-outcome relationship in pancreatic surgery: the situation in Germany. Surgery. 2012;152(3 Suppl 1):S50-5.
3. Anderson J, Mekeel K, Chang DC, Talamini M, Hemming AW. Surgical management trends for cholangiocarcinoma in the United States 1998-2009. HPB. 2012;14:5.
4. Balzano G, Capretti G, Braga M, Pecorelli N, Zerbi A, Di Carlo V. The effect of surgeon volume on the outcome of pancreaticoduodenectomy in a high-volume institution. HPB. 2010;12:94-5.
5. Bhayani NH, Hamed OH, Gupta A, Ortenzi G, Kaifi JT, Kimchi ET, et al. Do patients outcomes suffer when surgical fellows are involved in hepatic resection? Surgery (United States). 2013;154(5):1024-30.
6. Bilimoria KY, Bentrem DJ, Feinglass JM, Stewart AK, Winchester DP, Talamonti MS, et al. Directing surgical quality improvement initiatives: Comparison of perioperative mortality and long-term survival for cancer surgery. Journal of Clinical Oncology. 2008;26(28):4626-33.
7. Bilimoria KY, Bentrem DJ, Tomlinson JS, Merkow RP, Stewart AK, Ko CY, et al. Quality of pancreatic cancer care at Veterans Administration compared with non-Veterans Administration hospitals. American Journal of Surgery. 2007;194(5):588-93.
8. Boudourakis LD, Wang TS, Roman SA, Desai R, Sosa JA. Evolution of the surgeon-volume, patient-outcome relationship. Annals of Surgery. 2009;250(1):159-65.
9. Clark W, Hernandez J, McKeon BA, Kahn A, Morton C, Toomey P, et al. Surgery residency training programmes have greater impact on outcomes after pancreaticoduodenectomy than hospital volume or surgeon frequency. HPB. 2010;12(1):68-72.
10. Cox DD, Miller A, Edge S, Kuvshinoff B. Regionalization of pancreatic resection for malignancy in NY state and the effect of hospital volume on perioperative mortality. Annals of Surgical Oncology. 2010;17:S80.
11. Csikesz NG, Simons JP, Tseng JF, Shah SA. Surgical specialization and operative mortality in hepato-pancreatico-biliary (HPB) surgery. Journal of Gastrointestinal Surgery. 2008;12(9):1534-9.
12. Dai C, Xu Z, Qian Z, Jiang K, Wu J, Gao W, et al. Analysis of outcomes after pancreaticoduodenectomy in pancreatic specialty group and non-pancreatic group. Pancreatology. 2011;11:67.
13. De Wilde RF, Besselink MG, Rinkes IHB, Van Eijck CH, Dejong CH, Porte RJ, et al. Centralization of pancreaticoduodenectomy in the Netherlands: Trends and impact on mortality. HPB. 2011;13:9.
14. de Wilde RF, Besselink MGH, van der Tweel I, de Hingh IHJT, van Eijck CHJ, Dejong CHC, et al. Impact of nationwide centralization of pancreaticoduodenectomy on hospital mortality. British Journal of Surgery. 2012;99(3):404-10.
15. Dixon E, Bathe OF, McKay A, You I, Dowden S, Sadler D, et al. Population-based review of the outcomes following hepatic resection in a Canadian health region. Canadian Journal of Surgery. 2009;52(1):12-7.
16. Dixon E, Schneeweiss S, Pasieka JL, Bathe OF, Sutherland F, Doig C. Mortality following liver resection in US medicare patients: does the presence of a liver transplant program affect outcome? Journal of Surgical Oncology. 2007;95(3):194-200.
17. Eppsteiner RW, Csikesz NG, Simons JP, Tseng JF, Shah SA. High volume and outcome after liver resection: surgeon or center? Journal of Gastrointestinal Surgery. 2008;12(10):1709-16; discussion 16.
18. Garcea G, Breukink SO, Marlow NE, Maddern GJ, Barraclough B, Collier NA, et al. A systematic review of the impact of volume of hepatic surgery on patient outcome. Surgery. 2009;145(5):467-75.

19. Ghaferi AA, Birkmeyer JD, Dimick JB. Hospital volume and failure to rescue with high-risk surgery. Medical Care. 2011;49(12):1076-81.
20. Gooiker GA, van der Geest LGM, Wouters MWJM, Vonk M, Karsten TM, Tollenaar RAEM, et al. Quality improvement of pancreatic surgery by centralization in the western part of the Netherlands. Annals of Surgical Oncology. 2011;18(7):1821-9.
21. Gooiker GA, van Gijn W, Wouters MWJM, Post PN, van de Velde CJH, Tollenaar RAEM, et al. Systematic review and meta-analysis of the volume-outcome relationship in pancreatic surgery. British Journal of Surgery. 2011;98(4):485-94.
22. Ho V, Heslin MJ, Yun H, Howard L. Trends in hospital and surgeon volume and operative mortality for cancer surgery. Annals of Surgical Oncology. 2006;13(6):851-8.
23. Hyder O, Dodson RM, Nathan H, Schneider EB, Weiss MJ, Cameron JL, et al. Influence of patient, physician, and hospital factors on 30-day readmission following pancreatoduodenectomy in the United States. JAMA Surgery. 2013;148(12):1095-102.
24. Jensen LS, Bendixen A, Kehlet H. Organisation and early outcomes of major upper gastrointestinal cancer surgery in Denmark 1996-2004. Scandinavian Journal of Surgery: SJS. 2007;96(1):41-5.
25. Joseph B, Morton JM, Hernandez-Boussard T, Rubinfeld I, Faraj C, Velanovich V. Relationship between hospital volume, system clinical resources, and mortality in pancreatic resection. Journal of the American College of Surgeons. 2009;208(4):520-7.
26. Kanhere HA, Trochsler MI, Kanhere MH, Lord AN, Maddern GJ. Pancreaticoduodenectomy: outcomes in a low-volume, specialised Hepato Pancreato Biliary unit. World journal of surgery. 2014;38(6):1484-90.
27. Kennedy TJ, Cassera MA, Wolf R, Swanstrom LL, Hansen PD. Surgeon volume versus morbidity and cost in patients undergoing pancreaticoduodenectomy in an academic community medical center. Journal of Gastrointestinal Surgery. 2010;14(12):1990-6.
28. Kim C-G, Jo S, Kim JS. Impact of surgical volume on nationwide hospital mortality after pancreaticoduodenectomy. World Journal of Gastroenterology. 2012;18(31):4175-81.
29. Kim C-G, Kwak EK, Lee S-I. The relationship between hospital volume and outcome of gastrointestinal cancer surgery in Korea. Journal of Surgical Oncology. 2011;104(2):116-23.
30. Kohn GP, Nikfarjam M. The effect of surgical volume and the provision of residency and fellowship training on complications of major hepatic resection. Journal of Gastrointestinal Surgery. 2010;14(12):1981-9.
31. La Torre M, Nigri G, Ferrari L, Cosenza G, Ravaioli M, Ramacciato G. Hospital volume, margin status, and long-term survival after pancreaticoduodenectomy for pancreatic adenocarcinoma. American Surgeon. 2012;78(2):225-9.
32. Lancaster RT, Tanabe KK, Schifftner TL, Warshaw AL, Henderson WG, Khuri SF, et al. Liver resection in veterans affairs and selected university medical centers: results of the patient safety in surgery study. Journal of the American College of Surgeons. 2007;204(6):1242-51.
33. LaPar DJ, Kron IL, Jones DR, Stukenborg GJ, Kozower BD. Hospital procedure volume should not be used as a measure of surgical quality. Annals of Surgery. 2012;256(4):606-15.
34. Learn PA, Bach PB. A decade of mortality reductions in major oncologic surgery: the impact of centralization and quality improvement. Medical Care. 2010;48(12):1041-9.
35. Lemmens VEPP, Bosscha K, van der Schelling G, Brenninkmeijer S, Coebergh JWW, de Hingh IHJT. Improving outcome for patients with pancreatic cancer through centralization. British Journal of Surgery. 2011;98(10):1455-62.
36. Lin H-C, Lin C-C. Surgeon volume is predictive of 5-year survival in patients with hepatocellular carcinoma after resection: a population-based study. Journal of Gastrointestinal Surgery. 2009;13(12):2284-91.
37. Lordan JT, Karanjia ND, Quiney N, Fawcett WJ, Worthington TR. A 10-year study of outcome following hepatic resection for colorectal liver metastases - The effect of evaluation in a multidisciplinary team setting. European Journal of Surgical Oncology. 2009;35(3):302-6.

38. Massarweh NN, Flum DR, Symons RG, Varghese TK, Pellegrini CA. A critical evaluation of the impact of Leapfrog's evidence-based hospital referral. Journal of the American College of Surgeons. 2011;212(2):150-9.e1.
39. McColl RJ, Shaheen AAM, Brar B, Kaplan G, Myers R, Sutherland F, et al. Survival after hepatic resection: impact of surgeon training on long-term outcome. Canadian Journal of Surgery. 2013;56(4):256-62.
40. McDade TP, Smith JK, Chau Z, Witkowski ER, West JK, Tseng JF. Inequal benefits from regionalization of cancer care: The pancreatic cancer surgery paradigm. Journal of Clinical Oncology. 2012;1).
41. McKay A, You I, Bigam D, Lafreniere R, Sutherland F, Ghali W, et al. Impact of surgeon training on outcomes after resective hepatic surgery. Annals of Surgical Oncology. 2008;15(5):1348-55.
42. Merkow RP, Bentrem DJ, Chung JW, Paruch JL, Ko CY, Bilimoria KY. Differences in patients, surgical complexity, and outcomes after cancer surgery at National Cancer Institute-designated cancer centers compared to other hospitals. Medical Care. 2013;51(7):606-13.
43. Minami Y, Sekido H, Harada S, Nakayama G, Gyoda Y, Sato S, et al. Pancreaticoduodenectomy by young trainee. HPB. 2011;13:102.
44. Mukherjee S, Kocher HM, Hutchins RR, Bhattacharya S, Abraham AT. Impact of hospital volume on outcomes for pancreaticoduodenectomy: a single UK HPB centre experience. European Journal of Surgical Oncology. 2009;35(7):734-8.
45. Nathan H, Cameron JL, Choti MA, Schulick RD, Pawlik TM. The volume-outcomes effect in hepato-pancreato-biliary surgery: hospital versus surgeon contributions and specificity of the relationship. Journal of the American College of Surgeons. 2009;208(4):528-38.
46. Nguyen GC, Thuluvath NP, Segev DL, Thuluvath PJ. Volumes of liver transplant and partial hepatectomy procedures are independently associated with lower postoperative mortality following resection for hepatocellular carcinoma. Liver Transplantation. 2009;15(7):776-81.
47. Nienhuijs SW, Rutten HJT, Luiten EJT, van Driel OJR, Reemst PHM, Lemmens VEPP, et al. Reduction of in-hospital mortality following regionalisation of pancreatic surgery in the south-east of the Netherlands. European Journal of Surgical Oncology. 2010;36(7):652-6.
48. Pal N, Axisa B, Yusof S, Newcombe RG, Wemyss-Holden S, Rhodes M, et al. Volume and outcome for major upper GI surgery in England. Journal of Gastrointestinal Surgery. 2008;12(2):353-7.
49. Pecorelli N, Balzano G, Capretti G, Zerbi A, Di Carlo V, Braga M. Effect of surgeon volume on outcome following pancreaticoduodenectomy in a high-volume hospital. Journal of Gastrointestinal Surgery. 2012;16(3):518-23.
50. Rangelova E, Sadr Azodi O, Nilsson M, Segersvard R. Short and long-term mortality after pancreatic resections is decreased in high-volume centers. Pancreatology. 2012;12 (6):561.
51. Ravaioli M, Pinna AD, Francioni G, Montorsi M, Veneroni L, Grazi GL, et al. A partnership model between high- And low-volume hospitals to improve results in hepatobiliary pancreatic surgery. Annals of Surgery. 2014;260(5):871-7.
52. Reames BN, Ghaferi AA, Dimick JB. Hospital volume and operative mortality in the modern era. Journal of Surgical Research. 2013;179 (2).
53. Riall TS, Nealon WH, Goodwin JS, Townsend CM, Jr., Freeman JL. Outcomes following pancreatic resection: variability among high-volume providers. Surgery. 2008;144(2):133-40.
54. Rosemurgy A, Cowgill S, Coe B, Thomas A, Al-Saadi S, Goldin S, et al. Frequency with which surgeons undertake pancreaticoduodenectomy continues to determine length of stay, hospital charges, and in-hospital mortality. Journal of Gastrointestinal Surgery. 2008;12(3):442-9.
55. Scarborough JE, Pietrobon R, Clary BM, Marroquin CE, Bennett KM, Kuo PC, et al. Regionalization of hepatic resections is associated with increasing disparities among some patient populations in use of high-volume providers. Journal of the American College of Surgeons. 2008;207(6):831-8.

56. Schmidt CM, Turrini O, Parikh P, House MG, Zyromski NJ, Nakeeb A, et al. Effect of hospital volume, surgeon experience, and surgeon volume on patient outcomes after pancreaticoduodenectomy: a single-institution experience. Archives of Surgery. 2010;145(7):634-40.
57. Schneider E, Weiss M, Herman JM, Haider A, Hirose K, Makary M, et al. Underlying variation in length of stay following pancreaticoduodenectomy: Surgeon, hospital or patient? Journal of Surgical Research. 2013;179 (2).
58. Schneider EB, Ejaz A, Spolverato G, Haider AH, Makary MA, Wolfgang CL, et al. Hospital volume and patient outcomes in hepato-pancreato-biliary surgery: Is assessing differences in mortality enough? Journal of Surgical Research. 2014;186 (2):520.
59. Schneider EB, Hyder O, Wolfgang CL, Dodson RM, Haider AH, Herman JM, et al. Provider versus patient factors impacting hospital length of stay after pancreaticoduodenectomy. Surgery. 2013;154(2):152-61.
60. Shaw JJ, Macomber CW, Santry HP, Tseng JF, Shah SA. Surgeon specialization and utilization after hepatectomy in academic medical centers. HPB. 2012;14:68.
61. Shaw JJ, Santry HP, Shah SA. Specialization and utilization after hepatectomy in academic medical centers. Journal of Surgical Research. 2013;185(1):433-40.
62. Simunovic M, Rempel E, Theriault M-E, Coates A, Whelan T, Holowaty E, et al. Influence of hospital characteristics on operative death and survival of patients after major cancer surgery in Ontario. Canadian Journal of Surgery. 2006;49(4):251-8.
63. Simunovic M, Urbach D, Major D, Sutradhar R, Baxter N, To T, et al. Assessing the volume-outcome hypothesis and region-level quality improvement interventions: pancreas cancer surgery in two Canadian Provinces. Annals of Surgical Oncology. 2010;17(10):2537-44.
64. Skipworth RJE, Parks RW, Stephens NA, Graham C, Brewster DH, Garden OJ, et al. The relationship between hospital volume and post-operative mortality rates for upper gastrointestinal cancer resections: Scotland 1982-2003. European Journal of Surgical Oncology. 2010;36(2):141-7.
65. Stitzenberg KB, Meropol NJ. Trends in centralization of cancer surgery. Annals of Surgical Oncology. 2010;17(11):2824-31.
66. Swan RZ, Sindram D, Walters A, Martinie JB, Iannitti DA. The impact of regionalization of pancreaticoduodenectomy for pancreatic cancer in North Carolina since 2004. Gastroenterology. 2011;1):S1039-S40.
67. Topal B, Van de Sande S, Fieuws S, Penninckx F. Effect of centralization of pancreaticoduodenectomy on nationwide hospital mortality and length of stay. British Journal of Surgery. 2007;94(11):1377-81.
68. van Heek NT, Kuhlmann KFD, Scholten RJ, de Castro SMM, Busch ORC, van Gulik TM, et al. Hospital volume and mortality after pancreatic resection: a systematic review and an evaluation of intervention in the Netherlands. Annals of Surgery. 2005;242(6):781-8, discussion 8-90.
69. Waljee JF, Greenfield LJ, Dimick JB, Birkmeyer JD. Surgeon age and operative mortality in the United States. Annals of Surgery. 2006;244(3):353-60.
70. Wellner UF, Makowiec F, Hopt UT, Keck T. Detailed analysis of learning curve in pancreatic surgery - Surgeon and hospital volume are equally important. Gastroenterology. 2011;1):S1039.
71. Yasunaga H, Horiguchi H, Matsuda S, Fushimi K, Hashimoto H, Ohe K, et al. Relationship between hospital volume and operative mortality for liver resection: Data from the Japanese Diagnosis Procedure Combination database. Hepatology Research. 2012;42(11):1073-80.
72. Young GD, Gannon CJ, Dombrovskiy V, Carpizo DR, Vogel TR. Complications following elective hepatic resection for malignancy: Are they associated with institutional volume? Annals of Surgical Oncology. 2010;17:S124.
73. Yun YH, Kim YA, Min YH, Park S, Won YJ, Kim DY, et al. The influence of hospital volume and surgical treatment delay on long-term survival after cancer surgery. Annals of Oncology. 2012;23(10):2731-7.

74. Zarate D, Colquist S, Walpole E. Pancreaticoduodenectomy (whipple procedure) survival is worse in low volume hospitals. Asia-Pacific Journal of Clinical Oncology. 2011;7:182.

APPENDIX 1. List of Identified Studies Included in at Least One of the Systematic Reviews in Table 1.

1. Balzano G, Zerbi A, Capretti G, Rocchetti S, Capitanio V, Di Carlo V. Effect of hospital volume on outcome of pancreaticoduodenectomy in Italy. British Journal of Surgery. 2008;95(3):357-62.
2. Birkmeyer JD, Sun Y, Wong SL, Stukel TA. Hospital volume and late survival after cancer surgery. Annals of Surgery. 2007;245(5):777-83.
3. Eppsteiner RW, Csikesz NG, McPhee JT, Tseng JF, Shah SA. Surgeon volume impacts hospital mortality for pancreatic resection. Annals of Surgery. 2009;249(4):635-40.
4. Gasper WJ, Glidden DV, Jin C, Way LW, Patti MG. Has recognition of the relationship between mortality rates and hospital volume for major cancer surgery in California made a difference?: A follow-up analysis of another decade. Annals of Surgery. 2009;250(3):472-83.
5. Hollenbeck BK, Dunn RL, Miller DC, Daignault S, Taub DA, Wei JT. Volume-based referral for cancer surgery: informing the debate. Journal of Clinical Oncology. 2007;25(1):91-6.
6. Lin H-C, Xirasagar S, Lee H-C, Chai C-Y. Hospital volume and inpatient mortality after cancer-related gastrointestinal resections: the experience of an Asian country. Annals of Surgical Oncology. 2006;13(9):1182-8.
7. Teh SH, Diggs BS, Deveney CW, Sheppard BC. Patient and hospital characteristics on the variance of perioperative outcomes for pancreatic resection in the United States: a plea for outcome-based and not volume-based referral guidelines. Archives of Surgery. 2009;144(8):713-21.

APPRENDIX 2. List of identified studies that confirmed the results and were not extracted in updated search (January 2014-May 2015).

1. Anderson JE, Chang DC. Does the effect of surgical volume on outcomes diminish over time. JAMA Surgery. 2014;149(4):398-400.
2. Ansari D, Williamsson C, Tingstedt B, Andersson B, Lindell G, Andersson R. Pancreaticoduodenectomy-the transition from a low- to a high-volume center. Scandinavian Journal of Gastroenterology. 2014;49(4):481-4.
3. Bliss LA, Yang CJ, Lagisetty K, Chau Z, Ng S, Kent TS, et al. Patient selection and the volume effect in pancreatic surgery: Unequal benefits? Hpb. 2014;16:9-10.
4. Chang CM, Yin WY, Wei CK, Lee CH, Lee CC. The combined effects of hospital and surgeon volume on short-term survival after hepatic resection in a population-based study. PLoS ONE. 2014;9(1).
5. Colavita PD, Tsirline VB, Belyansky I, Swan RZ, Walters AL, Lincourt AE, et al. Regionalization and Outcomes of Hepato-pancreato-biliary Cancer Surgery in USA. Journal of Gastrointestinal Surgery. 2014;18(3):532-41.
6. Donkervoort SC, Dijksman LM, Versluis PG, Clous EA, Vahl AC. Surgeon's volume is not associated with complication outcome after laparoscopic cholecystectomy. Digestive Diseases and Sciences. 2014;59(1):39-45.
7. Enomoto LM, Gusani NJ, Dillon PW, Hollenbeak CS. Impact of Surgeon and Hospital Volume on Mortality, Length of Stay, and Cost of Pancreaticoduodenectomy. Journal of Gastrointestinal Surgery. 2014;18(4):690-700.
8. Gooiker GA, Lemmens VEPP, Besselink MG, Busch OR, Bonsing BA, Molenaar IQ, et al. Impact of centralization of pancreatic cancer surgery on resection rates and survival. British Journal of Surgery. 2014;101(8):1000-5.
9. Horiuchi T, Shiba H, Shirai Y, Sakamoto T, Iwase R, Haruki K, et al. Assessment of surgical outcome after pancreaticoduodenectomy by junior surgeons. Hpb. 2015;17:144.
11. Lu CC, Chiu CC, Wang JJ, Chiu YH, Shi HY. Volume-outcome associations after major hepatectomy for hepatocellular carcinoma: a nationwide Taiwan study. Journal of gastrointestinal surgery : official journal of the Society for Surgery of the Alimentary Tract. 2014;18(6):1138-45.
12. Onasanya O, Boccola M, Usatoff V, Smith M, Choi J, Houli N, et al. Pancreaticoduodenectomy, volume and outcome effect: An Australian institution experience. Hpb. 2014;16:164.
13. Porembka M, Rubin DM, Gonen M, D'Angelica M, Allen P, Kingham T, et al. Impact of volume on outcomes in liver surgery: Hospital volume may outweigh surgeon volume. Annals of Surgical Oncology. 2014;1):S99.
14. Reames BN, Ghaferi AA, Birkmeyer JD, Dimick JB. Hospital volume and operative mortality in the modern era. Annals of Surgery. 2014;260(2):244-51.
15. Ross SB, Igartua AN, DeGori M, Teta AF, Luberice K, Toomey PG, et al. High-volume surgeons versus high-volume hospitals: Are best outcomes more due to who or where? Hpb. 2014;16:60.
16. Schneider EB, Ejaz A, Spolverato G, Haider AH, Makary MA, Wolfgang CL, et al. Hospital volume and patient outcomes in hepato-pancreato-biliary surgery: Is assessing differences in mortality enough? Journal of Surgical Research. 2014;186 (2):520.
17. Sutton JM, Wilson GC, Paquette IM, Wima K, Hanseman DJ, Quillin RC, et al. Cost effectiveness after a pancreaticoduodenectomy: Bolstering the volume argument. Hpb. 2014;16(12):1056-61.
18. Sutton JM, Wilson GC, Wima K, Hanseman DJ, Paquette IM, Shah SA, et al. Readmission after pancreaticoduodenectomy: The influence of the volume effect beyond mortality. Annals of Surgical Oncology. 2014;1):S28.

19. Wilson G, Sutton JM, Wima K, Quillin RC, Sussman JJ, Ahmad SA, et al. Barriers to care at high volume centers in hepatic surgery. Annals of Surgical Oncology. 2014;1):S134.
20. Wood TW, Ross SB, Smart AE, Ryan CE, Sukharamwala P, Rosemurgy AS. High volume hospitals with high-and low-volume surgeons: Is there a 'field effect' for pancreaticoduodenectomy? Gastroenterology. 2014;1):S-1092.

APPRENDIX 3. Members of the Expert Panel in December 2015

The 2015 Expert Panel was convened to include representation from across Ontario and across professional disciplines (surgery, pathology, radiology, medical oncology and radiation oncology).

Dr. Michael Marcaccio, Surgeon (Co-Chair) Juravinski Hospital and Cancer Center	Dr. Alice Wei (Co-Chair) University Health Network Quality Lead, Cancer Care Ontario Surgical Oncology Program
Dr. Jason Pantarotto, Radiation Oncologist The Ottawa Hospital	Dr. Douglas Quan, Surgeon London Health Sciences Centre
Dr. Paul Karanicolas, Surgeon Sunnybrook Health Sciences Centre	Dr. Natalie Coburn, Surgeon Sunnybrook Health Sciences Centre
Dr. Shiva Jayaraman, Surgeon St. Joseph's Health Centre Toronto	Dr. Fady Balaa, Surgeon The Ottawa Hospital
Dr. Jeff Shum, Surgeon Health Sciences North	Dr. Jeff Kolbasnik, Surgeon Milton District Hospital
Dr. Diederick Jalink, Surgeon Kingston General Hospital	Dr. Mohamed Husien, Surgeon Grand River Hospital
Dr. Korosh Khalili, Radiologist University Health Network	Dr. Peter Dauphinee, Surgeon Royal Victoria Regional Health Centre
Dr. Steve Gallinger University Health Network	Dr. Mark Hartmann Health Sciences North, Northeast Cancer Centre

Appendix 4- Document Assessment and Review Outcome Definitions

1. **EDUCATION AND INFORMATION** – An education and information document is a document that will no longer be tracked or updated but may still be useful for academic or other informational purposes. The document is moved to a separate section of our website, each page is watermarked with the word “EDUCATION AND INFORMATION”.

2. **ENDORSED** – An endorsed document is a document that the DSG/GDG has reviewed for currency and relevance and determined to be still useful as guidance for clinical decision making. A document may be endorsed because the DSG/GDG feels the current recommendations and evidence are sufficient, or it may be endorsed after a literature search uncovers no evidence that would alter the recommendations in any important way.

3. **DELAY** – A delay means that there is reason to believe new, important evidence will be released within the next year that should be considered before taking further action.

4. **UPDATE** – An Update means that the DSG/GDG recognizes that there is new evidence that makes changes to the existing recommendations in the guideline necessary but these changes are more involved and significant than can be accomplished through the Document Assessment and Review process. The DSG/GDG will rewrite the guideline at the earliest opportunity to reflect this new evidence. Until that time, the document will still be available as its existing recommendations are still of some use in clinical decision making.

Literature Search Strategy:

Medline

1. exp liver neoplasms/su
2. exp hepatectomy/
3. hepatic surgery.mp.
4. exp liver/su
5. exp pancreas/su
6. exp pancreatic neoplasms/su
7. pancrea$ surgery.mp.
8. exp pancreatectomy/
9. exp biliary tract diseases/su
10. biliary surgery.mp.
11. exp cholecystectomy/
12. exp biliary tract surgical procedures/
13. pancrea$ resection.mp.
14. liver resection.mp.
15. hepatic resection.mp.
16. exp pancreaticoduodenectomy/
17. bile duct surgery.mp.
18. biliary tract surgery.mp.
19. or/1-18
20. exp patient admission/
21. exp health manpower/
22. hospital volume$.mp.
23. exp hospital mortality/
24. surgeon volume$.mp.
25. surgical volume$.mp.
26. exp hospitals/
27. Or/20-26
28. 19 and 27
29. (2006: or 2007: or 2008: or 2009: or 201:).ed

Embase

1. exp liver tumor/su
2. exp liver resection/
3. exp liver/su
4. exp pancreas/su
5. exp pancreas tumor/su
6. exp pancreas resection/
7. exp biliary tract disease/su
8. exp biliary tract surgery/
9. exp pancreaticoduodenectomy/
10. or/1-9
11. hepatic surgery.mp.
12. pancrea$ surgery.mp.
13. biliary surgery.mp.
14. pancrea$ resection.mp.
15. liver resection.mp.
16. hepatic resection.mp.
17. bile duct surgery.mp.
18. biliary tract surgery.mp.
19. or/11-18
20. 10 or 19
21. exp hospital admission/
22. exp health care manpower/
23. exp mortality/
24. exp hospital/
25. hospital volume$.tw.
26. surgeon volume$.mp.
27. surgical volume$.mp.
28. or/21-27
29. 20 and 28
30. exp cancer mortality/
31. exp surgical mortality/
32. 21 or 22 or 24 or 25 or 26 or 27 or 30 or 31
33. 20 and 32
34. (2006: or 2007: or 2008: or 2009: or 201:).dd

Ontario Health
Cancer Care Ontario

Evidence-Based Series 17-2 Version 3

A Quality Initiative of the Program in Evidence-Based Care (PEBC), Ontario Health (Cancer Care Ontario)

Section 5: Document Assessment and Review

Hepatic, Pancreatic, Biliary Tract (HPB) Surgical Oncology Standards

K. Bertens, L.D. Durocher, and the Expert Panel on HPB Surgical Oncology

April 14, 2026

The 2006 guideline recommendations are

ENDORSED

This means that the recommendations are still current and relevant for decision making

OVERVIEW

The original version of this guidance document was released by Cancer Care Ontario's Program in Evidence-based Care in 2006 and reviewed in 2016.

In January 2023, this document was assessed in accordance with the PEBC Document Assessment and Review Protocol and was determined to require a review. As part of the review, a PEBC methodologist (LD) conducted an updated search of the literature. A clinical expert (KB) reviewed and interpreted the new eligible evidence and proposed the existing recommendations could be endorsed with minor modifications. The HPB Surgical Oncology Expert Panel (See Appendix 1 for membership) endorsed the recommendations found in Section 1 (Clinical Practice Guideline), with minor modifications, in April 2026.

DOCUMENT ASSESSMENT AND REVIEW RESULTS

Question Considered

What is the optimum organization for the delivery of cancer-related hepatic, pancreatic, and biliary tract surgery in Ontario?

Literature Search and New Evidence

The new search (December 2015 to November 2024) yielded 10 systematic reviews, 111 full text-primary studies, and 2 abstract publications of primary studies. The results of these publications are shown in the Document Review Tool.

Impact on the Guideline and Its Recommendations

The new data support existing standards. However, some modifications were required in light of new evidence. Discussions with the Expert Panel led to the following changes.

First, a systematic review of 26 studies demonstrated that increasing pancreaticoduodenectomy volume was associated with decreasing mortality rates, with 30-day mortality rates stabilizing at 3% once centres reached about 45 cases/year. Additional primary studies from the evidence review also support a 30-day mortality rate of less than 3%. Similarly, Cancer Care Ontario (CCO) data also demonstrate that many centres reach a 30-day mortality rate of less than 3%. There was agreement to adopt the following change: "The following outcomes are considered reasonable and achievable at HPB Centres across Ontario: A mortality rate (30-day plus in hospital) of less than ~~5%~~ **3%** for major pancreatic resection."

There were discussions around the addition of a 90-day mortality goal of 5% however there were concerns raised by the Expert Panel on the lack of robust evidence for a specific 90-day threshold for pancreas surgery.

Second, current HPB Centres should carry out a minimum of 50 index HPB cases per year, and this volume should include at least 20 pancreatic resections. There was a change proposed to clarify Whipple procedures and total pancreatic resections. There was agreement for redefining pancreas volumes to the following: "An HPB Centre should carry out a minimum of 50 index HPB cases per year (index cases include formal anatomic resection of one or more liver segments, all Whipple and total pancreatic resections, all resections with reconstruction of the biliary tract). The volume should include at least <u>20 Whipple and total</u> pancreatic resections."

Third, a population-based retrospective cohort study analyzing 8096 patients from 17 hospitals across Ontario undergoing pancreatectomy, hepatectomy, and esophagectomy for cancer found that care by high-volume anesthesiologists was independently associated with 15% lower odds of combined 90-day major morbidity (including mortality) and readmission, after adjusting for patient case mix, institutional volume and surgeon volume. All patients were treated at designated centers of excellence with policy mandated regionalization that met quality standards of Leapfrog Group. The Expert Panel recognizes that consistent anesthesia teams would improve outcomes, but that many sites lack dedicated HPB anesthesia. There was support to add the following new paragraph: "There is limited but emerging evidence suggesting that care provided by anesthesiologists with high procedure volume versus care by anesthesiologists with low procedure volume was associated with lower risk of combined 90-day major morbidity (including mortality) and readmission, after adjusting for patient case mix, institutional volume, and surgeon volume."

Fourth, a change was proposed under physical resources of HPB surgery to include 24/7 Interventional Radiology. The following standard was added: "Interventional Radiology on site (does not require patient transfer) available on call 24 hours per day, seven days per week"

Lastly, based on Ontario experience from other designated centres (head and neck, gynecology), departures or absences of surgeons have had a substantial effect on the program and require re-referrals of patients to a provincial system that has capacity challenges. It was suggested to change the minimum standard of two HPB surgeons to three: "A minimum of ~~two~~ three HPB surgeons should be on staff in order to provide intraoperative assistance and continuous preoperative and postoperative care, while allowing for appropriate personal and

professional leave. When appropriate, complex HPB cases may benefit from the involvement of two surgeons to optimize operative efficiency, safety, and outcomes."

With the above-mentioned modifications, the Expert Panel on HPB Standards ENDORSED the 2006 recommendations.

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Document Review Tool

Number and Title of Document under Review	17-2 Version 2 Hepatic, Pancreatic and Biliary Tract (HPB) Surgical Oncology Standards
Original Report Date	June 14, 2006
Date Assessed (by DSG or Clinical Program Chairs)	Jan 18, 2023
Health Research Methodologist	Lisa Durocher
Clinical Expert	Dr. Kimberly Bertens
Approval Date and Review Outcome (once completed)	April 14, 2026 ENDORSED

Original Question:
What is the optimum organization for the delivery of cancer-related hepatic, pancreatic, and biliary tract surgery in Ontario?

Target Population:
The following standards, developed by the Expert Panel on HPB Surgical Oncology, apply to hepatic, pancreatic, and biliary cancer surgery and include the full spectrum of multidisciplinary assessment and treatment:

- Management of primary and secondary liver cancer by hepatic resection or locally destructive techniques (ablation by any modality, hepatic artery embolization with or without chemotherapy, etc.).
- Management of cancer of the pancreas and peri-ampullary region by pancreatic resection.
- Management of tumors of the biliary tract (including gall bladder) by surgical resection.

Study Selection Criteria:
Inclusion Criteria
Articles were selected for inclusion in the systematic review of the evidence if they were fully published English language reports reporting volume-outcome measurements, for either surgeons or hospitals/institutions, in hepatic, pancreatic, or biliary cancer. Ideally, reports would provide both surgeon and hospital/institution volume-outcome measurements. The types of studies eligible for inclusion were randomized controlled trials (RCT), retrospective studies, and case-series reports (with at least 10 patients).

Outcomes of interest
The primary volume-outcome measurements that were of interest included short-term mortality/survival, adverse effects, hospital length of stay, and long-term survival (five-year optimal). Secondary outcomes of interest included costs (as reported in the jurisdiction where the trial was run), physician training, hospital/institutional requirements, and any diagnostic procedures used.

Search Details:
May 2015 to November 2024 (Medline and Embase Week 1) and Cochrane library via OVID.

Summary of new evidence:
A total of 4,085 were identified from the search strategy. Of these, 198 full-text articles were assessed for eligibility. Ultimately, 123 studies met inclusion criteria: 10 systematic reviews, 111 primary studies, and 2 abstracts.

The results of the systematic reviews can be found in Table 1. The primary studies and abstracts that were identified but not included in any of the systematic reviews are presented in Tables 2 to 8. Several primary studies (n= 46) were part of the systematic reviews; however, the results from those specific studies are not shown in the tables below. A complete bibliography of those studies is provided in Appendix 2.

5. Does any of the newly identified evidence contradict the current recommendations? (i.e., the current recommendations may cause harm or lead to unnecessary or improper treatment if followed)	No, but it was discussed there should be an update on the mortality rates as it has dropped in the past years.
6. Does the newly identified evidence support the existing recommendations?	For the most part, yes the newly identified evidence supports the existing recommendations.
7. Do the current recommendations cover all relevant subjects addressed by the evidence? (i.e., no new recommendations are necessary)	Yes, however the new evidence prompted some modifications to the standards.
Review Outcome as recommended by the Clinical Expert	Endorse
If outcome is UPDATE, are you aware of trials now underway (not yet published) that could affect the recommendations?	
DSG/Expert Panel Commentary	

Table 1. Systematic reviews and systematic reviews with meta-analyses meeting inclusion criteria for EBS 17-2

Author, year	Inclusion criteria	Methods	Intervention/ Comparison	Outcomes of Interest	Brief results
Ahola, 2020 [1] Systematic Review Pancreatic Various countries: Nordic countries, Europe, Japan, Taiwan, Australia, North America	Studies comparing mortality, morbidity, complication distribution, pathologic reporting, long term survival, and/or costs in open PRs, PD, or DP or the combined results of these) between different volume groups	PubMed: August 1999 to August 2019	Hospital Volume (high vs low) No specific criterion was used in defining HV or LV	Mortality Long-term survival LoS	Total n=44 *Studies used a variety of different criteria for HVC and LVC, which hampers the evaluating of the effect of operation volume. **30-day mortality or in-hospital mortality:** HVC 0.1%-8.1% vs LVC 3.5%-15% **90-day mortality:** HVC 0%-5.3% vs LVC 9.3%-16.1% Overall, studies report lower mortality rates in HVCs than in LVCs despite the heterogeneity of the volume criteria, but statistical significance was not reached in all studies on PRs. The mortality rates after PD resemble those for overall mortality after PR, probably due to the high proportions of PDs among the data of PRs. **Long-term survival (n=8 studies):** -2 studies resulted in significant differences in the median survival between LVCs and HVCs (16 mths in LVs vs 20-26 mths in HVs). - Another study- 1- and 2-year survival is higher among pts operated on in HVCs than in LVCs (1-year survival 72% vs 57% and 2-year survival 40% vs 31%). - 1 study showed that 5-year survival among PDAC pts undergoing PD may be higher in HVCs than in LVCs, 26% versus 13%, while another study found no association in their survival analysis. **LoS (n=10):** Several studies analyzed LoS resulting in the conclusion that hospital stay is shorter in HVCs than in LVCs. **Costs (n=9):** 1 SR concluded that high operation volume leads to lower health care costs, but the evidence is inconsistent. -retrospective study among PD pts reported that high operation volume leads to significant cost savings among pancreatic cancer pts. The association was also apparent in several other studies reporting their results on pancreatic cancer pts -another study found the costs for pts treated by LV surgeons at LV centres are higher than those for pts treated by low-volume surgeons at HV centres. -The cost-benefit association among pancreatic cancer pts by dividing costs by survival. The analysis showed that costs per survival are lowest among pancreatic cancer pts operated on at HVs
Acher et al. 2022 [2] Systematic Review	Peer reviewed original studies on the volume-outcome association as it pertains to pancreas cancer pts.	Pubmed: 1995-2020	Hospital Volume, Surgeon Volume	Postoperative mortality, OS	Hospital Volume: **Postoperative mortality:** -inverse relationship between hospital volume and short-term mortality in pts undergoing pancreas cancer surgery. - multiple studies have suggested that systems-level factors may underlie or complement the mortality benefit associated with

Author, year	Inclusion criteria	Methods	Intervention/ Comparison	Outcomes of Interest	Brief results
Pancreatic					HVH **OS:** -Hospital volume is associated with improved long-term survival in pts undergoing PR for cancer. - Pts treated at HVH attain better long-term survival, however, defining the exact etiology of this association remains difficult and it is possible that both hospital and surgeon volume are proxies for other system and human level variables that more directly influence both short- and long-term mortality. Surgeon Volume: **Postoperative mortality:** -Increasing surgeon volume is associated with improved mortality among pts undergoing pancreas surgery. -In pooled analyses, there was a consistent 2-to 4-fold increased odds of postoperative mortality in LVH vs HVH, depending on the volume cutoff (0-10, 10-20,>20). However, these trends must be contextualized by the inconsistent use of risk-adjusted analyses to control for factors associated with postoperative mortality
Fischer et al. 2023 [3] Systematic Review and Meta-analysis Pancreatic resections 55% (17/31) studies conducted in USA.	Studies on volume-outcome relationships in pancreatic surgery. Adults = > 18 undergoing Whipple procedure, total PAN, PD, and DP.	PubMed, Cochrane Database of Systematic Reviews, Cochrane Central Register of Controlled Trials and EMBASE were searched to identify studies on the volume-outcome relationship in pancreatic surgery published between the years 2000-2018	Hospital Volume, Surgical Volume 3 groups for LV: (LV1) <6 resections/year, (LV2)<11 resections/year, (LV3) <24 resections/ year. 3 groups for HV: (HV1) 5 to 20 resections/year, (HV2) >20 resections/year, (HV3) >40 resections/year HV surgeon cut-offs showed large variations, LV surgeon cut-offs were quite homogeneous (<6 resections/year)	short-term postoperative mortality, which included in-hospital mortality, 30-day mortality, and 90-day mortality postoperative complication	N = 31 studies **Postoperative mortality (pooled OR)**: a) hospital volume: HV1: OR 0.35 (95% CI: 0.29-0.44) HV2: OR of 0.37 (95% CI: 0.25-0.56) HV3: OR of 0.37 (95% CI: 0.25-0.56) strongest effect for PD: I2 = 0%; pooled OR: 0.17 (95% CI: 0.10-0.30) b) surgeon volume (n=6): LV: pooled OR 0.29 (95% CI: 0.22-0.37) with moderate heterogeneity (I2 = 52%) **Postoperative complication:** HV: 0.87 (95% CI: 0.80-0.94)
Hunger et al. 2022 [4] Systematic Review Pancreatic	eligible studies had to examine the impact of hospital and/or surgeon volume on short-term mortality (≤ 90 days) for pts (≥ 18 years) undergoing pancreatic	PubMed, Cochrane Central Register of Controlled Trials, Livivo and Medline.	Hospital volume, surgeon volume	Mortality	-73 studies on hospital volume, 89% reported a significantly increased mortality in the lowest hospital volume group. -6 studies examined surgeon volume effects, 2 failed significance despite a tendency of reduced mortality for high volume surgeons -5 studies reported significant effects for both hospital and surgeon volume, 1 study failed to demonstrate significant effects, although a tendency to decreased mortality was observed for high volume hospitals and surgeons

Author, year	Inclusion criteria	Methods	Intervention/ Comparison	Outcomes of Interest	Brief results
Majority of studies were from the USA (64%) or Europe (22%).	resection independently of primary diagnosis.				-The analysis showed large differences in the extent to which mortality-related covariates were taken into account, with a significant negative correlation between the extent of risk adjustment and hospital volume effects. With increasing numbers of covariates the volume effect decreased -There was no association between the extent of risk adjustment and surgeon volume, although this might be due to the low number of studies (n = 12) and the small differences between the studies (between 6 and 16 covariates).
Kotecha et al 2024 [5] Systematic review Pancreatic 7 studies from North America, 17 from Europe, 6 from Asia, and 2 from Australia	Studies were included if they compared the same center across different (high and low volume) time periods. Studies were included if they combined outcomes for PD performed for all pancreatic pathology, including benign or pre-malignant pathologies.	Google Scholar, PubMed, and Cochrane Library databases was conducted from 2001 to 2021 for full-text articles in English	Hospital volume	30-day Mortality, post operative morbidity, LoS	**30-day Mortality (26 studies):** -A continuously decreasing mortality rate is seen with increased volume up to a center volume of ~45 cases/year after which mortality remains below 3%. -The "zero-crossing" method graph showed that the mortality rate remained at ~3% with further increase in volume, with a further mortality benefit seen (below 2%) at 70 cases/year and subsequently again at 135 cases/year **Postoperative morbidity (9 studies):** -Semiparametric regression models confirmed significant nonlinear associations between operating volume and morbidity. -The "zero-crossing" method showed that centers with operating volume of ~55 cases/year had the lowest morbidity. **LoS (16 studies):** - nonsignificant decreasing linear associations between operating volume and length of stay (edf= 2.04, P=0.099). This reduction was from average postoperative stay of 15 to 14 days as volume increased to almost 150 cases/year.
Kovoor et al. 2022 [6] Systematic Review and Meta-Analysis Pancreatic Included studies were from five countries across North America, Europe and Asia.	Pts undergoing PD, including classical PD and pylorus-preserving PD	PubMed/MEDLINE Embase and Cochrane Library were searched to 4 January 2021	hospital volume 25th percentile cut off (20 PDs per year) 75th percentile cut off (32 PDs per year	in-hospital mortality, 30 and 90-day postoperative mortality, postoperative hospital length of stay (LOS)	**In-hospital mortality (17 studies):** RR= 0.37 (95% CI 0.30-0.45): 63% less in hospitals conducting an annual volume of PDs above the HV threshold than in hospitals performing an annual volume of PDs below this thresh-old. (This is a statistically significant result, as one is not within the 95% CI). **30- and 90-day mortality (2 studies):** 2 studies reported inverse relationship between post admission mortality and annual hospital volume of PDs **LoS (7 studies):** -All studies found an inverse relationship, with a higher volume of PDs being associated with a shorter postoperative LOS after PD.

Author, year	Inclusion criteria	Methods	Intervention/ Comparison	Outcomes of Interest	Brief results
Krautz et al. 2017 [7] Systematic Review Pancreatic Germany	studies that analyzed volume-outcome relationships and effects of min. caseload requirements	Medline database	Hospital volume	1-year Mortality	Narrative systematic review, but overall finding was a strong inverse relationship between hospital volume and mortality following pancreatic surgery in Germany that persists for up to 1 year The results of these studies show that outcomes following complex surgery also depend in large parts on the expertise of all persons and teams involved in complication management and not only on the surgeon's experience. This is particularly obvious concerning post pancreatectomy hemorrhage, the most feared complication in pancreatic surgery, that is best treated by interventional radiology rather than surgery in most of the cases.
Polonski 2019 [8] Systematic Review Pancreatic Europe	Studies concerning centralization of pancreatic surgery in Europe	Medline database	Hospital Volume	Mortality rate	14 retrospective cohort studies In 12 studies, the **mortality rate** in the highest-volume cut-off group is significantly lower than overall mortality in the whole patient cohort. Institutions which cannot provide 24-h access to endoscopy, interventional radiology and ICU that should not perform pancreatic procedures.
Ratnayake et al. 2022 [9] Systematic Review and Meta-Analysis	Articles reporting patient volume and outcomes after pancreatic cancer resection	Google Scholar, PubMed, and Cochrane Library databases were systematically searched from February 2015 until June 2021	Hospital Volume Low-volume 0 (range 0-9), medium-volume 9 (range 3-29), high-volume 19 (range 9-97), and very-high-volume 28 (range 17-60) pts.	30-day mortality, 90-day mortality, postoperative morbidity, median survival	Total N =46 **30-day Mortality (n=23 studies):** -lower 30-day mortality in VHV/HV compared with VLV/LV centers and compared with MV centers in 18 studies and 9 studies. - meta-analysis: 30-day mortality was significantly lower in VHV/HV centers compared with VLV/LV centers (VHV/HV 3.2% VLV/LV 8.2%, OR 0.43 [95% CI 0.36-0.52] P < .001) and MV centers (VHV/HV 4.4% MV 5.2%, OR 0.61 [95% CI 0.50-0.75] P < .001) **90-day mortality (n=10 studies):** -lower in VHV/HV compared with VLV/LV centers in 9 studies. Four of these reported a lower 90-day mortality in VHV/HV compared to MV centers - meta-analysis: 90-day mortality was significant lower in VHV/HV compared with VLV/LV centers (VHV/HV 5.8% VLV/LV 9.7%, OR 0.54 [95% CI 0.44-0.68] P < .001) and MV centers (VHV/HV 5.7% MV 8.5%, OR 0.62 [95% CI 0.53-0.73] P < .001). **Median Survival (n=4 studies):** - all that reported on median survival found improved survival in VHV/HV compared with VLV/LV centers. One found a longer median survival in VHV/HV compared to MV centers. **Postoperative morbidity (n=9 studies)**: -6 studies showed lower overall postoperative morbidity in VHV/HV compared to VLV/LV centers and 3 studies for VHV/HV compared to MV centers. Meta-analysis: On meta-analysis, overall postoperative morbidity was lower in VHV/HV compared with VLV/LV centers (VHV/HV 47.1% VLV/LV 56.2%,

Author, year	Inclusion criteria	Methods	Intervention/ Comparison	Outcomes of Interest	Brief results
					OR 0.75 [95% CI 0.65-0.88] P =.005 and MV centers (VHV/HV 46.9% MV 50.7%, OR 0.81 [95% CI 0.72-0.91] P = .001.
Yin et al. 2022 [10] Systematic Review and Meta-Analysis Pancreatic India, Spain, NL. China, UK, South Korea, France, Egypt, Italy, Japan, and USA.	RCTs, database research studies, and cohort studies that compared mortality in pts who underwent LPD and OPD	PubMed, Cochrane, Embase, and Web of Science for studies published before February 1, 2021	Hospital Volume *subgroup analyses	Mortality, LoS, complications, OS	46,729 pts, 4705 LPD and 42,024 OPD N= 34 studies -The mortality was similar in both HV hospitals (OR, 1.066; 95% CI, 0.694–1.638; P = 0.770; I 2 = 0.0%) and LV hospitals (OR, 0.550; 95% CI, 0.258–1.170; P = 0.120; I2 =0.0%) -Lower CR-DGE, shorter LOS, shorter ICU stay, more R0 resection, and more lymph node harvest were observed in the LPD group in high-volume hospitals (all P < 0.05), but they were similar between the two groups in low-volume hospitals (all P > 0.05). Lower EIBL and longer operative time were observed in the LPD group in both high- and low-volume hospitals (all P < 0.05). Meanwhile, severe complications, CR-POPF, CR-BL, CR-PPH, intra-abdominal infection, reoperation, readmission, OS, 2-year relapse and total cost were similar between LPD and OPD regardless of the surgical volume (all P > 0.05).

CI, confidence interval; CR-BL, clinically relevant biliary leak; CR-DGE, clinically relevant delayed gastric emptying; CR-POPF, clinically relevant postoperative pancreatic fistula; CR-PPH, clinically relevant pancreatectomy hemorrhage; DP, distal pancreatectomy; EBS, evidence-based series; edf, estimated degrees of freedom; EIBL, estimated intraoperative blood loss; EMBASE, Excerpta Medica dataBASE; HV, high volume; ICU, intensive care unit; OS, overall survival; HVC, high volume centre; HVH, High volume hospital; LPD, lapascopic pancreaetoduodenectomy; LOS, length of stay; LV, low volume; LVC, low-volume centers; MEDLINE, Medical Literature Analysis and Retrieval system Online; mths, months; MV, medium volume; OR, odds ratio; OPD, open pancreatuduodenectomy; PAN, pancreatectomy; PD, pancreatoduodenectomy; PDAC, pancreatic ductal adrenocarinoma; PR, pancreatic resection; pts, patients; RR, risk ratio; SR, systematic review; VHV, very high volume; VLV, very low volume.

Table 2a. Pancreatic and hospital volume primary studies meeting inclusion criteria for EBS 17-2

Author, year	Procedure and population	Methods	Intervention	Outcomes of Interest	Brief results
Aquina et al. 2021 [11] USA	PAN	Data sources include Medicare, the Statewide Planning and Research Cooperative System, and Nationwide Inpatient Sample between Jan 1, 2013 - Sept 30, 2017.	Hospital Volume (high vs low; PAN ≥20) Based on Leapfrog group's min. annual standards ** surgeon volume data was also extracted and can be found in Table 2b	Complications 90-day mortality	Hospital Volume *Multivariate analysis controlling for age, sex, race, Elixhauser comorbidities, nonelective admission, minimally invasive approach, procedure type, year of surgery **Complication (medicare population vs New York state population; OR (95% CI):** 0.73 (0.66-0.80) vs 0.75 (0.61-0.93) **90-day Mortality (medicare population vs New York state population; OR (95% CI):** 0.66 (0.56-0.76) vs 0.59 (0.42-0.89) % 90-day mortality: 8.2%
Bliss et al. 2014 [12] USA	Pts undergoing total PAN, PD and partial PAN. N= 129,609	Nationwide Inpatient Sample 2004-2011	Hospital volume (low <5, medium 5-18, high >18)	Mortality Rate, Median LoS, Complication Rate	**Mortality Rate (%):** Low 8.1, medium 5.9, high 3.1, p<0.001 **Median LoS:** Low 12, medium 11, high 9, p<0.001 **Complication rate (%):** Low 45.8, medium 39.7, high 33.1, p<0.001
Conroy et al. 2022 [13] USA	Resectable pancreatic adenocarcinoma pts undergoing minimally invasive (MI) PD	National Cancer Database (2010-17) Multivariable modeling	Hospital volume MIPD (median, IQR) LV- 5 (2-8) HV- 33 (23-61)	LOS, 30- and 90-day mortality	Unadjusted (LV vs HV) **LOS:** 8 vs. 7 days; p<0.001 30-day mortality: 3.3% vs. 0.8%; p=0.001 90-day mortality: 6.3% vs. 2.4%; p<0.001 Adjusted:

Author, year	Procedure and population	Methods	Intervention	Outcomes of Interest	Brief results
			Open PD (Median, IQR) LV- 14 (7-24) HV- 67 (51-76)		**LOS-** no difference **30-day:** OR 4.32; 95% CI 1.50-12.45; p=0.007 **90-day:** OR 2.69; 95% CI 1.42-5.09; p=0.002
Diaz et al. 2019 [14] USA	Pts who underwent PD	California Office of Statewide Health Planning database (2005-2016)	Hospital volume Leap frog criteria HV: annual PD volume >20	LOS, 30-day mortality	**LOS:** LV: mean LOS, 17.0 days vs HV mean LOS, 14.1 day **30-day mortality:** LV in hospital mortality, 5.9% vs HV in hospital mortality, 2.4% (both P < .05) The odds of undergoing PD at a high-volume hospital was higher among pts who had bypassed the nearest hospital (OR, 3.82, 95% CI, 3.31-4.41).
Diaz et al. 2021 b [15] USA	Pts who underwent a pancreatectomy (n = 13,393, 78%) or a liver resection (n = 3,594, 21.2%) for cancer	100% Medicare Inpatient Standard Analytic Files.	hospital volume, social vulnerability index (SVI) HV = 8 surgeries/yr	30-day postoperative mortality, postoperative complications	-the risks of postoperative complications and mortality were higher low- versus high-volume hospitals across all SVI groups (complications, low- vs high-volume hospitals: low SVI, 26.6% vs 20.5%; average SVI: 30.7% vs 24.0%; high SVI: 32.7% vs 25.8%; mortality, low- vs high-volume hospitals, low SVI: 5.3% vs 3.0%; average SVI: 6.5% vs 3.7%; high SVI: 7.8% vs 4.4%; all P < .05)
Ganjouei et al 2024 (abstract) [16] USA	6580 pts who underwent pancreaticoduodenectomy	California Cancer Registry (2004-2022)	hospital volume: LV (<20/yr) vs HV (>20/y) hospitals	90-day mortality, surgeon volume	-majority of cases (71%) were performed at low-volume centers -Within the cohort, 384 (5.8%) pts died within 90 days LV hospital, surgeon volume and 90-day mortality: OR 0.94, 95% CI 0.90-0.98) HV hospital, surgeon volume and 90-day mortality: OR 1.01, 95%CI 0.97-1.05)
Ghauri et al. 2023 [17] USA	Pts undergoing PR between 2012-2015	California Health and Human Services Agency (CHHS) California Hospital Inpatient Mortality Rates and Quality Ratings public dataset	hospital volume (HV > 20 PR)	risk-adjusted mortality rates	LV vs HV: Mean=4.45 (SD 11.86) vs 1.72 (SD=2.61), t(3.849), p =0.001
Hallet et al. 2023 [18] Canada	Adults undergoing esophagectomy, pancreatectomy, or hepatectomy for cancer from 2007 to 2018.	Population-based retrospective cohort study using administrative health care data sets in Ontario.	high-volume anesthesiology care at the hospital level Hepato-pancreatico-biliary cancer surgery has been concentrated to 10 designated centers of excellence since 2006 with minimum	90-day major morbidity defined as the hospital rate of pts receiving care by an anesthesiologist with procedure volume ≥6	- Hepatectomy and pancreatectomy accounted for 58.6% of surgeries -The median anesthesiologist volume was 6 (interquartile range: 3.5-10.5) procedures per year, median surgeon volume was 27 (interquartile range: 15.5-45.5) procedures per year, and the median hospital volume was 189.0 (71.5-358.0) procedures per year. -Ninety-day major morbidity occurred in 2793 (35.4%) pts, including 393 (5%) death events. -the unadjusted RR between the hospital rate of high-volume anesthesiology care (by 10% increments) and the hospital rate of postoperative major morbidity was 0.97 (95% CI, 0.95-0.98; P=0.002

Author, year	Procedure and population	Methods	Intervention	Outcomes of Interest	Brief results
			requirements for institution annual procedural volume, surgeon fellowship training, and postoperative care resources, including availability of interventional radiology, etc. **data on hospital volume for hepatic was also extracted and can be found in Table 3a.	procedures per year	-After adjusting for patient age, sex, and comorbidity burden, type of procedure, surgery approach, hospital teaching status, intraoperative anesthesia handover, year of surgery, and annual surgeon volume, the association remained significant with adjusted RR of 0.96 (95% CI, 0.95-0.98; P<0.001).
Ho et al. 2017 [19] USA	Pts undergoing PR	Medicare hospital and inpatient claims 2005-2009 6 cancer resections: colectomy, rectal resection, pulmonary lobectomy, pneumonectomy, esophagectomy, and PR. Only PR reported.	Hospital Volume ** data on surgeon volume was also extracted and can be found in Table 2b.	Costs	Higher hospital volume is associated with lower patient costs for esophagectomy, but not for other operations.
Huerta et al. 2023 [20] USA	Pts who underwent open PD for pancreatic carcinoma.	The Nationwide Readmissions Database (2010-2014)	Hospital Volume HV = 20 or more PDs were performed per year.	in-hospital mortality, complications	-Pts treated at LVCs experienced a longer LOS compared to their counterparts treated at HVCs and had higher rates of nearly all complications including infections, sepsis, pneumonia, pancreatic fistula, jejunostomy tube complication, and gastrointestinal bleeding, all P < .001 -Pts receiving surgery at HVCs had a higher rate of concomitant operations. - Propensity score-match analysis: those treated at LVCs experienced longer LOS, higher health care costs, and were less frequently discharged home with home health care. Likewise, complications remained higher in the LVC cohort. - After propensity score-matched analysis: LV mortality, 5%; HV mortality, 3%.
Huhta et al. 2022 [21] Finland	Pts undergoing PR for cancer in Finland	Retrospective, nationwide population-based cohort study using Nationwide registries from	Annual hospital volume	5 yr mortality, 1-year, and 3-year all-cause mortalities	**5 yr mortality** adjusted for age sex, Charlson comorbidity index, year of surgery, and center annual volume annual volume 19-36: HR 1.43 (1.16-1.75) annual volume 10-18: HR 1.31 (1.07-1.62) annual volume 5-9: HR 1.62 (1.32-1.99) annual volume <=4: HR 1.62 (1.32-1.99)

Author, year	Procedure and population	Methods	Intervention	Outcomes of Interest	Brief results
		Finland during 1997-2016			**1 yr mortality** adjusted for age sex, Charlson comorbidity index, year of surgery, and center annual volume annual volume 19-36: HR 1.25 (0.87-1.80) annual volume 10-18: HR 1.27 (0.87-1.83) annual volume 5-9: HR 1.55 (1.08-2.22) annual volume <=4: HR 1.48 (1.03-2.12) **3 yr mortality** adjusted for age sex, Charlson comorbidity index, year of surgery, and center annual volume annual volume 19-36: HR 1.40 (1.11-1.75) annual volume 10-18: HR 1.33(1.06-1.67) annual volume 5-9: HR 1.65 (1.31-2.07) annual volume <=4: HR 1.65 (1.32-2.08)
Hunger et al. 2022 [22] Germany	Pts receiving distal pancreatectomies (DP), pancreatoduodenectomies (Whipple-procedure, PD), and pylorus-preserving pancreatoduodenectomies (PPD) performed between 2011 and 2015	The German nationwide hospital discharge data (diagnosis-related groups-statistics)	Hospital volume (5 categories, no cuts off giving)	mortality	**Adjusted mortality rate:** DP Very low to very high: 9.7, 9.2, 9.7, 7.3, 6.4 PD: Very low to very high: 17.3, 14.2, 12.3, 8.9, 8.8 PPD (pylorus-preserving pancreaticoduodenectomy) Very low to very high: 10.3, 8.9, 8.0, 7.9, 5.8
Jaquet et al. 2024 [23] France	Any French adult operated for digestive cancer from January 1, 2019 to December 31, 2021	comparative observational study	hospital volume (<5 or ≥5 interventions/year)	90-day mortality **data on hospital volume for hepatic and hepato-pancreatico-biliary was also extracted and can be found in Tables 3a and 4a.	LV vs HV Gastric surgery 7.2% (127/1757) vs 5.1% (330/6526) p=0.0004 Liver surgery 6.6% (64/970) vs 4.7% (824/17698) p=0.006 Pancreatic surgery 8.3% (74/895) vs 5.9% (608/10325) p=0.004 Multivariate analysis: high-volume center was significantly associated with a reduction in 90-d mortality (OR 0.85, CI95 [0.74–0.97], p = 0.017). (includes all groups) Risk factors liver (OR 1.62, CI95 [1.44–1.81], p < 0.001), gastric (OR 1.64, CI95 [1.44–1.86], p < 0.001), pancreatic (OR 2.3, CI95 [2.05–2.58], p < 0.001),
Ju et al. 2024 [24] USA	Adult NCDB pts undergoing PD between 2004-2015	NCDB hospital registry	Hospital Volume HV status: 25 cases/year	30- and 90-day postoperative mortality, OS	All HV facilities were academic centers. Among pts treated at LV centers, 3.8% were treated at community facilities, 29.4% at comprehensive community cancer programs, 50.4% at academic centers, and 16.4% at INCP. **Post-operative mortality:** Adjusting for age, sex, race, comorbidities, stage, and histology (adenocarcinoma vs. other): HV center was associated with significantly lower odds of 30-day mortality (OR 0.34, 95% CI 0.25-0.46) and 90-day, postoperative mortality (OR 0.48, 95% CI 0.40-0.58) 30-day mortality: LV, 3.6%; HV, 1.3%

Author, year	Procedure and population	Methods	Intervention	Outcomes of Interest	Brief results
					90-day mortality: LV, 7.2%; HV, 3.8% **OS:** OS benefit to undergoing treatment at a HV center for all stages combined, with a median survival of 27.0 mths (95% CI 26.0-28.1) versus 21.2 mths (95% CI 20.8-21.6) at LV centers
Kalagara et al. 2022 [25] USA	Pts undergoing surgery for pancreatic adenocarcinoma from 2010 to 2015	National Cancer Database	Hospital volume (Low less than 6, medium 6 to 19, and high 20 cases or more per year)	textbook outcome (TO), survival *Requirements for TO listed at bottom of table	**TO:** more pts in higher-volume hospitals (23.4% in low-volume, 28.4% in medium-volume, and 37.5% in high-volume; p < 0.001 for overall and pairwise comparisons) **Survival:** When stratified by hospital procedure volume level alone, pts at medium- and high-volume centers had increased survival at 1 year and 3 years compared with low-volume hospitals. However, after 5 years, pts at medium-volume centers had increased survival, with similar survival between low- and high-volume hospitals -improvement in long-term survival for medium-volume vs low-volume (HR 0.88, 95% CI 0.79 to 0.98) but not for high-volume vs low-volume hospitals (HR 0.94, 95% CI 0.80 to 1.11)
Kemp Bohan et al. 2023 [26] USA	pts undergoing surgery for non-metastatic pancreatic adenocarcinoma (PAC)	National Cancer Database 2004-2016	Hospital volume (low <11, med 11-19, and high = > 20 cases/year)	30-day and 90-day surgical mortality, death	**30-day and 90-day surgical mortality:** Lowest at HV compared with LV and MVC (1.7% versus 2.6% and 2.4%, p <0.001; and 4.0% versus 5.2% and 5.4%, p <0.001, respectively) **Death:** On Cox proportional-hazards regression with IPTW, pts treated at both MVC and LV had a higher risk of death when compared with pts treated at HV (HR 1.07, CI 1.04-1.10 and HR 1.11, CI 1.09-1.14, respectively)
Kuemmerli et al. 2022 [27] Switzerland	Retrospective analyses of reported nationwide data on pancreatic resections	Nationwide data from 1998 to 2018 from all hospitals performing pancreatic surgery	Hospital volume National cut-off for regulatory accredited volume centres (AVC) was ≥ 12. Non-accredited volume centre (nAVC) < 12 cases per year. International benchmark definition for high volume (≥ 20 surgeries/year) Definition of AVC was ≥ 12 surgeries/year and based on the accreditation requirements by the	mortality	PAN **Mortality (AVC vs nAVC):** 5.6% vs 6.2%, p=0.156 -After multivariable adjustment, (nAVC vs AVC) OR 1.25 [95% CI 0.98-1.60], p=0.072) for PD DP **Mortality (AVC vs nAVC):** 1.3% vs 2.0%, p=0.15 -no significant effect of centre volume or time period on mortality after DP. Using international cut-off of ≥ 20 cases: LV centres had a higher mortality compared to HV after PD (OR 1.45 [95% CI 1.15-1.84], p=0.002) and again no significant differences were found after DP

Author, year	Procedure and population	Methods	Intervention	Outcomes of Interest	Brief results
			Swiss government to promote centralisation.		
Kwon et al. 2024 [28] Korea	pts undergoing minimally invasive pancreatoduodenectomy (MIPD)	Cohort study was conducted across 10 institutions and included 1552 pts who underwent MIPD registered with the Korean Study Group on MIPD btn May 2007 and April 2020	hospital volume HV >20 MIPD/y vs LV =< 20 MIPDs/year).	90-day mortality, 90-day readmission, LoS	HV vs LV **90-day mortality:** (0.5% vs. 2.7%, P< 0.001) **90-day readmission:** (4.5% vs. 9.6%, P= 0.006) **LoS:** 13.5 (±11.0) vs 15.2 (±10.2) P=0.062
Mitsakos et al. 2021[29] USA	Pts undergoing PD	Retrospective review of a prospective pancreatic surgery database was undertaken from July 2007 to June 2020	Hospital volume low (≤12/year), high (13-29/year), and very high volume (≥30/year)	30-day mortality, LoS, long term survival	Peri-operative outcomes **30-day mortality (LV vs HV vs VHV):** 8.3%, 6.9%*, 3.9%** **LoS (mean ± SD; LV vs HV vs VHV):** 13 ± 9.1, 16 ± 9.2*, 11.5 ± 10.4*** * P > .05 vs low volume. ** P > .05 vs low volume and vs high volume. ***P < .05 vs low volume and vs high volume **1 year survival (LV vs HV vs VHV):** 75.0%, 58.6%*, 53.0%** **3-year survival (LV vs HV vs VHV):** 25.0%, 27.6%*, 26.3%** *P > .05 vs low volume. ** P > .05 vs low volume and vs high volume.
Mok et al. 2024 (abstract) [30] Australia	adults aged >/= 50 years who underwent pancreatectomy for pancreatic or periampullary cancer between 2009-2020	New South Wales (NSW) Hospitalisation, Death and Cancer Registry data	hospital volume low (</= 5) (LVs), medium (6-33) (MVs) or high (>/= 34) (HVs)	post operative mortality, 1-year survival	**post operative mortality:** HVHs had the lowest rates of post-operative mortality at 30 (1.3%), 90 (4.3%) and 365 (18.1%) days **1-year survival:** Improvements in 1-year post-operative survival in HVHs were significant in univariate analysis (0.77; 95%CI 0.59-1.01) and after adjustment for hospital and patient factors (0.71; 95%CI 0.58-0.87), but not after inclusion of year (0.87; 95%CI 0.66-1.15)
Panni et al. 2021 [31] USA	Pts undergoing PD	National Cancer Database from 2004 to 2015	hospital volume	90-day mortality	- institutional volume is significantly associated with decreased overall 90-day mortality when adjusting for age, gender, elective status, and comorbid disease. -improvement in 90-day mortality is noticed if the average annual hospital volume was greater than 9.17 cases per year (9.17, rounded to 9 in manuscript) (OR = 0.647 (0.595-0.702), p < 0.0001 -subset analysis- limiting average volume to > than 9 cases/y - significant improvement in 90-day mortality at hospitals that performed >= 35.92 cases per year (35.92, rounded to 36 in manuscript)(OR = 0.458 (0.399-0.525), p < 0.0001) -Based on these results, we can classify hospitals into low (average annual volume less than 9 cases per year), medium volume (average annual volume 9 to 35 cases per year), and high volume centers (average annual volume greater than 35 cases per year) for PD

Author, year	Procedure and population	Methods	Intervention	Outcomes of Interest	Brief results
Papageorge et al. 2022 [32] USA	Pts >65 years old who underwent PD for pancreatic adenocarcinoma	SEER-Medicare (2008-2015)	upper gastrointestinal operations (UGI) hospital volume 4 volume cohorts using PD tertiles and UGI median: low (1st tertile PD), mixed-low (2nd tertile PD, low UGI), mixed-high (2nd tertile PD, high UGI) and high (3rd tertile PD) PD volume was divided into tertiles (1st: <5, 2nd: 5-4, 3rd: >= 15). UGI volume was divided by median (low volume <16, high volume >= 16; IQR 8, 30)	Major complications; 30-day mortality; 90-day mortality; LoS	**Major complications:** (HV ref group) LV: OR 1.441 (1.165-1.783), p=0.0008 Mixed-LV: OR 1.374 (1.085-1.740), p=0.0083 Mixed-HV: OR 1.418 (1.098-1.832), p=0.0074 **30-day mortality:** LV: OR 2.632 (1.476-4.694), p=0.001 Mixed-LV: OR 1.85 (0.963-3.551), p=0.0646 Mixed-HV: OR 1.587 (0.773-3.257), p=0.2084 **90-day mortality:** LV: 9.5%; OR 2.16 (1.454-3.209), p=0.0001 Mixed-LV: 9.4%; OR 2.068 (1.347-3.175), p=0.0009 Mixed-HV: 9.6%; OR 1.96 (1.245-3.086), p=0.0037 HV: 4.7% **LoS:** LV: OR 1.3119 (1.243-1.385),p <0.0001 Mixed-LV: OR 1.161 (1.093-1.233), p <0.0001 Mixed-HV: OR 1.151 (1.078-1.229),p <0.0001
Stoop 2021 [33] Sweden	Pts undergoing total PAN	Karolinska University Hospital were retrospectively analysed (2008-2017)	Hospital Volume High volume was defined as >20 total PANs/year.	in hospital and 90-day mortality, major morbidity	-multivariable logistic regression analysis revealed that performing >20 total PANs per year is an independent "protective" prognostic factor for major morbidity (OR=0.225, 95% CI, 0.097-0.521; p<0.001), whereas multiple comorbidity (OR=2.133, 95% CI, 0.877-5.188; p=0.095) and extended resections (OR=1.974, 95%CI, 0.909-4.286; p=0.086) tended to be associated with major morbidity. -In the years 2016 and 2017, >20 total PANs were performed annually. In these years, overall major morbidity (n=31, 49.2% vs. n=19, 23.2%; p=0.001) and relaparotomy rate (n=13, 20.6% vs. n=5, 6.1%; p=0.009) were lower compared with the period 2008-2015 (≤20 total PANs/year) In-hospital mortality: 2008-2015: 6.3% 2016-2017: 1.2% 90-day mortality: 2008-2015: 7.9% 2016-2017: 3.7%
Sutton et al. 2015 [34] USA	Pts undergoing PD from 2009-2011	The University Healthsystems Consortium data-base	Hospital volume Q1 ''Lowest''-volume: approx 1–22 cases/y Q2 ''low''-volume approx 23–35 cases/y	30-day readmission rate	-undergoing PD at a hospital within the highest two volume quintiles demonstrated a protective effect on readmission (high-volume, OR 0.84, 95 % CI 0.71-0.96, p = 0.04; highest-volume, OR 0.78, 95 % CI 0.66-0.93, p = 0.004) Perioperative mortality: Q1: 3.5%

Author, year	Procedure and population	Methods	Intervention	Outcomes of Interest	Brief results
			Q3 ''middle''-volume: approx 37–56 cases/y Q4 ''high''-volume approx 58–90 cases/y Q5 ''highest''-volume approx 97–200 cases/y		Q2: 2.2% Q3: 1.4% Q4: 1.5% Q5: 1.3%
Sutton et al 2023 [35] USA	pts with PDAC 1997-2018	A population-based retrospective review of the Oregon State Cancer Registry was performed from 1997 to 2019 with a median 4.3 mths of follow-up	hospital volume HV 20 or more PAN/y LV less than 20 PAN/y	OS	Of pts with sufficient data to determine site(s) of diagnosis and treatment (n = 6649), first-course treatment at both HVs and LVs had improved median OS for locoregional (Figure, A) and metastatic disease (Figure, B, 16.6 [95 % CI, 15.3-17.9] and 6.1 [95% CI, 4.9-7.3] mths, respectively) compared with HV only (11.5 [95% CI, 10.7-12.3] and 3.9 [95% CI, 3.5-4.3] mths, respectively) or LV only treatment (8.2 [95% CI, 7.7-8.7] and 2.1 [95% CI, 1.9-2.3] mths, respectively; P < .001 for all comparisons). -OS of pts diagnosed at HVs was higher than those diagnosed at LVs (median 10.4 [95% CI, 9.5-11.2] vs 9.9 [95% CI, 9.4-10.4] mths; log-rank P = .03)
Swanson et al. 2014 [36] USA	Pts undergoing PAN	National Cancer Data Base (NCDB) during 2007–2010	annual hospital volume (AHV)	30- and 90- day mortality	The mortality rates were similar for AHVs of 10–39 cases and for an AHV of 40 cases or more, so four AHV groups (0–5, 5–9, 10–39, >=40 cases) were used in the bi- and multivariate analyses **Unadjusted 30-day mortality % (95% CI):** 1-4 = 7.2 (6.4–8.0) 5-9 = 4.6 (3.8–5.5) 10–39 = 3.0 (2.5–3.5) >=40 = 1.6 (1.2–2–0) **Unadjusted conditional 90-day mortality (excludes death within first 30 days):** 1-4 = 5.7 (5.0–6.5) 5-9 = 4.5 (3.6–5.4) 10–39 = 3.4 (2.9–3.9) > =40 = 2.8 (2.2–3.4)
Taniyama et al. 2021 [37] Japan	Pts who received curative surgery for esophageal, biliary tract, and pancreatic cancers. Esophageal results not reported.	Osaka Cancer Registry data from 2006–2013	Hospital volume For pancreatic cancer, 5 high-volume hospitals with 13.8 to 28.4 surgical cases per year, 14 middle-volume with 4.1 to 12.8 cases, and 70 low-volume with 0.1 to 4.0 cases ** data on biliary tract was also extracted and can be found in Table 5.	3-year survival, 3 yr mortality	**3 yr survival:** pancreatic: (HV, MV, LV) 54.2%,43.7% and 34.7% Adjusted for age, sex, year of diagnosis, chemotherapy, radiation therapy, and residence and medical referral regions. Pancreas (high ref group): Middle 1.38 (1.16–1.63) Low 1.90 (1.60–2.25)
Thobie et al. 2023 [38]	763 pts resected for PDAC	4 French digestive tumor registries	Hospital volume LV <41 hepatobiliary/pancrea		-Univariate analysis (level 2): LV ref group MV (HR 0.77 [0.62-0.95] HV (HR 0.64 [0.50-0.82]

Author, year	Procedure and population	Methods	Intervention	Outcomes of Interest	Brief results
France		between 2000 and 2014	tic/y), MV 41-233 and HV (HV) >233		-Multivariate analysis (includes variables of age, sex, metastatic status, lymph node status, margin, chemotherapy and volume): LV ref group MV (0.71 [0.56-0.89]) HV (0.58 [0.42-0.81]) 90-day postoperative mortality: LV: 12.5% MV: 7.5% HV: 2.2%
Toomey et al. 2016 [39] USA	Pts undergoing PD	Outcomes after the last 50 PDs undertaken by 2 surgeons at HVH hospital (using the Leapfrog definition) in 2012 (ie, before relocation) were compared with the outcomes after the first 50 PDs undertaken by the same 2 surgeons at a LVH (no PDs in over 5 years) in 2012 to 2013 (ie, after relocation).	Hospital Volume (leapfrog criteria)	LoS, 30 d mortality	HV vs LV **LoS:** 8 (12 +/- 13.2) vs 7 (11 +/- 13.1), p=0.01 **30-d mortality:** 6% vs 4%, p=ns
Torphy et al. 2021 [40] USA	Pts with pancreatic cancer diagnosed from 2010-2016 undergoing MIPD	National Cancer Database	hospital volume	90-day and 30-day mortality	-On univariate analysis, both 90-day and 30-day mortality were reduced at higher cumulative MIPD volume facilities (P <0.001 and P <0.001) HV (>/= 35 MIPD cases): 90-day mortality, 2.36% 30-day mortality, 1.23% -After controlling for patient, tumor and facility-related variables, there was a significant association of higher facility cumulative MIPD case volume and reduced 90-day mortality (OR for log-transformed cumulative MIPD case volume 0.81; 95% CI [0.69, 0.95]; P = 0.009) -Annual open PD volume was independently protective for pts undergoing MIPD (OR 0.98; 95% CI [0.97, 0.99]; P = 0.049)
vanderGeest et al. 2016 [41] Netherlands	420 pts underwent PD for primary pancreatic or periampullary carcinoma (2005–2013)	the Netherlands Cancer Registry	hospital volume (<5, 5–19, 20–39 and >=40 PDs/year)	90 d postoperative mortality, survival	**90-d postoperative mortality:** Univariate (>= 40/year ref group), OR (95% CI), p=0.002 <5/y: OR 2.41 (1.28-4.56) 5–19/y: OR 2.18 (1.39-3.41) 20–39/y: OR 1.75 (1.11-2.78) Multivariate (>= 40/year ref group), OR (95% CI) <5/y: OR 2.59 (1.32-5.09), p=0.006 5–19/y: OR 2.11 (1.32-3.38), p=0.002 20–39/y: OR 1.72 (1.08-2.74), p=0.023 % 90-d mortality:

Author, year	Procedure and population	Methods	Intervention	Outcomes of Interest	Brief results
					<5/y: 9.7% 5–19/y: 8.9% 20–39/y: 7.3% >40/y: 4.3% **OS:** Univariate (>= 40/year ref group), OR (95% CI), p=0.002 <5/y: OR 1.31 (1.08-1.59) 5–19/y: OR 1.23 (1.09-1.40) 20–39/y: OR 1.10 (0.97-1.26) Multivariate (>= 40/year ref group), OR (95% CI) <5/y: OR 1.34 (1.09-1.65), p=0.006 5–19/y: OR 1.24 (1.09-1.42), p=0.002) 20–39/y: OR 1.10 (0.97-1.26), p=0.14
Wirth et al. 2022 [42] Switzerland	272 pts undergoing pancreatic resections	Retrospective analysis is based on anonymized claims data of pts with mandatory health insurance and hospital volume from Helsana Groupand Quality Indicators dataset	Hospital Volume ≤15, 16–30, 31–40, >40	inpatient cost (CHF), LoS, mortality	**Inpatient cost (Mean (SD)/Median):** ≤15: 21,421 (12,131) / 20,739 16–30: 21,907 (10,234) / 19,595 31–40: 21,989 (11,981) / 20,542 >40: 25,143 (26,557) / 16,098 **LoS (Mean (SD)/Median):** ≤15: 22 (13) / 19 16–30: 24 (13) / 21 31–40: 21 (11) / 18 >40: 21 (21) / 14 **Mortality N (%):** ≤15: 7 (9%) 16–30: 7 (9%) 31–40: 4 (5%) >40: 1 (4%)

AHV, annual hospital volume; AVC, annual volume centres; CHF, Confoederatio Helvetica franc; CHHS, California Health and Human Services Agency; CI, confidence interval; DP, distal pancreatectomy; EBS, evidence-based series; HR, hazard ratio; HV, high volume; HVC, high volume centre; HVH, high volume hospital; INCP, Integrated Network Cancer Program; IPTW, inverse probability of treatment weighting; IQR, interquartile range; LOS, length of stay; LV, low volume; LVC, low-volume centers; MI, minimally invasive; MIPD, minimally invasive pancreaticoduodectomy; mths, months; MV, medium volume; MVC, medium-volume centers; nAVC, non-accredited volume centre; NCDB, National Cancer Data Base; NSW, New South Wales; OR, odds ratio; OS, overall survival; PAC, pancreatic adenocarcinoma; PAN, pancreatectomy; PD, pancreatoduodenectomy; PDAC, pancreatic ductal adrenocarinoma; PPD, pylorus-preserving pancreaticoduodenectomy; PR, pancreatic resection; pts, patients; RR, risk ratio; SD, standard deviation; SEER, Surveillance, Epidemiology and End Results; SVI, social vulnerability index; TO, textbook outcome; UGI, upper gastrointestinal; VHV, very high volume; y, year; yr, year.

* The requirements for TO are as follows: lymph node count is adequate (12 or more nodes), margins are negative (defined as microscopically negative or R0), length of stay is less than the 75th percentile (13 days), there is no 30-day readmission, there is no 30-day mortality, and appropriate timely adjuvant therapy is given.

Table 2b. Pancreatic and surgeon volume primary studies meeting inclusion criteria for EBS 17-2

Author, year	Procedure and population	Methods	Intervention	Outcomes of Interest	Brief results
Aquina et al. 2021 [11] USA	PAN	Data sources include Medicare, the Statewide Planning and Research Cooperative System, and Nationwide Inpatient Sample	Surgeon Volume (high vs low; pancreatectomy ≥10) Based on Leapfrog group's minimum annual standards	Complications 90-day mortality	Surgical Volume *Multivariate analysis of association between leapfrog minimum volume strata and outcomes controlling for age, sex, race, Elixhauser comorbidities, nonelective admission, minimally invasive approach, procedure type, year of surgery

Author, year	Procedure and population	Methods	Intervention	Outcomes of Interest	Brief results
		between Jan 1, 2013 - Sept 30, 2017.	**data on hospital volume was also extracted and can be found in Table 2a.		**Complication (medicare population vs New York state population; OR (95% CI):** LVS at LVH: Reference LVS at HVH: 0.74 (0.64-0.85) vs. 0.81 (0.61-1.05) HVS at LVH: 0.80 (0.66-0.94) vs. 0.61 (0.41-0.86) HVS at HVH: 0.63 (0.56-0.70) vs. 0.63 (0.49-0.80) LVS at LVH: Reference LVS at HVH: 0.59 (0.46-0.74) vs. 0.94 (0.63-1.47) HVS at LVH: 0.79 (0.62-1.03) vs. 0.53 (0.26-1.05) HVS at HVH: 0.53 (0.44-0.64) vs. 0.55 (0.37-0.83) % 90-day mortality: 8.2%
Cannas et al. 2024 [43] USA	Pts undergoing PD	A total of 8189 PDs performed by 82 surgeons at 18 international, high-volume institutions (median: 140 PD/year) composing the PFSG were accrued from January 2003 to April 2023.	Surgeon Volume 4 quartiles (≤ 150, 151-285, 286-525, and ≥ 526 PDs)	Mortality, LOS	N= 8189 **Mortality (low quartile to high):** 2.1, 2.6, 2.5, 1.8 **LoS (low quartile to high):** ≤ 8 days: 47.8, 44.7, 60.2, 63.3 > 8 days: 52.2, 55.3, 39.8, 36.7 Multivariate analysis (low quartile reference group): **Mortality:** 2nd quartile: OR = 1.226 (0.787-1.90), p =0.367 3rd quartile: OR = 1.186 (0.765-1.839), p =0.446 4th quartile: OR = 1.094 (0.656-1.823), p=0.731 **LOS:** 2nd quartile: OR = 0.885 (0.748-1.049, p =0.159 3rd quartile: OR = 0.617 (0.522-0.73), p =<0.001 4th quartile: OR = 0.704 (0.575-0.86), p=0.001
Gani et al. 2016 [44] USA	969 pts undergoing pancreatic surgery from 2011-2013	Retrospective cross-sectional study	Surgeon volume and anesthesiologist volumes providers (anesthesiologist and surgeons) were categorized as "low" and "high" providers based on the 75th percentile for their respective annual volume (surgeon; >54 cases/y, anesthesiologist; >7 cases/y)	LOS, total hospital charges	Annual case volume for surgeons: 5-101 cases/yr Each anesthesiologist was involved in a fewer number of pancreatic resection cases per year compared with each surgeon with a maximum of 15 pts treated by the same anesthesiologist. Multivariate analysis adjusting for surgeon and anesthesiologist volume, age, CCI, ASA physical classification, grade, BMI, and in-hospital complication **Extended LOS:** (LV ref group) HV surgeon: OR 1.74 (95% CI 1.20-2.53), p=0.003 HV anesthesiologist: OR=0.80 (95% CI 0.55-1.17), p=0.254 Multivariate analysis adjusting for surgeon and anesthesiologist volume, age, CCI, ASA physical classification, grade, BMI, insurance status, in-hospital complication and LOS

Author, year	Procedure and population	Methods	Intervention	Outcomes of Interest	Brief results
					Total hospital charges: (LV ref group) HV surgeon: OR 0.98 (95% CI 0.94-1.04), p=0.652 HV anesthesiologist: OR 0.96 (95% CI 0.92-1.02), p=0.174 In hospital mortality: LV surgeon: 1.1% HV surgeon: 0.3%
Ho et al. 2017 [19] USA	Pts undergoing PR	Medicare hospital and inpatient claims 2005-2009 were analyzed for 6 cancer resections: colectomy, rectal resection, pulmonary lobectomy, pneumonectomy, esophagectomy, and pancreatic resection. Only PR reported.	Surgical Volume ** data on hospital volume was also extracted and can be found in Table 2a	Costs	Higher surgeon volume reduces costs for most procedures, but this result weakens when processes of care are added to the regressions.
Paredes et al. 2020 [45] USA	Pts who underwent PD	Medicare SAFs from 2013-2015	PD surgeon specific volume The median annual number of PDs performed by surgeons in the highest volume tier was 24 (IQR 21-29), whereas surgeons in the lowest tier performed 2 PDs annually (IQR 1-3) (p < 0.001)	complications	-Annually, surgeons with the lowest surgical volume operated at a hospital with the fewest median number of annual PDs (highest volume tier: 34, IQR 27-74 vs lowest volume tier 4, IQR 2-10, p < 0.001) -Pts of surgeons in the lowest volume PD tier had 43% greater odds of suffering a complication versus pts of surgeons in the highest PD volume tier (OR 1.43, 95% CI 1.11-1.84) 30-day mortality: Lowest surgeon volume: 8% Highest surgeon volume: 3.3% 90-day mortality: Lowest surgeon volume: 12.4% Highest surgeon volume: 5%
Pointer et al. 2018 [46] USA	adults (≥18 years) with pancreatic cancer who underwent either pancreatic resection or other interventions.	Nationwide Inpatient Sample (NIS) database, 2003-2009.	low-volume surgeons group (1-5 surgeries/year) and high-volume surgeons group (≥6 surgeries/year) ** data on hospital volume was also extracted and can be found in Table 2a	postoperative complication risk, mortality risk, length of stay ≈	-Pts who underwent pancreatic surgery by high-volume surgeons had a lower postoperative complications risk (10.4% vs. 18.1%, P<0.001), and lower mortality risk (2.1% vs.4.8%, P=0.008) -surgeries performed by high-volume surgeons associated with a shorter hospital stay and lower healthcare cost (P<0.05 for all).

Author, year	Procedure and population	Methods	Intervention	Outcomes of Interest	Brief results
Uttinger et al. 2022 [47] Germany	57,343 pancreatic pts	Retrospective analysis of anonymized nationwide hospital billing data (DRG data, 2009-2017)	surgical minimum caseload (SMC) The annual minimum caseload was 20 PR **data on hepatic surgeon volume was also extracted and can be found in Table 3b.	LoS, in-house mortality	**LoS (fulfilled SMC over yrs vs not):** Pancreatic 24.9 (+/- 19.0) vs 26.5 (+/- 17.8) **in-house mortality (fulfilled SMC over yrs vs not):** Pancreatic 6.1% vs 9.8%, p <0.001 -Multivariate regression, adjusting for age, comorbidities, and surgery complexity, SMC fulfillment was 0.59 (95% CI 0.49-0.71, p < 0.001) for pancreatic resections.
Vuong et al. 2018 [48] USA	pts undergoing distal pancreatectomy (DP) and pancreaticoduodenectomy (PD) between January 2014 and July 2017	Retrospective review of a prospectively collected administrative database	Surgeon volume "volume pledge" criteria (HV = >5 PDs/year) Second analysis was performed using the Leapfrog group's definition of a high-volume hospital (HVH) (>= 11 pancreatic resections annually), which was applied to surgeon volume	Median LoS, 30-day and 90-day mortality rates, costs	Volume pledge **LoS (d,mean; median):** (LV vs HV) PD: 14.1; 11.0 vs 11.0; 9.0, p<0.001 DP: 10.8; 7.0 vs 7.3; 6.0 p<0.001 **30-d mortality (n, %):** (LV vs HV) PD: 4 (5.0) vs 11 (2.5), p= 0.26 DP: 1 (1.2) vs 0 (0.0), p= 0.31 **90-d mortality (n, %):** (LV vs HV) PD: 4 (5.0) vs 15 (3.4), p=0.51 DP: 2 (2.4) vs 3 (1.6), p=0.65 **Total Cost, $, mean; median:** (LV vs HV) PD: 27,175; 24,706 vs 24,241; 21,026, p=0.005 DP: 22,792; 15,856 vs 17,579; 14,016, p= 0.25 Leapfrog **LoS (d,mean; median):** (LV vs HV) PD: 12.1, 10.0 vs 11.2, 8.0, p=0.01 DP: 10.0, 6.5 vs 7.0, 6.0, p=0.005 **30-d mortality (n, %):** (LV vs HV) PD: 7 (4.2) vs 8 (2.2), p= 0.26 DP: 1 (0.8) vs 0 (0.0), p =0.46 **90-d mortality (n, %):** (LV vs HV) PD: 8 (4.8) vs 11 (3.1), p =0.33 DP: 3 (2.4) vs 2 (1.4), p= 0.66 **Total Cost, $, mean; median:** (LV vs HV) PD: 24,572; 21,605 vs 24,742; 21,373, p =0.55 DP: 21,440; 14,622 vs 17,299; 14,015, p= 0.15

ASA, American Society of Anesthesiologists; BMI, body mass index; CCI, Charlson Comorbidity Index; CI, confidence interval; DP, distal pancreatectomy; DRG, diagnosis-related group; EBS, evidence-based series; HV, high volume; HVH, High volume hospital; HVS, high-volume surgeon; IQR, interquartile range; LOS, length of stay; LV, low volume; LVH, low-volume hospital; LVS, low-volume surgeon; NIS, Nationwide Inpatient Sample; OR, odds ratio; PAN, pancreatectomy; PD, pancreatoduodenectomy; PFSG, Pancreas Fistula Study Group; PR, pancreatic resection; pts, patients; SAFs, standard analysis files; SMC, surgical minimum caseload; y, year; yr, year.

Table 3a. Hepatic and hospital volume primary studies meeting inclusion criteria for EBS 17-2

Author, year, etc	Procedure and population	Methods	Intervention	Outcomes of Interest	Brief results
Ardito et al. 2020 [49] Italy	Liver resection for hepatocellular carcinoma	Surgical Italian registry of HCC Recurrence collected pts who underwent liver resection for Hepatocellular carcinoma between 2008 and 2018 (retrospective) and prospective data started September 2019	Hospital volume Volume cutoff: LVC 21 to 50 liver resections/y intermediate volume centre 51 to 100 liver resections/y HVC >100 liver resections/y	90-day mortality, major complications, failure to rescue	**Ninety-day mortality rate:** 3.7%, 4.2% and 0.9% for low-, intermediate- and high-volume centers, p< 0.001 **Major complication:** 8.6%, 12.3%, and 7.0% for low-, intermediate- and high-volume centers, respectively, p= 0.001 **Failure to rescue:** Low (28.6%), intermediate (26.5%) were higher than high volume centers (6.1%, p=0.002)
Beal et al. 2019-b [50] USA	pts undergoing surgical resection of hepatocellular carcinoma. Procedures included wedge/segmental resections (N = 7354, 59.9%), hemi-hepatectomy (N = 4003, 32.6%), and extended hepatectomy (N = 909, 7.5%)	Pts identified using 2004-2015 National Cancer Database.	Hospital volume LV- <= 1 case per year intermediate LV- 1.1-4 intermediate HV- 4.1-12.5 HV- = > 12.5	mortality, OS, positive surgical margin (PSM)	N = 12,266 pts **Mortality:** -HV hospital was associated with decreased hazard of mortality (HR 0.69, 95% CI 0.58-0.82, p < 0.001). -only HV hospital was associated with mortality (HR 0.67, 95% CI 0.56-0.80, p < 0.001) after controlling for both travel distance and hospital volume **OS:** -pts treated at high-volume hospitals(> 12.5 cases per year) had the highest median survival (median survival; 1st 30.49 mths vs 2nd 31.84 mths vs 3rd 37.65 mths vs 4th 51.7 mths, log-rank p value = 0.030) **PSM:** HV was not associated with decreased risk of PSM (HV: OR 0.72, 95% CI 0.47-1.12). -In addition, when both hospital volume and travel distance were included, neither variables were associated with decreased risk of PSM (HV: OR 0.71, 95% CI 0.46-1.10; Long Travel: OR 1.05, 95% CI 0.86-1.29) (all p > 0.05).
Buettner et al. 2016 [51] USA	Pts undergoing liver surgery for cancer, 61.0% partial hepatectomy, 39.0% hepatic lobectomy	Nationwide Inpatient Sample 2001-2009	Hospital Volume- low to high, <= 11 cases/yr, >11 and <45 cases/yr, = > 46 cases/yr	in-hospital mortality **data on surgeon volume was also extracted and can be found in Table 3b.	N= 5,075 pts **In-hospital mortality:** low vs intermediate vs high hospital volume: 4.5 vs 3.2 vs 1.8%, p < .001 Multivariable regression adjusting for sociodemographic and hospital characteristics Hospital volume (without surgeon volume): high (ref group) med OR 2.00 (1.24-3.21), p=0.004 low OR 2.13 (1.31-3.47), p=0.002
Chang et al. 2014 [52] Taiwan	13,159 pts who underwent hepatic resection	Taiwan National Health Insurance Research Database (2002-2006)	hospital volume: HV = >245 cases	30-day, 3-month, 1 year mortality risk	Multivariate regression adjusted for pts' age, gender, indication for surgery, surgical procedure, comorbidity, hepatitis/cirrhosis, pre-and post-operative cirrhosis-related complication, socioeconomic status, geographic region and urbanization level of residence.

Author, year, etc	Procedure and population	Methods	Intervention	Outcomes of Interest	Brief results
				**data on surgeon volume was also extracted and can be found in Table 3b.	**Mortality risk:** LV hospital compared to HV: 30-day: HR 1.50 (95% CI, 1.09-2.07) **3-month:** HR 1.56 (95% CI, 1.30-1.86) **1 year:** HR 1.33 (95% CI, 1.21-1.46) Combined effect compared to HV surgeon in HV hospital: **30-day mortality risk:** LV surgeon HV hospital: HR 1.81 (1.06-3.08), p=0.028 HV surgeon LV hospital: HR 1.98 (0.99-3.96), p=0.051 LV surgeon LV hospital: HR 2.15 (1.33-3.46), p=0.002 **3-month mortality risk:** LV surgeon HV hospital: HR 1.66 (1.24-2.22), p=0.001 HV surgeon LV hospital: HR 1.90 (1.30-2.79), p=0.001 LV surgeon LV hospital: HR 2.08 (1.61-2.69), p<0.001 **1-yr mortality risk:** LV surgeon HV hospital: HR 1.33 (1.16-1.53), p <0.001 HV surgeon LV hospital: HR 1.28 (1.05-1.56), p=0.013 LV surgeon LV hospital: HR 1.58 (1.40-1.78), p<0.001
deGeus et al. 2021 [53] USA	7,265 pts who underwent liver resection for hepatocellular carcinoma.	The National Cancer Database (2004-2014)	Hospital volume LV hospital for both liver resection and HPB; Mixed-volume hospital- LV liver resection but HV HPB operations; HV hospital- HV for both liver resection and HPB operations Hospitals dichotomized as LV- and HV based on: HPB: less than vs more than or equal to 22 operations/y LR: less than vs more than or equal to 7/y	30-day mortality, LOS, OS	**30-day mortality:** LV: 8.1%, Mixed volume 3.3%, HV 4.0% LV (vs HV): OR 1.753; 95% CI, 1.389 to 2.212; p < 0.001 MV vs HV: OR 0.789; 95% CI, 0.495 to 1.257; p = 0.318 **LOS:** LV 28.2% (n =769), MV: 23.0% (n = 147), HV: 23.6% (n = 921) LV (vs HV: OR 1.201; 95% CI, 1.061 to 1.359; p = 0.004) MV (vs HV: (OR 0.952; 95% CI, 0.778 to 1.164; p = 0.630) **OS:** Median unadjusted OS 5 yrs: LV : 37.5 mths (95% CI, 34.8 to 39.8 mths) MV : 46.8 mths (95% CI, 40.4 to 55.5 mths) HV: 48.7 mths (95% CI, 45.8 to 51.5 mths) -After stratifying for tumor size and operation types (wedge or segmental resection or hepatectomy NOS and lobectomy or extended lobectomy) or only tumor size, pts who underwent hepatectomy: LV vs MV (HR 1.235; 95% CI, 1.095 to 1.393; p < 0.001) LV vs HV (HR 1.247; 95% CI, 1.166 to 1.333; p < 0.001). MV vs HV (HR 0.994; 95% CI, 0.882 to 1.119; p = 0.915).
Diaz et al. 2021 [54] USA	13,379 adults underwent a hepatectomy in 229 hospitals	the California Office of Statewide Health Planning database (2005-2016)	hospital volume HV= = > 15 cases/yr	LOS, mortality	**LOS:** LV 6 days vs HV 6 days **mortality:** LV 2.2% vs HV 1.4% Among pts who bypassed a closer hospital, 9258 (75.5%) individuals

Author, year, etc	Procedure and population	Methods	Intervention	Outcomes of Interest	Brief results
					underwent hepatectomy at a HV center; in contrast, only 418 (37.3%) pts who did not bypass the nearest hospital had surgery at a HV center (p < 0.05).
Diggs et al., 2021 [55] USA	4263 pts with primary liver malignancies managed with major hepatectomy	National Cancer Database (2006-2015)	Hospital Volume HV > 15 hepatectomies/yr	90-day mortality	**90-day mortality** LV vs HV 12.0% vs 7.5%, p<0.001 RR = 1.60 (CI 1.25-2.05; P < .001)
Endo et al. 2024 [56] USA	22,969 pts from 340 institution who underwent hepatectomy	Medicare Standard Analytic Files and linked with facility-level data from the American Hospital Association Survey database 2013-2021	hospital volume Using a cut-off of 20 cases per year, 34 hospitals were categorized as HV centers, whereas 306 were classified as LV centers.	post operative complications, in-hospital mortalities	HV centers remained less likely to experience postoperative complications (n = 3,893, 39.9% vs n=4,069, 41.7%, P=.01) and in-hospital mortality (n = 215, 2.2% vs n = 269, 2.8%, P = .02 Relative to risk of complications, 42.3% of the difference noted among HV compared LV centers was attributable to indirect mediators rather than hospital volume itself. Notably, other hospital characteristics, such as bed capacity and nurse-to-bed ratio, accounted for 29.9% of the total difference observed among HV compared LV centers. In contrast, teaching hospital status and LT program status contributed only 7.2% and 5.2% of the total difference. Relative to in-hospital mortality, 61.8% of the variability at HV compared LV centers were directly attributable to HV center status. In contrast, hospital bed capacity and nurse-to-bed ratio contributed 17.0% of the variability, whereas a smaller proportion of the variability was attributable to LT program status (11.8%) and teaching hospital status (9.4%)
Gani et al. 2017 [57] USA	A total of 14,296 pts >18 years undergoing an elective liver resection (LR) for cancer	Retrospective analysis using National Inpatient Sample from 2001 to 2011	Hospital volume across time Cut offs: LV <12 operations/year), intermediate-volume (12-45 operations/year), or HV (>45 operations/year) hospitals. 3 time periods: time period 1, 2001-2004; time period 2, 2005-2008; and time period 3, 2009-2011.	Postoperative mortality; postoperative morbidity	**postoperative morbidity:** Adjusting for patient case mix and time periods, LV reference group: HV: 29%, OR = 0.71, 95% CI = 0.59-0.86, p < 0.001 intermediate: 17%, OR = 0.83, 95 %CI = 0.74-0.94, p = 0.003 **postoperative mortality:** adjusting for patient characteristics and time period, LV reference group: HV: 32 %, OR = 0.68, 95% CI = 0.51-0.92, p = 0.011 intermediate: 22%, OR = 0.78, 95 % CI = 0.61-0.99, p = 0.044
Hallet et al. 2023 [18] Canada	Adults undergoing esophagectomy, pancreatectomy, or hepatectomy for cancer from 2007 to 2018.	Population-based retrospective cohort study using administrative health care data sets in Ontario.	high-volume anesthesiology care at the hospital level Hepato-pancreatico-biliary cancer surgery has been concentrated	90-day major morbidity defined as the hospital rate of pts receiving care by an	- Hepatectomy and pancreatectomy accounted for 58.6% of surgeries -The median anesthesiologist volume was 6 (interquartile range: 3.5-10.5) procedures per year, median surgeon volume was 27 (interquartile range: 15.5-45.5) procedures per year, and the median hospital volume was 189.0 (71.5-358.0) procedures per year. -Ninety-day major morbidity occurred in 2793 (35.4%) pts, including 393 (5%) death events.

Author, year, etc	Procedure and population	Methods	Intervention	Outcomes of Interest	Brief results
			to 10 designated centers of excellence since 2006 with minimum requirements for institution annual procedural volume, surgeon fellowship training, and postoperative care resources, including availability of interventional radiology, etc. **data on hospital volume for pancreatic was also extracted and can be found in Table 2a.	anesthesiologist with procedure volume ,≥6 procedures per year	-the unadjusted RR between the hospital rate of high-volume anesthesiology care (by 10% increments) and the hospital rate of postoperative major morbidity was 0.97 (95% CI, 0.95-0.98; P=0.002 -After adjusting for patient age, sex, and comorbidity burden, type of procedure, surgery approach, hospital teaching status, intraoperative anesthesia handover, year of surgery, and annual surgeon volume, the association remained significant with adjusted RR of 0.96 (95% CI, 0.95-0.98; P<0.001).
Hashimoto et al. 2017 [58] USA	18 years who underwent wedge hepatectomy or lobectomy	The New York Statewide Planning and Research Cooperative System inpatient database-2000-2014	Annual Surgeon volume + surgeon experience + surgeon specialty	inpatient mortality	On subset analysis, annual surgeon volume was a significant predictor of inpatient mortality for early career surgeons and general surgeon. For every ten additional cases performed per year there were significantly decreased odds of inpatient mortality for early career surgeons (OR 0.81, 95% CI 0.73-0.92, p=0.001) and general surgeons (OR 0.65, 95% CI 0.5-0.85, p=0.002). Annual surgeon volume was not a significant factor in prediction of inpatient mortality for late career surgeons (OR 0.97, 95% CI 0.89-1.06, p=0.5), SO (OR 1.08, 95% CI 0.92-1.28, p=0.3), or TS (OR 0.92, 95% CI 0.8-1.04, p=0.2).
Khalil et al. 2023 [59] USA	Pts who underwent surgery for hepatocellular carcinoma (HCC) between 2004 and 2018	National Cancer Database	Hospital volume HV 22 cases/yr; low <5 cases/yr TO: TO was defined as R0 margin resection, no extended length of stay, no 30-day readmissions, no 90-day mortality, and no extended length of stay.	5 yrs OS; readmission within 30 days, LOS, mortality at 90 days	Pts treated at high-volume hospitals were less likely to experience readmission within 30 days (5.7% vs. 6.7%), mortality within 90 days of the index operation (4.4% vs. 11.9%), extended length of stay (21.1% vs. 24.2%), and were more likely to achieve an R0 surgical resection (95.4% vs. 82.5%) versus pts who underwent surgery at low-volume hospitals (all p<0.001) **5-yr OS:** both the achievement of TO (TO vs. no TO: 63.0% vs. 50.4%) and treatment at a high-volume hospital (high-volume hospital vs. low-volume hospital: 71.1% vs. 40.4%) were independently associated with improved 5-year OS -pts who underwent surgery at a high-volume hospital who did not achieve TO still had better 5-year OS than pts who underwent surgery at a low-volume hospital and achieved TO (TO vs. no **TO:** high volume hospitals: 74.9% vs. 62.6%, low volume hospitals; 48.6% vs. 26.5%; p<0.001) -After accounting for competing risk factors, including the achievement of a TO, undergoing HCC resection at a high-volume hospital was

Author, year, etc	Procedure and population	Methods	Intervention	Outcomes of Interest	Brief results
					independently associated with a 54% reduction in long-term mortality (HR=0.46, 95% CI 0.42-0.50)
Magnin et al. 2023 [60] France	39 286 Pts who underwent liver resection between 2011 and 2019	retrospective study using a nationwide database	Hospital volume HV > 25 resections/y	in-hospital mortality	multivariable analysis, adjusted **post-operative mortality (HV vs LV):** adjusted OR 0.74, 95% CI 0.58 to 0.93; P< 0.001 Rates of in-hospital postoperative mortality and failure to rescue related to general complications were higher in liver resections performed by laparotomy Minor hepatectomies: adjusted OR 0.80, 0.65 to 0.99; P=0.004 Major hepatecomies: adjusted OR 0.83, 0.63 to 1.10; P=0.190 In-hospital mortality, 30-day mortality, and 90-day mortality rates were lower in high- than in low-volume center (2.6% vs 3%; P < 0.001).
Olthof et al. 2020 [61] Netherlands	pts who underwent liver surgery in the Netherlands	retrospective nationwide study Dutch Hepato Biliary Audit between 2014 and 2017	hospital volume In the NL, requirements for treating several tumors, including liver tumors and surgery, have been defined by SONCOS. These include requirements such as 24/7 availability of an interventional radiologist, 2 skilled hepatobiliary surgeons, etc.	morbidity	Multivariable analyses with corrections for confounding variables **Morbidity:** 20-39 (reference) <20 OR 0.82 (0.45-1.44) 40-59 OR 1.16 (0.81-1.67) 60-79 OR 1.05 (0.73-1.53) = > 80 OR 1.41 (0.91-2.19)
Sahara et al. 2020 [62] USA	Pts undergoing LR (liver resection) between 2013 and 2015 minimally invasive LR (MILR) Open LR (OLR)	Medicare inpatient Standard Analytic Files	Hospital volume **data on surgeon volume was also extracted and can be found in Table 3b.	complication, mortality, 30- and 90-day readmission	Hospital Volume -pts treated at high-volume hospitals were less likely to experience a post-operative complication (n = 343, 19.4% vs. n = 570, 23.8%, p < 0.001), 30-day mortality (n = 63, 3.6% vs. n = 158, 6.6%, p < 0.001), 90-day mortality (n = 110, 6.2% vs. n = 260, 10.9%, p < 0.001), and longer LOS (median LOS 6, IQR 4-8 vs. 6, IQR 5-10, p < 0.001) compared with pts treated at low volume centers. 90-day mortality: HV hospital: 6.2%; LV hospital 10.9%
Shaikh 2024 [63] USA	Pts diagnosed with hepatocellular carcinoma from 2013 to 2017	Medicare Standard Analytic Files	Hospital volume High-volume centers were defined as the top decile of facilities performing hepatectomies in a year	complication, cost	**Complication:** -resection at an HV was associated with a lower incidence of experiencing at least 1 complication (LV: n = 1,392, 26.8%, HV: n = 1,976, 23.3%; P < .001 **Cost:** - overall expenditures associated with an episode of care for a patient undergoing resection of HCC was higher at an HV versus LV (LV: $19,631,

Author, year, etc	Procedure and population	Methods	Intervention	Outcomes of Interest	Brief results
					IQR $15,525-28,551 HV: $18,209, IQR $14,959-29752; P < .001). -univariate analysis: the cost differential associated with resection of HCC at a HV versus LV was $1,722(95% CI $850-$2,594) with a survival benefit of 0.16 years (95% CI 0.08-0.24) or 2 mths. - After adjustment for demographic, clinicopathologic, and facility differences among pts, the cost differential associated with a surgical episode of care at an HV versus LV was $1,070 (95% CI$479-$1,392) with a survival benefit of 0.14 years (95% CI 0.06-0.22) or 1 month and 3 weeks. The adjusted ICER for the cost of this survival benefit was $7,951 per life-year (95% CI $4,236-$21,217).
Sutton et al. 2016 [64] USA	pts undergoing hepatic lobectomy	The University HealthSystems Consortium database (2009-2011)	hospital volume (for 2010) LV- 1-16 cases MV- 17-29 cases HV- 30-86 cases	readmission,	**readmission:** surgical intervention at a high-volume hospital was associated with a lower risk of readmission (OR 0.67, [0.53-0.85], p<0.001) relative to low-volume centers **cost:** when both index and readmission costs were considered relative to center volume and readmission rates, per-patient cost at low-volume centers was 21.9 % higher than at high-volume centers ($19,669 vs. $16,137), this was associated with readmission rates of 10.6 and 16 % for high and low volume hospitals. Perioperative mortality: LV: 2.3% MV: 3.0% HV: 1.7%
Uhlig et al. 2019 [65] USA	Pts with hepatocellular carcinoma (HCC).	2004–2015 NCDB	Hospital Volume Top 10% = HV Lower 90% = LV	OS	**OS:** (LV ref) multivariable after adjustment for cancer variables and pts demographics HV = HR 0.789 (0.771-0.808), p <0.001 30-day mortality: HV academic: 1.0% HV non-academic: 1.2% 90-day mortality: HV academic: 1.8% HV non-academic: 2.1%

CI, confidence interval; EBS, evidence-based series; HCC, heptatocellular carcinoma; HPB, hepatopancreaticobiliary; HR, hazard ratio; HV, high volume; HVC, high volume centre; ICER, incremental cost-effectiveness ratio; IQR, interquartile range; LOS, length of stay; LR, liver resection; LT, liver transplant; LV, low volume; LVC, low-volume centers; MILR, minimally invasive liver resection; mths, months; MV, medium volume; NCDB, National Cancer Data Base; NOS, not otherwise specified; OLR, open liver resection; OR, odds ratio; OS, overall survival; PSM, positive surgical margin; pts, patients; RR, risk ratio; SO, surgical oncology; TO, textbook outcome; TS, transplant surgeon; y, year; yr, year.

Table 3b. Hepatic and surgeon volume primary studies meeting inclusion criteria for EBS 17-2

Author, year	Procedure and population	Methods	Intervention	Outcomes of Interest	Brief results
Buettner et al. 2016 [51] USA	Pts undergoing liver surgery for cancer, 61.0% partial	Nationwide Inpatient Sample 2001-2009	Surgery Volume -low to high, <=4 cases/yr, >4 and <16 cases/yr, = > 16 cases/yr	in-hospital mortality	N= 5,075 pts **In-hospital mortality:** low vs intermediate vs high surgical volume: 4.7 vs 3.4 vs 1.4%, p < .001

Author, year	Procedure and population	Methods	Intervention	Outcomes of Interest	Brief results
	hepatectomy, 39.0% hepatic lobectomy		**data on hospital volume was also extracted and can be found in Table 3a.		Multivariable regression adjusting for sociodemographic and hospital characteristics Surgeon volume (without hospital volume): high (ref group) med OR 2.56 (1.54-4.26), p< .001 low OR 3.01 (1.80-5.04), p<.001
Chang et al. 2014 [52] Taiwan	13,159 pts who underwent hepatic resection	Taiwan National Health Insurance Research Database (2002-2006)	surgeon volume: HV = > 25 cases. **data on hospital volume was also extracted and can be found in Table 3a.	30-day, 3-month, 1 year mortality risk	Multivariate regression adjusted for pts' age, gender, indication for surgery, surgical procedure, comorbidity, hepatitis/cirrhosis, pre-and post-operative cirrhosis-related complication, socioeconomic status, geographic region and urbanization level of residence. **Mortality risk:** LV surgeon compare to HV 30-day mortality: HR 1.64 (95% CI, 1.12-2.41) 3 month: HR 1.62 (95% CI, 1.31-2.00) 1 year: HR 1.41 (95% CI, 1.27-1.56) Combined effect compared to HV surgeon in HV hospital: **30-day mortality risk:** LV surgeon HV hospital: HR 1.81 (1.06-3.08), p=0.028 HV surgeon LV hospital: HR 1.98 (0.99-3.96), p=0.051 LV surgeon LV hospital: HR 2.15 (1.33-3.46), p=0.002 **3-month mortality risk:** LV surgeon HV hospital: HR 1.66 (1.24-2.22), p=0.001 HV surgeon LV hospital: HR 1.90 (1.30-2.79), p=0.001 LV surgeon LV hospital: HR 2.08 (1.61-2.69), p<0.001 **1-yr mortality risk:** LV surgeon HV hospital: HR 1.33 (1.16-1.53), p <0.001 HV surgeon LV hospital: HR 1.28 (1.05-1.56), p=0.013
Chapman et al. 2017 [66] USA & Puerto Rico	12,757 pts undergoing hepatic resection for hepatocellular carcinoma	National Cancer Data Base (NCDB) (1998 to 2011) retrospective cohort study	Academic cancer program (ACP) Comprehensive community cancer program (CCCP) Community Cancer programs (CCP) High volume cancer program (HVCP) = > 10 or more hepatectomies/yr	5- and 10-year OS	**Adjusted 5-year OS:** ACP, CCCP, CCP= 46.7%, 42.8%, 37.9%, p = 0.0124 **Adjusted 10-year OS:** ACP, CCCP, CCP= 31.7%, 28.0%, 23.5%, p = 0.0332 **Adjusted 5 year OS:** high volume ACP: 43.9% high volume CCCP: 43.3% low volume ACP: 39.9% low volume CCCP: 39.7% **Adjusted 10 year OS:** high volume ACP: 28.7% high volume CCCP: 28.2% low volume ACP: 25.1% low volume CCP: 24.9%
Sahara et al. 2020 [62] USA	Pts undergoing LR (liver resection) between 2013 and 2015	Medicare inpatient Standard Analytic Files	Surgeon volume: low (≤ 2 cases), medium (3-5 cases), or high (≥ 6 cases)	complication, mortality, 30- and 90-day readmission	Surgeon Volume -The RCS plot demonstrated that increasing surgeon volume was associated with decreasing odds of experiencing a postoperative complication and death within 90 days

Author, year	Procedure and population	Methods	Intervention	Outcomes of Interest	Brief results
	minimally invasive LR (MILR) Open LR (OLR)		**hospital volume data was also extracted and can be found in Table 3a.		- On multivariate analysis, the odds of experiencing a complication, 90-day readmission, and 90-day mortality did not differ among pts undergoing surgery with an MIS versus open approach among either low- or high-volume surgeons. Unadjusted 90-day mortality: HV surgeons: 5%; LV surgeons: 9.9% 30-day mortality: HV surgeons: 3%; LV surgeons: 10.9%
Uttinger et al. 2022 [47] Germany	28,791 liver resections pts	Retrospective analysis of anonymized nationwide hospital billing data (DRG data, 2009-2017)	surgical minimum caseload (SMC) The annual minimum caseload as set by the DKG (2019) was 25 for liver resections (including benign diagnoses) **data on surgeon volume for pancreatic was also extracted and can be found in Table 2b.	LoS, in-house mortality	**LoS (fulfilled SMC over yrs vs not):** Liver 21.9 (+/-19.2) vs 19.1 (+/- 14.8) **in-house mortality (fulfilled SMC over yrs vs not):** Liver 7.6% vs 7%. p =0.079 -Multivariate regression, adjusting for age, comorbidities, and surgery complexity, SMC fulfillment was 0.87 (95% CI 0.65-1.17, p = n.s.) for primary or secondary liver malignancy resections.

ACP, academic cancer program; CCCP, comprehensive community cancer program; CCP, community cancer programs; CI, confidence interval; DKG, Deutsche Krebsgesellschaft (German Cancer Society); DRG, diagnosis-related group; EBS, evidence-based series; HR, hazard ratio; HV, high volume; HVCP, high volume cancer program; LOS, length of stay; LR, liver resection; LV, low volume; MILR, minimally invasive liver resection; MIS, minimally invasive surgery; NCDB, National Cancer Data Base; n.s., not significant; OLR, open liver resection; OR, odds ratio; OS, overall survival; pts, patients; RCS, restricted cubic spline; SMC, surgical minimum caseload; yr, year.

Table 4a. Hepatico-pancreatico-biliary and hospital volume primary studies meeting inclusion criteria for EBS 17-2

Author, year	Procedure and population	Methods	Intervention	Outcomes of Interest	Brief results
Beal et al. 2019 [67] USA	Pts with a histologic diagnosis of cholangiocarcinoma with the primary site of liver or bile duct. Metastatic disease were excluded.	2004-2015 National Cancer Database	Hospital Volume Volume cutoff: 1st quartile (low volume): 6 cases/year 2nd quartile (intermediate low volume): 7 cases/year 3rd quartile (intermediate high volume): 12 cases/year 4th quartile (high volume): 24 cases/year	Mortality	N= 5,124 **Mortality (HR (95% CI):** LV was reference group: intermediate LV: 1.07 (0.96-1.20) p= 0.20 intermediate HV: 0.93 (0.83-1.04) p= 0.21 HV: 03 (0.93-1.15) p= 0.50 *multivariate analysis adjusted for age, sex, race, Charlson-Deyo score, insurance status, patient residence area, median income, education level, cT stage, and cN stage.

Author, year	Procedure and population	Methods	Intervention	Outcomes of Interest	Brief results
Julian et al. 2024 [68] USA	Pts who underwent surgery for liver (LC), biliary tract (BTC), and pancreatic (PDAC) cancer	National Cancer Database (2004-2018)	Hospital volume Hospitals were stratified by operative volume percentile. The top quintile comprised high-volume centers (HV) and the bottom quintile comprised low-volume centers (LV); the middle three quintiles comprised medium-volume centers (MVC) as performed in prior analyses.	LoS, 30- and 90-day mortality	Liver Cancer: (LV, MV, HV)% **LoS:** 5, 4, 4, p=0.045 **30-day mortality (LV, MV, HV) %:** 7.2, 4.6, 2.8, p<0.001 **90-day mortality (LV, MV, HV) %:** 11, 8, 5.8, p<0.001 BTC: (LV, MV,HV) % **LoS:** 8, 7, 6, p<0.001 **30-day mortality (LV, MV, HV) %:** 6.7, 4.9, 3.3, p<0.001 **90-day mortality (LV, MV, HV) %:** 13.3, 9.7, 6.7, p<0.001 Pancreatic: (LV, MV, HV) % **LoS:** 8, 7, 5, p<0.001 **30-day mortality (LV, MV, HV) %:** 4.1, 3.1, 2.1, p<0.001 **90-day mortality (LV, MV, HV) %:** 7.8, 6.6, 4.8, p<0.001
Ravaioli et al 2014 [69] Italy	Pts undergoing curative HPB resection	Pts were evaluated at an LV hospital before (2006-2008) and during the collaboration (2009-2012) and at 2 hospitals with HV for either liver or pancreatic resection (2009-2012).	hospital volume	mortality rate, LoS	The annual number of HPB surgeries at the LV center approximately doubled during the partnership, from 18 in 2006 to 40 in 2012. **Mortality Rate:** Liver 2006-2008 10.3% 2009-2010 5.7% 2011-2012 4% **Mortality Rate:** Pancreas 2006-2008 29.4% 2009-2010 14.8% 2011-2012 2.8% Length of hospital stay was shorter in the collaborative period than before, decreasing from a median of 10 to 7 days for liver procedures and from 14 to 11 days for pancreatic procedures, although neither change reached statistical significance.
Schneider et al 2014 [70] USA	Pts undergoing HPB surgery	Surveillance, Epidemiology and End Results (SEER)-Medicare linked data from 1986 to 2002	Hospital Volume Low volume [LV] <4 cases/year; intermediate volume [IV] 4-10 cases/year; high volume [HV] ≥11 cases/year	LoS, incidence of complications, in hospital mortality, mortality during readmission	**LoS (LV, IV, HV) days, SD:** 16.0 (15.7), 15.4 (13.8), 13.8 (11.1), p <0.001 **Complications (LV, IV, HV):** 1,352 (44.8 %), 1,588 (41.9 %), 1,328 (39.1 %), p<0.001 **In-hospital mortality (LV, IV, HV):** 317 (10.5 %), 306 (8.1 %), 182 (5.4 %), p <0.001 Mortality during readmission (among pts readmitted within 30 days n=1,733) (LV, IV, HV): 47 (10.4 %), 57 (8.5 %), 46 (7.5 %), p= 0.249

BTC, biliary tract; CI, confidence interval; cN, clinical node stage; cT, clinical tumor stage; EBS, evidence-based series; HR, hazard ratio; HPB, hepatopancreaticobiliary; HV, high volume; IV, intermediate volume; LC, liver cancer; LOS, length of stay; LV, low volume; MVC, medium-volume centers; PDAC, pancreatic ductal adrenocarinoma; pts, patients; SD, standard deviation; SEER, Surveillance, Epidemiology and End Results.

Table 4b. Hepatico-pancreatico-biliary and surgeon volume primary studies meeting inclusion criteria for EBS 17-2

Author, year	Procedure and population	Methods	Intervention	Outcomes of Interest	Brief results
Mise et al. 2023 [71] Japan	20 111 pts who underwent pancreatoduodenectomy (PD) and 9666 who underwent advanced hepatectomy defined as hepatectomy of more than one section during 2019 and 2020	National Clinical Database	Surgical Volume Minimum numbers of surgeries for board-certified A and B institutions are 50 and 30	30-day mortality, in-hospital mortality, LoS	PD (non-certified vs B vs A) **30 day mortality:** 1.7 vs 0.9 vs 0.6, p <.001 The OR of 30-day mortality after PD was greatly reduced at certified A (OR: 0.36, CI 0.26-0.50, p<.001) and certified B (OR: 0.50, CI: 0.34-0.73, p<.001) compared with non-certified institutions **in-hospital mortality:** 2.7 vs 1.4 vs 0.9, p<.001 The OR of in-hospital mortality after PD was less than one at certified A (OR: 0.39, CI: 0.30-0.50, p<.001) and certified B institutions (OR: 0.54, CI: 0.40-0.73, p<.001). **LoS (days, mean):** 33 vs 30 vs 28, p<.001 Hepatic (non-certified vs B vs A) **30-day mortality:** 2.1 vs 1.4 vs 1.0, <.001 Certified A institutions: the OR of 30-day mortality was half that of non-certified institutions (OR: 0.51, CI: 0.34-0.76, p = .001) **in-hospital mortality:** 3.2 vs 2.3 vs 1.7, <.001 The OR of in-hospital mortality after advanced hepatectomy was reduced to about half at certified A institutions (OR: 0.57, CI: 0.41-0.78, p<.001) compared with non-certified institutions. No differences were found in the OR of 30-day and in-hospital mortality after advanced hepatectomy between certified B and non-certified institutions **LoS (days, mean):** 21.2 vs 21.0 vs 20.2, p=.135

CI, confidence interval; EBS, evidence-based series; LOS, length of stay; OR, odds ratio; PD, pancreatoduodenectomy; pts, patients.

Table 5. Biliary and hospital volume primary studies meeting inclusion criteria for EBS 17-2

Author, year	Procedure and population	Methods	Intervention	Outcomes of Interest	Brief results
Beal et al. 2020 [72] USA	10,174 pts undergoing gallbladder cancer resection	2004-2015 National Cancer Database	Hospital Volume (1st quartile <=3, 2nd quartile 3.1-6, 3rd quartile 6.1-11 and 4th quartile >=11 pts per year.)	OS/mortality, PSM	**OS:** unadjusted: -increasing travel distance and hospital volume were associated with improved OS (both p < 0.001) Adjusted for competing risk factors: -the 4th quartile of hospital volume was associated with a decreased hazard of long-term death (HR 0.831, 95% CI 0.751-0.920, p < 0.001). When both hospital volume and travel distance were included, the association with improved OS persisted only for hospital volume (4th quartile HR 0.835, 95% CI 0.753-0.925, p < 0.001), whereas there was no independent association of increasing travel distance with OS. **PSM:** -Risk of a positive surgical margin was not associated with either travel distance or hospital volume
Taniyama et al. 2021 [37] Japan	Pts who received curative surgery for esophageal, biliary tract, and pancreatic cancers. Esophageal results not reported.	Osaka Cancer Registry data from 2006–2013	Hospital volume For biliary tract cancer, 10 high-volume hospitals with 7.4 to 18.0 surgical cases per year, 18 middle-volume with 3.8 to 7.3 cases, and 72 low-volume with 0.1 to 3.6 cases For pancreatic cancer, 5 high-volume hospitals with 13.8 to 28.4 surgical cases per year, 14 middle-volume with 4.1 to 12.8 cases, and 70 low-volume with 0.1 to 4.0 cases ** data on pancreas was also extracted and can be found in Table 2a.	3 year survival, 3 yr mortality	**3 yr survival:** biliary tract: (HV, MV, LV): 67.9%, 58.3%, and 58.0% Adjusted for age, sex, year of diagnosis, chemotherapy, radiation therapy, and residence and medical referral regions. Biliary tract (high ref group): Middle: 1.39 (1.15–1.67) Low: 1.57 (1.30–1.89)

CI, confidence interval; EBS, evidence-based series; EIBL, estimated intraoperative blood loss; HR, hazard ratio; HV, high volume; LV, low volume; MV, medium volume; OS, overall survival; PSM, positive surgical margin; pts, patients; yr, year

Table 6. Hepatobiliary and hospital volume primary studies inclusion criteria for EBS 17-2.

Author, year	Procedure and population	Methods	Intervention	Outcomes of Interest	Brief results
Guglielmi et al. 2023 [73] Italy	pts who underwent hepatobiliary surgery for malignant disease	retrospective population study in a single Italian administrative region (Veneto) from 2010 to 2021	hospital volume Very-LV hospital: <5 surgeries/y LV hospital: 5-19 surgeries/y Intermediate volume hospital: 20-99 surgeries/y High specialized hospital: ≥100 surgeries/y.	in-hospital, 30- and 90-day postoperative mortality	Multivariate analysis adjusted for confounders (age, gender, Charlson index) **In-hospital mortality:** (HV ref) intermediate: OR 1.28 (0.75-2.18) low: OR 2.66 (1.63-4.34) very low: 1.42 (0.61-3.34) **30-day postoperative mortality:** (HV ref) intermediate: OR 1.17 (0.71-1.93) low: OR 2.65 (1.69-4.17) very low: 3.42 (1.85-6.32) **90-day postoperative mortality:** (HV ref) intermediate: OR 0.93 (0.71-1.23) low: OR 1.55 (1.19-2.02) very low: OR 2.17 (1.47-3.19) In-hospital mortality: 100+: 1.3% 20-99: 1.8% 5-19: 3.6% 0-4: 2.0% 30-day mortality: 100+: 1.3% 20-99: 1.6% 5-19: 3.5% 0-4: 4.6% 90-day mortality: 100+: 4.6% 20-99: 4.6% 5-19: 7.3% 0-4: 10.3%

EBS, evidence-based series; HV, high volume; OR, odds ratio; pts, patients.

Table 7. Cholangiocarcinoma and hospital volume primary studies inclusion criteria for EBS 17-2.

Author, year	Procedure and population	Methods	Intervention	Outcomes of Interest	Brief results
Idrees et al 2019 [74] USA	pts undergoing resection for Cholangiocarcinoma (CCA)	National Cancer Database (NCDB) 2004-2015	hospital volume Low (1-5 pts/yr), med (6-20 pts/yr), High (20+ pts/yr)	survival	-On multivariable analysis, both receipt of surgery at a high-volume hospital (Hazard Ratio [HR] = 0.92, 95% CI: 0.88-0.97, p < 0.001) and compliance with NCCN guidelines (HR = 0.83, 95% CI: 0.79-0.86, p < 0.001) were independently associated with improved survival

					Long term mortality: (LV ref) Medium volume HR 0.99 (0.95-1.04), p=0.755) High volume HR = 0.92 (0.88-0.97), p<0.001 After propensity matching, overall mortality: 2004-2007: 62.2 2011-2015: 33.2

CCA, Cholangiocarcinoma; CI, confidence interval; EBS, evidence-based series; HR, hazard ratio; NCCN, National Comprehensive Cancer Network; NCDB, National Cancer Database; LV, low volume; pts, patients; yr, year.

Table 8a. Hepatopancreatic and hospital volume primary studies inclusion criteria for EBS 17-2.

Author, year	Procedure and population	Methods	Intervention	Outcomes of Interest	Brief results
Mehta et al. 2020 [75] USA	8,035 pts undergoing hepatopancreatic surgery from 2013 to 2015 for a malignant indication	Medicare Inpatient Standard Analytic File	hospital surgical volume	textbook outcome (lack of complication, prolonged length-of-stay (LOS), readmission, and death after the HP procedure); mortality	**TO (LV vs HV):** pancreatic: 40.5% vs 47.1%, P < .001; OR 1.30, 95% CI 1.15-1.47; liver: 41.8% versus 46.6%; P = .005, OR 1.19, 95% CI 1.03- 1.38, P = .018 **Mortality (LV vs HV) pancreatic:** OR 0.62, 95% CI 0.50-0.77, P < .001 hepatic: OR 0.79, 95% CI 0.59-1.04, P = .095 **LoS (LV vs HV):** pancreatic: OR 0.59, 95% CI 0.52-0.68, P < .001 hepatic: OR 0.97, 95% CI 0.79-1.20, P = .803 Unadjusted mortality (LV vs HV) pancreatic: 9.8% vs 6.5% Hepatic: 8% vs 5.7%

CI, confidence interval; EBS, evidence-based series; HP, hepatopancreatic; HV, high volume; LOS, length of stay; LV, low volume; OR, odds ratio; pts, patients; TO, textbook outcome.

Table 8b. Hepatopancreatic and surgeon volume primary studies meeting inclusion criteria for EBS 17-2

Author, year	Procedure and population	Methods	Intervention	Outcomes of Interest	Brief results
Moazzam et al. 2023 [76] USA	Pts who underwent either hepatic or pancreatic surgical procedures 2013-2017	Medicare Standard Analytic Files	Surgery subspecialization index (SSI) -defined as a composite measure of the degree of surgeon and hospital subspecialization in pancreatic surgical procedures	90-day mortality; extended LOS, hospital volume	Multivariable mixed effect logistic regression, controlled for age, gender, Charlson Comorbidity Index, race/ethnicity, hospital teaching status **Extended LoS:** (low SSI ref group) Intermediate SSI OR 0.85 (0.77-0.94), p=0.002 High SSI OR 0.84 (0.75-0.94), p=0.003 **90-day mortality:** (low SSI ref group) Intermediate SSI OR 0.81 (0.69-0.95), p=0.009 High SSI OR 0.78 (0.66-0.92), p=0.003 Stratified by hospital volume status Low volume: **Extended LoS:** (low SSI ref group) Intermediate SSI OR 0.94 (0.82-1.07), p=0.330 High SSI OR 0.87 (0.75-1.02), p=0.081

					High volume: **90-day mortality:** (low SSI ref group) Intermediate SSI OR 0.74 (0.61-0.88, p=0.001 High SSI OR 0.73 (0.60-0.88), p=0.001 90-day mortality: Low SSI vs intermediate SSI vs high SSI: 9.1% vs 7.5% vs 7.3%

EBS, evidence-based series; LOS, length of stay; OR, odds ratio; pts, patients; SSI, surgery subspecialization index.

References

1. Ahola R, Sand J, Laukkarinen J. Centralization of Pancreatic Surgery Improves Results: Review. Scand J Surg. 2020;109(1):4-10.
2. Acher AW, Weber SM, Pawlik TM. Does the Volume-Outcome Association in Pancreas Cancer Surgery Justify Regionalization of Care? A Review of Current Controversies. Ann Surg Oncol. 2022;29(2):1257-68.
3. Fischer C, Alvarico SJ, Wildner B, Schindl M, Simon J. The relationship of hospital and surgeon volume indicators and post-operative outcomes in pancreatic surgery: a systematic literature review, meta-analysis and guidance for valid outcome assessment. HPB. 2023;25(4):387-99.
4. Hunger R, Seliger B, Ogino S, Mantke R. Mortality factors in pancreatic surgery: A systematic review. How important is the hospital volume? International Journal Of Surgery. 2022;101:106640.
5. Kotecha K, Tree K, Ziaziaris WA, McKay SC, Wand H, Samra J, et al. Centralization of Pancreaticoduodenectomy: A Systematic Review and Spline Regression Analysis to Recommend Minimum Volume for a Specialist Pancreas Service. Ann Surg. 2024;279(6):953-60.
6. Kovoor JG, Ma N, Tivey DR, Vandepeer M, Jacobsen JHW, Scarfe A, et al. In-hospital survival after pancreatoduodenectomy is greater in high-volume hospitals versus lower-volume hospitals: a meta-analysis. ANZ J Surg. 2022;92(1-2):77-85.
7. Krautz C, Denz A, Weber GF, Grutzmann R. Influence of Hospital Volume Effects and Minimum Caseload Requirements on Quality of Care in Pancreatic Surgery in Germany. Visceral Medicine. 2017;33(2):131-4.
8. Polonski A, Izbicki JR, Uzunoglu FG. Centralization of Pancreatic Surgery in Europe. J Gastrointest Surg. 2019;23(10):2081-92.
9. Ratnayake B, Pendharkar SA, Connor S, Koea J, Sarfati D, Dennett E, et al. Patient volume and clinical outcome after pancreatic cancer resection: A contemporary systematic review and meta-analysis. Surgery. 2022;172(1):273-83.
10. Yin T, Qin T, Wei K, Shen M, Zhang Z, Wen J, et al. Comparison of safety and effectiveness between laparoscopic and open pancreatoduodenectomy: A systematic review and meta-analysis. Int J Surg. 2022;105:106799.
11. Aquina CT, Becerra AZ, Fleming FJ, Cloyd JM, Tsung A, Pawlik TM, et al. Variation in outcomes across surgeons meeting the Leapfrog volume standard for complex oncologic surgery. Cancer. 2021;127(21):4059-71.
12. Bliss LA, Yang CJ, Chau Z, Ng SC, McFadden DW, Kent TS, et al. Patient selection and the volume effect in pancreatic surgery: unequal benefits? HPB. 2014;16(10):899-906.
13. Conroy PC, Calthorpe L, Lin JA, Mohamedaly S, Kim A, Hirose K, et al. Determining Hospital Volume Threshold for Safety of Minimally Invasive Pancreaticoduodenectomy: A Contemporary Cutpoint Analysis. Ann Surg Oncol. 2022;29(3):1566-74.
14. Diaz A, Burns S, Paredes AZ, Pawlik TM. Accessing surgical care for pancreaticoduodenectomy: Patient variation in travel distance and choice to bypass hospitals to reach higher volume centers. J Surg Oncol. 2019;120(8):1318-26.

15. Diaz A, Hyer JM, Azap R, Tsilimigras D, Pawlik TM. Association of social vulnerability with the use of high-volume and Magnet recognition hospitals for hepatopancreatic cancer surgery. Surgery. 2021;170(2):571-8.

16. Ganjouei AA, Wang JJ, Romero-Hernandez F, Peng J, Thornblade L, Hirose K, et al. Exploring the relationship between volume and outcomes after pancreaticoduodenectomy in California: is it hospital-wide or surgeon-specific volume that matters? Hpb. 2024;26(Supplement 1):S373-S4.

17. Ghauri MS, Juste J, Shabbir T, Berry N, Reddy AJ, Farkoufar N, et al. Exploring the Surgical Outcomes of Pancreatic Cancer Resections Performed in Low- Versus High-Volume Centers. Cureus. 2023;15(4):e37112.

18. Hallet J, Jerath A, Perez d'Empaire P, Eskander A, Carrier FM, McIsaac DI, et al. The Association Between Hospital High-volume Anesthesiology Care and Patient Outcomes for Complex Gastrointestinal Cancer Surgery: A Population-based Study. Ann Surg. 2023;278(3):e503-e10.

19. Ho V, Short MN, Aloia TA. Can postoperative process of care utilization or complication rates explain the volume-cost relationship for cancer surgery? Surgery. 2017;162(2):418-28.

20. Huerta CT, Collier AL, Hernandez AE, Rodriguez C, Shah A, Kronenfeld JP, et al. Nationwide Outcomes of Pancreaticoduodenectomy for Pancreatic Malignancies: Center Volume Matters. Am Surg. 2023;89(12):6020-9.

21. Huhta H, Nortunen M, Merilainen S, Helminen O, Kauppila JH. Hospital volume and outcomes of pancreatic cancer: a Finnish population-based nationwide study. HPB. 2022;24(6):841-7.

22. Hunger R, Mantke R. Outcome Quality Beyond the Mean - An Analysis of 43,231 Pancreatic Surgical Procedures Related to Hospital Volume. Ann Surg. 2022;276(1):159-66.

23. Jaquet R, Challine A, Tzedakis S, de Ponthaud C, Katsahian S, Lefevre J, et al. Impact of the thresholds of surgical volume on mortality in oncological digestive surgery: A French National Cohort. Eur J Surg Oncol. 2024;50(10):108581.

24. Ju MR, Karalis JD, Leonard G, Mansour JC, Karagkounis G, Wang SC, et al. Defining Volume Targets for Regionalization of Pancreaticoduodenectomy, Esophagectomy, and Major Lung Resection Centers to Improve Oncologic and Surgical Outcomes. Ann Surg Oncol. 2024;31(1):499-513.

25. Kalagara R, Norain A, Chang YH, Stucky CC, Wasif N. Association of Textbook Outcome and Surgical Case Volume with Long-Term Survival in Patients Undergoing Surgical Resection for Pancreatic Cancer. J Am Coll Surg. 2022;235(6):829-37.

26. Kemp Bohan PM, Chang SC, Grunkemeier GL, Spitzer HV, Carpenter EL, Adams AM, et al. Impact of Mediating and Confounding Variables on the Volume-Outcome Association in the Treatment of Pancreatic Cancer. Ann Surg Oncol. 2023;30(3):1436-48.

27. Kuemmerli C, Schneider MA, Joliat GR, Moeckli B, Ukegjini K, Bolli M, et al. Trends in pancreatic surgery in Switzerland: a survey and nationwide analysis over two decades. Langenbecks Arch Surg. 2022;407(8):3423-35.

28. Kwon J, Kang CM, Jang JY, Yoon YS, Kwon HJ, Choi IS, et al. Perioperative textbook outcomes of minimally invasive pancreatoduodenectomy: a multicenter retrospective

cohort analysis in a Korean minimally invasive pancreatic surgery registry. International Journal Of Surgery. 2024;110(7):4249-58.

29. Mitsakos AT, Vohra NA, Fitzgerald TL, Buccini P, Parikh AA, Snyder RA, et al. Improvement in Surgical Quality Following Pancreaticoduodenectomy With Increasing Case Volume in a Rural Hospital. Am Surg. 2022;88(4):746-51.

30. Mok J, Close J, Gandy R, Harvey L. Re-examining institutional volume for pancreatectomy in a low-density population: a population-based study in New South Wales, Australia. Hpb. 2024;26(Supplement 1):S363-S4.

31. Panni RZ, Panni UY, Liu J, Williams GA, Fields RC, Sanford DE, et al. Re-defining a high volume center for pancreaticoduodenectomy. HPB (Oxford). 2021;23(5):733-8.

32. Papageorge MV, de Geus SWL, Woods AP, Ng SC, McAneny D, Tseng JF, et al. The impact of upper gastrointestinal surgical volume on short term pancreaticoduodenectomy outcomes for pancreatic adenocarcinoma in the SEER-Medicare population. HPB. 2022;24(6):868-74.

33. Stoop TF, Ateeb Z, Ghorbani P, Scholten L, Arnelo U, Besselink MG, et al. Surgical Outcomes After Total Pancreatectomy: A High-Volume Center Experience. Ann Surg Oncol. 2021;28(3):1543-51.

34. Sutton JM, Wilson GC, Wima K, Hoehn RS, Cutler Quillin R, 3rd, Hanseman DJ, et al. Readmission After Pancreaticoduodenectomy: The Influence of the Volume Effect Beyond Mortality. Ann Surg Oncol. 2015;22(12):3785-92.

35. Sutton TL, Beneville B, Johnson AJ, Mayo SC, Gilbert EW, Lopez CD, et al. Socioeconomic and Geographic Disparities in the Referral and Treatment of Pancreatic Cancer at High-Volume Centers. JAMA Surg. 2023;158(3):284-91.

36. Swanson RS, Pezzi CM, Mallin K, Loomis AM, Winchester DP. The 90-day mortality after pancreatectomy for cancer is double the 30-day mortality: more than 20,000 resections from the national cancer data base. Ann Surg Oncol. 2014;21(13):4059-67.

37. Taniyama Y, Tabuchi T, Ohno Y, Morishima T, Okawa S, Koyama S, et al. Hospital Surgical Volume and 3-Year Mortality in Severe Prognosis Cancers: A Population-Based Study Using Cancer Registry Data. J Epidemiol. 2021;31(1):52-8.

38. Thobie A, Bouvier AM, Bouvier V, Jooste V, Queneherve L, Nousbaum JB, et al. Survival variability across hospitals after resection for pancreatic adenocarcinoma: A multilevel survival analysis on a high-resolution population-based study. Eur J Surg Oncol. 2023;49(8):1450-6.

39. Toomey PG, Teta AF, Patel KD, Ross SB, Rosemurgy AS. High-volume surgeons vs high-volume hospitals: are best outcomes more due to who or where? Am J Surg. 2016;211(1):59-63.

40. Torphy RJ, Friedman C, Halpern AL, Ahrendt SA, McCarter MD, Del Chiaro M, et al. Implementation of Minimally Invasive Pancreaticoduodenectomy at Low and High-Volume Centers. J Surg Res. 2021;268:720-8.

41. van der Geest LG, van Rijssen LB, Molenaar IQ, de Hingh IH, Groot Koerkamp B, Busch OR, et al. Volume-outcome relationships in pancreatoduodenectomy for cancer. HPB. 2016;18(4):317-24.

42. Wirth K, Napflin M, Graber SM, Blozik E. Does hospital volume affect outcomes after abdominal cancer surgery: an analysis of Swiss health insurance claims data. BMC Health Serv Res. 2022;22(1):262.

43. Cannas S, Casciani F, Vollmer CM, Pancreas Fistula Study G. Extending Quality Improvement for Pancreatoduodenectomy Within the High-Volume Setting: The Experience Factor. Ann Surg. 2024;279(6):1036-45.

44. Gani F, Kim Y, Weiss MJ, Makary MA, Wolfgang CL, Hirose K, et al. Effect of surgeon and anesthesiologist volume on surgical outcomes. J Surg Res. 2016;200(2):427-34.

45. Paredes AZ, Hyer JM, Tsilimigras DI, Sahara K, White S, Pawlik TM. Interaction of Surgeon Volume and Nurse-to-Patient Ratio on Post-operative Outcomes of Medicare Beneficiaries Following Pancreaticoduodenectomy. J Gastrointest Surg. 2020;24(11):2551-9.

46. Pointer DT, Jr., Al-Qurayshi Z, Hamner JB, Slakey DP, Kandil E. Factors leading to pancreatic resection in patients with pancreatic cancer: a national perspective. Gland Surgery. 2018;7(2):207-15.

47. Uttinger KL, Diers J, Baum P, Pietryga S, Baumann N, Hankir M, et al. Mortality, complications and failure to rescue after surgery for esophageal, gastric, pancreatic and liver cancer patients based on minimum caseloads set by the German Cancer Society. Eur J Surg Oncol. 2022;48(4):924-32.

48. Vuong B, Dehal A, Uppal A, Stern SL, Mejia J, Weerasinghe R, et al. What Are the Most Significant Cost and Value Drivers for Pancreatic Resection in an Integrated Healthcare System? J Am Coll Surg. 2018;227(1):45-53.

49. Ardito F, Famularo S, Aldrighetti L, Grazi GL, DallaValle R, Maestri M, et al. The Impact of Hospital Volume on Failure to Rescue after Liver Resection for Hepatocellular Carcinoma: Analysis from the HE.RC.O.LE.S. Italian Registry. Ann Surg. 2020;272(5):840-6.

50. Beal EW, Mehta R, Merath K, Tsilimigras DI, Hyer JM, Paredes A, et al. Outcomes After Resection of Hepatocellular Carcinoma: Intersection of Travel Distance and Hospital Volume. J Gastrointest Surg. 2019;23(7):1425-34.

51. Buettner S, Gani F, Amini N, Spolverato G, Kim Y, Kilic A, et al. The relative effect of hospital and surgeon volume on failure to rescue among patients undergoing liver resection for cancer. Surgery. 2016;159(4):1004-12.

52. Chang CM, Yin WY, Wei CK, Lee CH, Lee CC. The combined effects of hospital and surgeon volume on short-term survival after hepatic resection in a population-based study. PLoS ONE [Electronic Resource]. 2014;9(1):e86444.

53. de Geus SW, Woods AP, Papageorge MV, Zheng J, Ng SC, McAneny D, et al. Combined Hepatopancreaticobiliary Volume and Hepatectomy Outcomes in Hepatocellular Carcinoma Patients at Low-Volume Liver Centers. J Am Coll Surg. 2021;232(6):864-71.

54. Diaz A, Cloyd JM, Manilchuk A, Dillhoff M, Beane J, Tsung A, et al. Travel Patterns among Patients Undergoing Hepatic Resection in California: Does Driving Further for Care Improve Outcomes? J Gastrointest Surg. 2021;25(6):1471-8.

55. Diggs LP, Aversa JG, Wiemken TL, Martin SP, Drake JA, Ruff SM, et al. Patient Comorbidities Drive High Mortality Rates Associated with Major Liver Resections Irrespective of Hospital Volume. Am Surg. 2021;87(7):1163-70.

56. Endo Y, Woldesenbet S, Kawashima J, Tsilimigras DI, Rashid Z, Catalano G, et al. Impact of hospital volume and facility characteristics on postoperative outcomes after hepatectomy: A mediation analysis. Surgery. 2024;176(6):1653-60.

57. Gani F, Azoulay D, Pawlik TM. Evaluating Trends in the Volume-Outcomes Relationship Following Liver Surgery: Does Regionalization Benefit All Patients the Same? J Gastrointest Surg. 2017;21(3):463-71.

58. Hashimoto DA, Bababekov YJ, Mehtsun WT, Stapleton SM, Warshaw AL, Lillemoe KD, et al. Is Annual Volume Enough? The Role of Experience and Specialization on Inpatient Mortality After Hepatectomy. Ann Surg. 2017;266(4):603-9.

59. Khalil M, Tsilimigras DI, Endo Y, Khan MMM, Munir MM, Katayama E, et al. Association of Textbook Outcome and Hospital Volume with Long-Term Survival Following Resection for Hepatocellular Carcinoma: What Matters More? J Gastrointest Surg. 2023;27(12):2763-70.

60. Magnin J, Bernard A, Cottenet J, Lequeu JB, Ortega-Deballon P, Quantin C, et al. Impact of hospital volume in liver surgery on postoperative mortality and morbidity: nationwide study. Br J Surg. 2023;110(4):441-8.

61. Olthof PB, Elfrink AKE, Marra E, Belt EJT, van den Boezem PB, Bosscha K, et al. Volume-outcome relationship of liver surgery: a nationwide analysis. Br J Surg. 2020;107(7):917-26.

62. Sahara K, Merath K, Hyer JM, Tsilimigras DI, Paredes AZ, Farooq A, et al. Impact of Surgeon Volume on Outcomes and Expenditure Among Medicare Beneficiaries Undergoing Liver Resection: the Effect of Minimally Invasive Surgery. J Gastrointest Surg. 2020;24(7):1520-9.

63. Shaikh CF, Woldesenbet S, Munir MM, Lima HA, Moazzam Z, Endo Y, et al. Is surgical treatment of hepatocellular carcinoma at high-volume centers worth the additional cost? Surgery. 2024;175(3):629-36.

64. Sutton JM, Hoehn RS, Ertel AE, Wilson GC, Hanseman DJ, Wima K, et al. Cost-Effectiveness in Hepatic Lobectomy: the Effect of Case Volume on Mortality, Readmission, and Cost of Care. J Gastrointest Surg. 2016;20(2):253-61.

65. Uhlig J, Sellers CM, Khan SA, Cha C, Kim HS. Hepatocellular carcinoma: Impact of academic setting and hospital volume on patient survival. Surg Oncol. 2019;31:111-8.

66. Chapman BC, Paniccia A, Hosokawa PW, Henderson WG, Overbey DM, Messersmith W, et al. Impact of Facility Type and Surgical Volume on 10-Year Survival in Patients Undergoing Hepatic Resection for Hepatocellular Carcinoma. J Am Coll Surg. 2017;224(3):362-72.

67. Beal EW, Mehta R, Hyer JM, Paredes A, Merath K, Dillhoff ME, et al. Association Between Travel Distance, Hospital Volume, and Outcomes Following Resection of Cholangiocarcinoma. J Gastrointest Surg. 2019;23(5):944-52.

68. Julian WT, Elshami M, Ammori JB, Hardacre JM, Ocuin LM. Comparison of Hospital Volume and Risk-Standardized Mortality Rate as a Proxy for Hospital Quality in Complex Oncologic Hepatopancreatobiliary Surgery. Ann Surg Oncol. 2024;31(8):4922-30.

69. Ravaioli M, Pinna AD, Francioni G, Montorsi M, Veneroni L, Grazi GL, et al. A partnership model between high- and low-volume hospitals to improve results in hepatobiliary pancreatic surgery. Ann Surg. 2014;260(5):871-5; discussion 5-7.

70. Schneider EB, Ejaz A, Spolverato G, Hirose K, Makary MA, Wolfgang CL, et al. Hospital volume and patient outcomes in hepato-pancreatico-biliary surgery: is assessing differences in mortality enough? J Gastrointest Surg. 2014;18(12):2105-15.

71. Mise Y, Hirakawa S, Tachimori H, Kakeji Y, Kitagawa Y, Komatsu S, et al. Volume- and quality-controlled certification system promotes centralization of complex hepato-pancreatic-biliary surgery. J Hepatobiliary Pancreat Sci. 2023;30(7):851-62.

72. Beal EW, Mehta R, Tsilimigras DI, Hyer JM, Paredes AZ, Merath K, et al. Travel to a high volume hospital to undergo resection of gallbladder cancer: does it impact quality of care and long-term outcomes? HPB. 2020;22(1):41-9.

73. Guglielmi A, Tripepi M, Salmaso L, Fedeli U, Ruzzenente A, Saia M. Trends in hospital volume and operative mortality in hepato-biliary surgery in Veneto region, Italy. Updates Surg. 2023;75(7):1949-59.

74. Idrees JJ, Merath K, Gani F, Bagante F, Mehta R, Beal E, et al. Trends in centralization of surgical care and compliance with National Cancer Center Network guidelines for resected cholangiocarcinoma. HPB (Oxford). 2019;21(8):981-9.

75. Mehta R, Paredes AZ, Tsilimigras DI, Moro A, Sahara K, Farooq A, et al. Influence of hospital teaching status on the chance to achieve a textbook outcome after hepatopancreatic surgery for cancer among Medicare beneficiaries. Surgery. 2020;168(1):92-100.

76. Moazzam Z, Lima HA, Alaimo L, Endo Y, Ejaz A, Beane J, et al. Hepatopancreatic Surgeons Versus Pancreatic Surgeons: Does Surgical Subspecialization Impact Patient Care and Outcomes? J Gastrointest Surg. 2023;27(4):750-9.

Appendix 1. Members of the Expert Panel

Name	Affiliation	Declarations of Interest
Authors		
Kim Bertens	Assistant Professor, Department of Surgery Senior Clinician Investigator, Clinical Epidemiology Program, The Ottawa Hospital, Ottawa, ON	None declared
Lisa Durocher Health Research Methodologist	Program in Evidence-based Care, McMaster University, Hamilton, ON	None declared
Expert Panel		
Kengo Asai	Health Sciences North - Northeast Cancer Centre, Sudbury, ON	None declared
Fady Balaa	The Ottawa Hospital - General Campus, Ottawa, ON	None declared
Scott Berry	Trillium Health Partners, Mississauga, ON	Advisory Boards for BMS, Merck, Amgen, advisor and travel support from OncologyEducation.com
Julie Hallet	Odette Cancer Centre (Sunnybrook HS), Toronto, ON	Speaking honoraria for Ipsen and Novartis.
Diederick Jalink	Kingston General Hospital, Kingston, ON	None declared
Shiva Jayaraman	St Joseph's Health Centre, Toronto, ON	None declared
Naheed Jivraj	Sunnybrook Health Sciences Centre, Toronto, ON	None declared
Ken Leslie	London Health Sciences - University Hospital, London, ON	None declared
Ken Leung	Grand River Hospital, Kitchener-Waterloo Site, Kitchener, ON	None declared
Chaya Shwaartz	University Health Network - Toronto General Hospital, Toronto, ON	None declared
Pablo Serrano	Juravinski Hospital, Hamilton, ON	None declared
Anton Skaro	London Health Sciences - University Hospital, London, ON	Speaker honoraria for Boston Scientific
Anand Swaminath	Juravinski Cancer Centre, Hamilton, ON	Grants from Hoffman-La Roche and Bristol-Myers-Squibb.

Nathan Zilbert	Trillium Health Partners, Mississauga, ON	None declared

Appendix 2. Primary studies in an included Systematic Review

Adam 2017	Defining a Hospital Volume Threshold for Minimally Invasive Pancreaticoduodenectomy in the United States
Ahola 2019	Pancreatic resections are not only safest but also most cost-effective when performed in a high-volume centre: A Finnish register study
Alsfasser 2016	Volume-outcome relationship in pancreatic surgery
Amini 2015	Trends in Hospital Volume and Failure to Rescue for Pancreatic Surgery
Ansari 2014	Pancreaticoduodenectomy--the transition from a low- to a high-volume center
Antila 2019	Management of postoperative complications may favour the centralization of distal pancreatectomies. Nationwide data on pancreatic distal resections in Finland 2012-2014
Balzano 2020	Modelling centralization of pancreatic surgery in a nationwide analysis
Bateni 2018	Drivers of Cost for Pancreatic Surgery: It's Not About Hospital Volume
Capretti 2018	Management and Outcomes of Pancreatic Resections Performed in High-Volume Referral and Low-Volume Community Hospitals Lead by Surgeons Who Shared the Same Mentor: The Importance of Training
Colavita 2014	Regionalization and outcomes of hepato-pancreato-biliary cancer surgery in USA
Creighton 2017	Pancreatectomy is underused in NSW regions with low institutional surgical volumes: a population data linkage study
deGeus 2022	Volume of Pancreas-Adjacent Operations Favorably Influences Pancreaticoduodenectomy Outcomes at Lower Volume Pancreas Centers
Delitto 2016	Standardization of surgical care in a high-volume center improves survival in resected pancreatic head cancer
Derogar 2015	Hospital teaching status and volume related to mortality after pancreatic cancer surgery in a national cohort
ElAmrani 2018	Failure-to-rescue in Patients Undergoing Pancreatectomy: Is Hospital Volume a Standard for Quality Improvement Programs? Nationwide Analysis of 12,333 Patients
Endo 2023	Hospital Volume and Textbook Outcomes in Minimally Invasive Hepatectomy for Hepatocellular Carcinoma
Enomoto 2014	Impact of surgeon and hospital volume on mortality, length of stay, and cost of pancreaticoduodenectomy
Gani 2017	Hospital Volume and the Costs Associated with Surgery for Pancreatic Cancer
Gorgec 2021	Comparing practice and outcome of laparoscopic liver resection between high-volume expert centres and nationwide low-to-medium volume centres
Hata 2016	Effect of Hospital Volume on Surgical Outcomes After Pancreaticoduodenectomy: A Systematic Review and Meta-analysis
Idrees 2019	Cost of Major Complications After Liver Resection in the United States: Are High-volume Centers Cost-effective?
Jogerst 2022	Identifying the Optimal case-volume threshold for pancreatectomy in contemporary practice
Kagedan 2017	The Impact of Increasing Hospital Volume on 90-Day Postoperative Outcomes Following Pancreaticoduodenectomy
Krautz 2018	Effect of Hospital Volume on In-hospital Morbidity and Mortality Following Pancreatic Surgery in Germany
Krautz 2020	In-hospital mortality and failure to rescue following hepatobiliary surgery in Germany - a nationwide analysis
Lau 2014	The effect of a regional hepatopancreaticobiliary surgical program on clinical volume, quality of cancer care, and outcomes in the Veterans Affairs system
Lidsky 2017	Going the Extra Mile: Improved Survival for Pancreatic Cancer Patients Traveling to High-volume Centers
Lu 2014	Volume-outcome associations after major hepatectomy for hepatocellular carcinoma: a nationwide Taiwan study
Macedo 2017	The Impact of Surgeon Volume on Outcomes After Pancreaticoduodenectomy: a Meta-analysis
Mamidanna 2016	Surgeon Volume and Cancer Esophagectomy, Gastrectomy, and Pancreatectomy: A Population-based Study in England
Mehta 2016	Relative impact of surgeon and hospital volume on operative mortality and complications following pancreatic resection in Medicare patients
Narendra 2019	Assessment of hospital characteristics associated with improved mortality following complex upper gastrointestinal cancer surgery in Queensland
Narendra 2020	Pancreaticoduodenectomy in a low-resection volume region: a population-level study examining the impact of hospital-volume on surgical quality and longer-term survival

O'Mahoney 2016	Centralization of pancreatoduodenectomy a decade later: Impact of the volume-outcome relationship
Sahni 2016	Surgeon specialization and operative mortality in United States: retrospective analysis
Saulle 2019	The combined effect of surgeon and hospital volume on health outcomes: a systematic review
Schneider 2014	Race-based differences in length of stay among patients undergoing pancreatoduodenectomy
Sheetz 2020	Association of Surgeon Case Numbers of Pancreaticoduodenectomies vs Related Procedures With Patient Outcomes to Inform Volume-Based Credentialing
Shi 2014	Temporal trends and volume-outcome associations in periampullary cancer patients: a propensity score-adjusted nationwide population-based study
Siegel 2021	Travel distance and overall survival in hepatocellular cancer care
Stella 2017	Impact of surgical experience on management and outcome of pancreatic surgery performed in high- and low-volume centers
Sutton 2014	Cost effectiveness after a pancreaticoduodenectomy: bolstering the volume argument
Wasif 2019	Contemporary Improvements in Postoperative Mortality After Major Cancer Surgery are Associated with Weakening of the Volume-Outcome Association
Waterhouse 2016	Determinants of Outcomes Following Resection for Pancreatic Cancer-a Population-Based Study
Wood 2016	High-Volume Hospitals with High-Volume and Low-Volume Surgeons: Is There a "Field Effect" for Pancreaticoduodenectomy?
Yoshioka 2014	Impact of hospital volume on hospital mortality, length of stay and total costs after pancreaticoduodenectomy

DEFINITIONS OF REVIEW OUTCOMES

1. **ARCHIVE** – ARCHIVE means that a Clinical Expert and/or Expert Panel has reviewed new evidence pertaining to the guideline topic and determined that the guideline is out of date or has become less relevant. The document will no longer be tracked or updated but may still be useful for academic or other informational purposes. The document is moved to a separate section of our website and each page is watermarked with the words "ARCHIVE."

2. **ENDORSE** – ENDORSE means that a Clinical Expert and/or Expert Panel has reviewed new evidence pertaining to the guideline topic and determined that the guideline is still useful as guidance for clinical decision making. A document may be endorsed because the Expert Panel feels the current recommendations and evidence are sufficient, or it may be endorsed after a literature search uncovers no evidence that would alter the recommendations in any important way.

3. **UPDATE** – UPDATE means the Clinical Expert and/or Expert Panel recognizes that the new evidence pertaining to the guideline topic makes changes to the existing recommendations in the guideline necessary but these changes are more involved and significant than can be accomplished through the Document Assessment and Review process. The Expert Panel advises that an update of the document be initiated. Until that time, the document will still be available as its existing recommendations are still of some use in clinical decision making, unless the recommendations are considered harmful.