ISPOR 2025

Global Evidence Gap Assessment for da Vinci Robotic-Assisted Surgery Over a 5-Year Time Horizon

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INTRODUCTION: Scientific publications are crucial to evidence-based evaluation of robotic-assisted surgery with da Vinci surgical systems (dV-RAS) across policymakers, payors, surgeons, and patients. Continuous gap assessments of the global evidence landscape are necessary to ensure comprehensive evidence generation.

AIM: We aim to assess the change in both publication volume and level of evidence (LOE) across country, surgical procedure, and outcome for dV-RAS from 2019 to 2024.

METHODS: Publications on dV-RAS were identified from PubMed, Scopus and Embase. Librarian-assigned metadata and a Python search algorithm were leveraged to select studies across 12 procedures, 9 outcomes, and 13 countries. Tableau data visualizations were analyzed after stratifying the data by country, procedure, and outcome. An Evidence Quality Index (EQI) score was assigned to each LOE to quantitatively assess evidence growth. Literature reviews and meta-analysis (level a LOEs) were excluded from this analysis as they are not country-specific.

Table 1: Level of Evidence Definitions* and EQI Scores

LOE	Definition	EQI
1a	Systematic reviews of Randomized Controlled Trials (no non-randomized studies included)	N/A
1b	Randomized Controlled Trials (RCTs)	5
1c	RCTs including robotic cases where randomization is not based on surgical approach/method (another factor is randomized, such as suture type or postoperative pain medicine)	5
2a	Systematic reviews of comparison studies (no single arm studies included)	N/A
2b	Prospective non-randomized comparative studies	4
2c	Database (ecological) studies	4
3a	Systematic reviews including some (or all) single arm studies in the analysis, including clinical practice guidelines	N/A
3b	Retrospective comparative studies	3
4a	All non-systematic literature reviews (comparative and single arm)	N/A
4b	Single arm or case series studies with n ≥ 10	2
5	Case reports (n < 10), animal or cadaveric studies, bench studies, editorials, technique descriptions, videos, protocols, retractions and errata, discussions and interviews, commentary	1
N/A	Not available in literature	N/A

GAP ASSESSMENT HEAT MAPS:.

Green numbers indicate the EQI score increase from 2019 to 2024 for each stratification.

Figure 1: Heat map of dV-RAS Publications by EQI Score for Benign Procedures Across Americas Countries (2024)

Country	Type of Outcome	Outcome	Cholecystectomy	Gastric Bypass	Hernia Inguinal	Hernia Ventral	Hysterectomy Benign
Brazil Total EQI: 78 EQI Growth Since 2019: +43 (122.8%)	Clinical	Blood Transfusions	N/A	N/A	N/A	N/A	4b
		Complications	4b	3b	4b	4b	3b
		Conversions	4b	4b	4b	4b	4b
		Estimated Blood Loss	5	N/A	4b	N/A	3b
		Mortality	N/A	3b	N/A	5	N/A
	Resource Utilization	Length of Stay	N/A	3b	N/A	1b	4b
		Operative Time	N/A	3b	2c	1b	4b
		Readmissions	N/A	3b	2c	4b	N/A
		Reoperations	N/A	3b	2c	4b	4b
Canada Total EQI: 36 EQI Growth Since 2019: +18 (100%)	Clinical	Blood Transfusions	N/A	N/A	N/A	N/A	2c
		Complications	5	2c	N/A	N/A	2c
		Conversions	N/A	2c	N/A	N/A	N/A
		Estimated Blood Loss	N/A	N/A	N/A	N/A	N/A
		Mortality	N/A	N/A	N/A	N/A	N/A
	Resource Utilization	Length of Stay	N/A	2c	N/A	3b	N/A
		Operative Time	5	N/A	N/A	3b	N/A
		Readmissions	N/A	2c	N/A	N/A	N/A
		Reoperations	N/A	2c	N/A	N/A	N/A
USA Total EQI: 195 EQI Growth Since 2019: +19 (10.8%)	Clinical	Blood Transfusions	2c	2c	4b	4b	2b
		Complications	1b	1c	1b	1b	1b
		Conversions	1b	2b	2c	2c	1c
		Estimated Blood Loss	2c	3b	3b	3b	1b
		Mortality	2c	2c	2c	1b	2c
	Resource Utilization	Length of Stay	2c	1c	2c	1b	1b
		Operative Time	1b	2c	1b	1b	1b
		Readmissions	2c	2c	1b	1b	1c
		Reoperations	2c	2b	1b	1b	1b
		Total EQI:	46	77	55	64	67
		EQI Growth Since 2019:	+10 (13.3%)	+7 (12.5%)	+6 (7.5%)	+25 (35.21%)	+11 (13.8%)

Figure 2: Heat map of dV-RAS Publications by EQI Score for Malignant Procedures Across Americas Countries (2024)

Country	Type of Outcome	Outcome	Colectomy	Hysterectomy Cervical	Hysterectomy Endometrial	Lobectomy	Partial Nephrectomy	Prostatectomy	Rectal Resection (LAR/TME)
Brazil Total EQI: 150 EQI Growth Since 2019: +37 (32.7%)	Clinical	Blood Transfusions	N/A	N/A	4b	N/A	3b	1b	4b
		Complications	4b	N/A	1b	1b	3b	1b	4b
		Conversions	2c	N/A	1b	4b	3b	1b	4b
		Estimated Blood Loss	N/A	N/A	1b	1b	3b	1b	4b
		Mortality	2c	N/A	N/A	4b	N/A	5	4b
	Resource Utilization	Length of Stay	2c	N/A	1b	1b	3b	1c	4b
		Operative Time	2c	N/A	1b	4b	3b	3b	3b
		Readmissions	N/A	N/A	N/A	1b	N/A	1c	4b
		Reoperations	N/A	N/A	N/A	N/A	3b	1c	4b
Canada Total EQI: 205 EQI Growth Since 2019: +18 (9.6%)	Clinical	Blood Transfusions	2c	3b	2c	4b	2c	2c	N/A
		Complications	1c	2c	2c	2b	2c	1c	1c
		Conversions	2c	3b	3b	2b	2c	N/A	2c
		Estimated Blood Loss	5	3b	3b	4b	2c	2c	3b
		Mortality	N/A	2c	N/A	2b	N/A	2c	N/A
	Resource Utilization	Length of Stay	2c	2c	3b	1c	2c	2b	2c
		Operative Time	2c	3b	3b	2c	2c	2c	2c
		Readmissions	2c	3b	3b	4b	4b	2c	2c
		Reoperations	2c	3b	4b	4b	3b	1c	2c
USA Total EQI: 268 EQI Growth Since 2019: +15 (5.9%)	Clinical	Blood Transfusions	2c	2b	2c	2c	2b	1b	2c
		Complications	2b	2b	2c	1b	1c	1b	1b
		Conversions	2b	3b	2c	1b	2c	2b	1b
		Estimated Blood Loss	2c	2b	3b	1b	1c	1b	3b
		Mortality	2c	2b	2c	1b	2c	2b	1b
	Resource Utilization	Length of Stay	1c	2b	2c	1b	1c	1c	1c
		Operative Time	2b	2b	3b	2c	1c	1c	2c
		Readmissions	2c	3b	2c	2b	2c	1c	2c
		Reoperations	2c	3b	2c	2c	1c	1c	2c
		Total EQI:	85	63	86	96	91	116	86
		EQI Growth Since 2019:	+10 (13.3%)	+7 (12.5%)	+6 (7.5%)	+25 (35.21%)	+11 (13.8%)	+9 (9.4%)	+2 (2.4%)

RESULTS:

- Total EQI score for malignant procedures was 2,198 in 2019 and 2,738 in 2024 (25% growth). For benign, the total EQI grew from 601 to 987 (64% growth).
- For malignant procedures, the largest EQI delta was 75 for EU Lobectomy (93.8% increase), followed by 52 for EU Endometrial Hysterectomy (62.7% increase). For benign, the largest EQI delta was 49 for EU Inguinal Hernia (700% increase), followed by 47 for APAC Benign Hysterectomy (66.2% increase).
- The smallest malignant EQI delta was 6 for both Americas Endometrial Hysterectomy and APAC Cervical Hysterectomy. For benign procedures, the APAC Gastric Bypass EQI grew by 0.
- The EQI of numerous benign procedures grew by several hundred percent. In comparison, only two malignant EQIs grew by more than 50%, given the existing mature evidence base.

CONCLUSIONS: These findings indicate that Malignant procedures have a significantly higher EQI score and are growing at a much slower rate than their Benign counterparts. This implies that evidence for Benign procedures is less mature, with far more room to grow.

It also highlights outliers requiring further investigation such as APAC Gastric Bypass, where unseen obstacles may be preventing the evidence from maturing.

This analysis should be regularly updated to continuously track evidence growth over time. Next steps include further investigating the impact of external factors (ie. COVID-19) on evidence generation, and also improving the outcome selection Python algorithm.

*Level of evidence definitions are in accordance with Evidence Based Medicine[1] pyramid and guided by the Oxford Centre for Evidence Based Medicine[2].

1. https://ebm.bmj.com/content/21/4/125

2. https:// cebm.ox.ac.uk/resources/levels-of-evidence/ocebm-levels-of-evidence